ASSESSMENT OF DETERMINANTS AND EFFECTS OF WASTE PREVENTION AND MANAGEMENT STRATEGIES POLICIES AND STRATEGIES

Deliverable 1.2

04/10/2017

Waste Resources Innovation

Version	18
WP	1
Dissemination level	Public
Deliverable lead	CHALMERS
Authors	José Espí, Lídia Vendrell, Mireia Mesas, Frederic Clarens (CTM) Svetlana Obydenkova, Leonardo Rosado (Chalmers)
Reviewers and contributors	Livia Mazzà, Isabelle Ronvaux (Ecosistemi), Rita Garcia (U. Coimbra), Ana Pires (NOVA.ID.FCT), Charlotte Voigt (SERI), Maurizio Pioletti (IUAV), Raquel Iglesias (Aj. Sabadell), Richard Elelman, Ana Antolín (CTM) Alexandra Ghenea, Adriana Gheorghe (Ecoteca), Florin Nenciu (GIS), Aldo M. Femia (ISTAT). EAB members: Pilar Chiva, Joan Prummel, Benedita Chaves (LIPOR).
Abstract	The report focuses on the assessment of the determining factors and effects of waste prevention and management policies and strategies. In particular, it covers an assessment based on: desk analysis of WMS polices and strategies; stakeholder surveys and interviews; and analysis of urban metabolism variables and preliminary indications for the definition of Urban Models for Strategic Waste Planning in the 8 pilot cities. Finally, the report presents the DPSIR (Drive-Pressure-State-Impact-Response) model waste framework.
Keywords	Waste prevention; waste management; waste policies; Determinants and Effects of waste prevention and management; UMAn Model, DPSIR

1 Contents

2 Executive summary

Briefly, the report includes 1) a comprehensive analysis of the waste policies and strategies in six European countries based on previous tasks within the project and surveys and interviews to relevant stakeholders. Main aim was to establish the determining factors concerning waste prevention and the most relevant management strategies and policies; 2) the DPSIR (Driving Forces-Pressures-State-Impact-Responses) model developed for waste management (WM) and the determinants related that affect these policies and regulations under the social sphere and 3) the identification of the explanatory variables of urban metabolism and their influence on material flows in general and waste generation for the 8 pilot cities.

The analysis of the waste policies and strategies has been performed with the objective to answer the following key questions: what are the emerging trends in this sector? What are the relevance of the policy instruments according to theoretical lessons? How are the policies developed and implemented? Do these instruments tackle the real waste prevention and management needs of cities? Do the available resources match the aims of the policies? What are the results achieved by these instruments?

The analysis shows that, although there is despite of exists a common framework in all countries (based on the translation of European directives, to national, regional and local level), the mechanisms of development and the objectives and targets for each country are adapted to their reality. For example, most of the countries show that the organic waste as is a key waste stream and indicate differences or difficulties to implement some kind of WM. The main aspects relate to different as a function of degrees of education, social position or due to geographical/logistics constrains (e.g. centre of historical cities).

Finally, the general recommendations considerations for a better waste management which can be drawn after all are:

- Participatory approaches since they are a key factor to improve the success of waste management strategies (WMS) in order to analyse needs, provide and debate ideas, and finally, to increase the level of awareness of the current/future WMS.
- Existing differences in priorities. Public agencies often consider the WMS as a balance between social and economic aspects. Meanwhile, private operators are focused in economic aspects as key drivers. There is a risk in the involvement of WM companies as their profits usually are directly related with the amount of waste.
- The power of the citizenship as consumers and hence in prevention can change the priorities. Around Europe and especially in Austria, this power has shown to be enough to change the set of priorities set as described previously, making environmental aspects increasingly more relevant for the selection of WMS.
- Design simple and more homogeneous regulations to enhance the results of the WM, limiting the bureaucratic, technical or economic (through taxes) restrictions for the implementation of the innovative waste management practices and strategies.

- Support innovative WMS that can be implemented at real scale. Green public procurement, can be a right element to support this point
- Circular economy (CE) practices and regulations are seen as an opportunity to enhance the current WMS. WM must be converted to resource management in order to create new opportunities, involving all value chain and life stage of products: design, production, use, reuse, recycling,… CE can be a key element to find the right answer to: How to produce and consume with less waste?

The DPSIR model (Driving Forces-Pressure-State-Impact-Responses approach) in the UrbanWINS project has been developed as a conceptual framework in order to establish how WM strategies encompass and deal with multidisciplinary and multi-sectorial approaches. The model was refined in working sessions with experts, mainly in Spain and Italy with the final goal to determine if they are effectively oriented to change determinants therefore reducing pressures on the environment.

The developed methodology describes the relationship between the origin and consequences of policies and strategies to which environmental problems are targeted, in order to understand their dynamics and establish links within the DPSIR elements. As a result, this approach allowed the identification of the main variables taking into account political, social and geographical aspects.

Based on the DPSIR model, the five main determinants identified were: Industrialization, Governance, Cultural barriers and the linked geographical context, Environmental Impacts and Human behaviour. The general waste DPSIR model must be locally evaluated in order to support the deployment of new WMS.

Finally, the identification of the Urban Metabolism main determinants are established and can be applied to the eight pilot cities. Moreover, the determinants can be used to replicate the knowledge gathered in the 8 pilot cities by clustering different types of cities based on their socio-economic characteristics, and therefore allowing to replicate good practices in WM strategies. These determinants are grouped into economic, socio-demographic, geophysical, technology development, urbanisation and infrastructure variables.

An inventory of main determinants for Urban Metabolism was created based on the literature and applied to the 8 pilot cities and has been interpreted in order to establish how economic, environmental, health and social issues can be examined in the context of urban metabolism, and how the connections to policy and urban design can be addressed in the definition of a new prevention and management waste plan. The main output is an overall assessment of how different urban features (socio-political, architectural, cultural, technological and gender factors) impact on the urban metabolism and if and how they affect waste prevention and management policies.

It is not possible to group the 8 pilot cities in clusters, since they show different groupings depending on the variable being analysed. For example, for population density there is a clear distinction between Bucharest and the other cities, while for climate, they all share a similar latitude. This leads to the conclusion that the number of determinants for explaining the urban metabolism can be quite extensive and may depend on a variety of factors like e.g. the development of industrial sector, waste prevention and management policies and such strategies set at a country or city level, the availability of a proper waste

management system infrastructure, environmental budget, environmental awareness, available living area in households, the time of staying at home, etc. However, this explanatory variables will be useful to inform Waste Management strategies design, considering the specific characteristics of each city. For example, densified areas show more waste collection rates but also lower concentration of stocks of materials per capita, hence, in a city it might be useful to devise different strategies for different areas in the city, depending on their density.

3 Objective

The main objective of this report is to undertake an investigation on the principal variables that affect urban metabolism and the subsequent relation to urban waste policies in 6 EU countries (Austria, Italy, Portugal, Romania, Spain and Sweden).

The general objective has been achieved through the following technical objectives:

- Interviews and surveys to relevant stakeholders
- Development of a DPSIR framework for waste management
- Identification of main determinants for urban metabolism and assessment of the 8 pilot cities

4 Introduction

In this task, a comprehensive analysis of the waste policies and strategies identified in Task 1.1 has been completed, in order to establish the determining factors concerning waste prevention and the relevant management strategies and polices. Furthermore, a preliminary investigation concerning the uptake of such factors and the impact on urban metabolism has been executed.

The analysis covers different key questions: what are the emerging trends in this sector? What is the relevance of the policy instruments according to theoretical lessons? How are the policies developed and implemented? Do these instruments tackle the real waste prevention and management needs of cities? Do the available resources match the aims of the policies? What are the results achieved by these instruments?

The analysis establishes how these strategies encompass and deal with multidisciplinary and multi-sectorial approaches. The goal is to determine if they are effectively orientated to change determinants in order to reduce pressures on the environment. With this approach, the DPSIR model (Driving Forces-Pressure-State-Impact-Responses approach) is used as a conceptual framework.

The methodology describes the relationship between the origin and consequences of policies and strategies targeting environmental problems, to understand their dynamics and establish links with the DPSIR elements.

As a result, this approach permits the identification of the principal variables taking into account political, social and geographical aspects. The variables reflect the causal

relationships between human behaviour, environmental consequences and responses to environmental changes related to waste prevention and management.

The analysis is focused on the study of results and impacts of policies, whilst answering the following questions:

- Is the efficiency of the instruments guaranteed (cost-benefit ratio)?
- What are their impact with regards to social acceptance?
- How are the instruments co-ordinated with the state, regional and local policy framework?
- What are the causes for unsuccessful innovative initiatives?
- What are the specific knowledge gaps and research needs?

Selected stakeholders have been interviewed in order to support the online survey, based on the stakeholder mapping done in the project (see Deliverable 3.1).

In addition, a preliminary "city types" for the elaboration of simplified urban metabolism models have been defined. Variables to be investigated are identified and data availability regarding non-material and material inputs are verified.

Available data has been collected and interpreted for 29 cities (6 in Portugal, 9 in Italy, 1 in Austria and 5 in Sweden, 4 in Spain and 4 in Romania). Specific focus has been placed on the 8 pilot cities for which methods to research and collect missing data are being defined in WP2.

The data has been interpreted in order to establish how economic, environmental, health and social issues can be examined in the context of urban metabolism, and how the connections to policy and urban design can be addressed in the definition of a new prevention and management waste plan. The main output is an overall assessment of how different urban features (socio-political, architectural, cultural, technological and gender factors) impact on the urban metabolism and if and how they affect waste prevention and management policies.

5 Analysis of the state of development concerning Waste Management Planning Policies and Strategies

5.1 Emergent trends in the waste sector

The assessment focused in 17 sectors. The general observations are:

Turning waste into a resource is one of the key aspects in the move towards a circular economy. The objectives and targets established by European legislation have been key drivers for the improvement of waste management, the stimulation of innovation in recycling, the limiting of the use of landfilling and the creation of incentives to change consumer behaviour. If we re-manufacture, reuse and recycle, and if one's industry waste

becomes another's raw material, we can achieve the conditions of more circular economy where waste is eliminated and resources are used in an efficient and sustainable way.

All countries are moving waste up the hierarchy set in the Waste Framework Directive (WFD) (Directive 2008/98/CE, 2008) by focusing on improving waste prevention, increasing waste reuse and recycling rates and promoting energy recovery from waste in order to achieve zero waste to landfill targets. The focus of integrated waste management is recycling and recovery as well as improving the supply of goods and services through the implementation of public projects with a reduced environmental impact. Selection criteria in Green Public Procurement included resource and energy efficiency and the reduction of waste generation.

One of the main ideas is to actively engage citizens in waste management and maximize the involvement of all stakeholders in order to reduce waste generation with regards to weight, volume, diversity and potential hazards.

Regarding waste management trends, some countries have prioritised thermal treatment, with a large percentage of their waste being sent for energy recovery, while other countries have prioritised recovery other than energy (e.g. recycling of waste). Although differences in waste management approaches (technology mix) exist between the different countries, the majority of them show a move away from waste disposal, to resource recovery (other than energy) including recycling and energy recovery.

The trend is even more pronounced when it comes to waste management options for municipal solid waste (MSW), where significant differences in technology solutions are evident. Strategies concerning waste food are also operative in most countries. Some countries have specific national or regional policies and plans addressing food waste reduction. There are also private sector initiatives for preventing food waste, which are mainly socially orientated. The most common strategy implemented at municipality level is the promotion of domestic composting or in the reduction of avoidable food waste, i.e. unsold products still suitable for consumption. Strategies and projects seek to identify the drivers of food waste generation and best practices prevention, develop methodologies for quantification and foster agreements between governments, business and local stakeholders. Furthermore, there are projects focused on developing innovative technologies or solutions for increasing the efficiency of separation.

The differences between countries and technology options are also evident when considering plastic recovery. Strategies concerning packaging waste are addressed mostly to promote and improve separate collection and are based on awareness campaigns and educational programmes.

Going into details for each analysed waste stream, it can be seen that packaging waste is covered by the Extended Producer Responsibility (EPR) principle in Austria, Portugal, Romania, Spain and Sweden, generically encompassing the whole life cycle of packaging. In some countries, measures to reduce plastic bags are implemented, namely by the application of an eco-tax (e.g., Portugal and Romania). In some countries, responsibilities for waste management are assigned to waste generators or to waste producers, for waste streams covered by the EPR (Extended Producer Responsibility) principle (e.g., batteries, and accumulators, other packaging, tires, WEEE, wood, waste lube oils, end-of-life vehicles).

The actions regarding bulky waste are aimed to increase the re-use in target estates by building links with local community and re-use organisations, tenants and resident's associations. They train the community groups on how to collect, repair and re-use bulky waste items as well as offering empty clearance services in agreement with local re-use organizations.

For construction and demolition waste, initiatives aim to investigate the CDW management situation identifying obstacles to recycling and non-compliance with EU waste legislation. A life cycle approach has been employed as a tool. However, some projects have sought to evaluate creative solutions regarding recycling strategies (the detail of such actions can be seen in the appendix A of the Deliverable 1.1).

Projects for end-of-life vehicles are mainly focused on innovative solutions and new technologies that have been developed with the final aim of improving ELV recycling and recovery rates (it can be seen in the appendix A of the Deliverable 1.1). Innovative systems mainly address material separation and recycling, such as tyres, glass-PVB, plastics and electronic equipment.

Regarding green public procurement, strategies tackle different issues (such as circular economy and waste management and public procurement of innovation for waste management), sectors (bio-waste disposal systems and food waste reduction, buildings or health), as well as general prevention and management aspects, including recycling.

Some projects are mostly concerned with the reduction of the hazardous content of products through the development of chemicals with a reduced health and environmental risk and the substitution of materials or substances by less hazardous alternatives. On the other hand, initiatives also emphasise processes that allow the removing or neutralizing of the hazardous characteristics of waste.

Mineral oils projects focus on replacing mineral oil with alternative renewable products and reducing the overall environmental footprint.

Paper waste projects improve multidisciplinary training programmes designed to develop the researcher's skills regarding their scientific expertise, technological knowledge and professional aptitude in relation to a critical aspect of sustainable packaging, life-cycle assessment and carbon footprint. An important increase in the recycling ratio has been observed.

The textile waste projects aim to recover textiles fibres, produce and use alternative fibre categories, use regenerated fibres, eliminate chemical residues and plastic micro-particles, increase the circular economy and raise awareness concerning legal regulations.

Most waste cooking oil initiatives are focused on developing new processes for waste recovery and more competitive and efficient production technologies for biofuel production from waste cooking oils.

Finally, regarding WEEE, the innovative actions undertaken seek solutions for the environmental problems caused by electrical and electronic equipment, material extraction, processing and the treatment of these wastes. There is also a priority to reduce the increasing WEEE collection rates and promoting integrated WEEE management systems for a more efficient use of resources though information and communication actions.

5.2 Policies development and implementation

5.2.1 Synergies with the analysis of current Strategic Planning

This section is complementary to the analysis on the Strategic Planning for each pilot city published in Deliverable 4.1.

In that document, the information collected aimed at providing an overview of the state of art of urban and metropolitan strategic planning in each pilot city. As comprehensive strategic plans are not always present at municipal level, sector strategies and initiatives were collected and analysed to identify elements and actions that can have an effect on resource consumption and waste production.

The analysis was based on a multi-scalar approach (from the municipal to the national level: municipal, provincial and metropolitan, territorial basin, regional, national) and four main categories of information sources were involved:

1. original documents, legally provided by local authorities, such as planning documents, municipal resolutions (or from other local governments), that activated the planning process, analysis and dissemination materials produced during the planning process, and any other relevant documents that are common knowledge;
2. information collected in situ through interviews from public and private groups, who took part into the technical preparation of plans and into the various decision stages which characterized the strategic planning process (Bußjäger P. et al., 2004);
3. specific information and data from analysed plans (for example, data on the engaged staff in preparation and management of plans, data on costs of preliminary activities plan management, staff organizational chart; information flows diagram, etc.) provided by main interviewed actor by information sheet);
4. Selection of local press and specialized literature.

The table in Annex B illustrates the main plans in each city and is based on original official documents.

5.2.2 Austria

The framework for waste management in Austria is laid by EU regulations. The definition of waste and the responsibilities of waste management follow the definitions stated in the EU Waste Framework Directive. These definitions can be found in the federal Waste Management Act of 2002 (AA). The federal Waste Management Act has been in place since 1990, as result of a change in constitutional law separating waste management onto the competences of the federal and state governments (Bußjäger P. et al., 2004). The fundamental principles of waste management in Austria, as stated in §1 of the Waste Management Act (AWG) of 2002 are defined to be the precautionary principle and sustainability, these must be considered in all regulations and amendments.

Through the AWG the creation of a Waste Management Plan and a Waste Prevention programme, at least every six years is prescribed. The Waste Management Plan includes a survey of the current waste management situation, processing sites, necessity for the closure or building of new sites as well as outlining the direction of the waste management for the next five years in the form of goals including planned measures to achieve these. Within this the federal government cannot interfere with the jurisdiction of the state laws. The waste prevention programme must include the goals of planned waste prevention measures, a description of these measures as well as indicators to measure their effectiveness (AWG, 2002).

The responsibilities of waste management in Austria are separated between the federal and the state government. The competence of the federal government in regard to waste management is defined in Article 10 of the constitutional law (Directive 2008/98/CE, 2008) and limited to the treatment of hazardous waste, unless there is the need for the creation of uniform laws on national scale for a defined waste stream. This has been done in order to incorporate EU regulation into national law, such as in the case of the regulation for the treatment of biogenic waste or the regulation on landfills in order to achieve the prescribed reduction of organic waste in landfills. A multitude of these regulations has shifted more responsibility towards the federal government.

The governments of the federal states are responsible for communal and commercial waste within their state. Each state must create a Waste Management Plan, yet there are no federal prescriptions in regard to how frequently this must be revised or what it must contain, this is set by each state individually. The contents of the state Waste Management Plans, concerning the disposal of non-hazardous waste, must be included in the federal waste management plan2.

Each state has a Waste Management Act, which dictates the structure of communal and commercial waste management in said state (Allgemeines zur Abfallwirtschaft, 2017). While the contents vary between the states, the Waste Management Act generally includes the method for calculating the waste fees, guidelines for the funding of investments to achieve stated goals, defines cases where an environmental impact assessment must be completed as well as responsibilities of the municipalities and regional waste management associations. In various states the municipalities are in charge of the waste collection while the waste management associations are responsible for the waste processing, an exception is Vienna where both sectors are taken care of by the municipality.

5.2.3 Italy

Italian legislation on waste can be largely found in the Single Environmental Text -Testo Unico Ambientale (TUA), known also as the Environmental Code, approved by Legislative Decree no. 152 of April the 3rd, 2006 (G.U. n. 88 of April the 14th, 2006). In particular, the legislation concerning waste management is contained in Part IV of the Environmental Code, which lays down “rules on waste management and the rehabilitation of polluted sites”.

Also the National Waste Prevention Programme (adopted by the Ministry of the Environment, Land and Sea by the Executive Decree of October the 7th, 2013 (G.U. n. 245 of October the 18th, 2013) in compliance with Directive 2008/98/EC) and successive updates establish general criteria for municipal waste management at the national level.

Waste management includes: methods and strategies of separate collection of municipal waste, the transport, recovery and disposal of waste, including the supervision of such operations and the subsequent interventions regarding the closure of disposal sites, including actions taken by dealers or brokers.

The regions are then required to establish specific strategies based on local characteristics according to criteria of economic sustainability within their Regional Waste Management Plans (as regulated by art. 199 of the National Environmental Code - Legislative Decree n. 152/2006 – (G. U. n. 88 of April the 14th, 2006), in compliance with these general criteria. Waste management follows the waste hierarchy of the EU Directive.

Organic waste represents the most important waste stream at municipal level in terms of weight and volume.

When discussing responsibilities for waste management:

- the State is responsible for: the direction and coordination; the developing of criteria and methodologies for the integrated management of individual waste management activities; the defining of guidelines concerning the minimum content of authorizations and energy recovery activities; identifying the recovery and disposal activities of major national interest; defining initiatives and actions, including financial, to encourage the recycling and recovery of waste, and promoting the market for materials recovered from waste and their use by public administrations and economic operators.
- Regions are in charge of planning the integrated system of waste management via the adoption of Regional Waste Management Plans in which they define: waste management within the geographical area of interest; measures for the improvement of environmental effectiveness of the various waste management operations; the assessment of how plans contribute to the implementation of national objectives.

Municipalities have the role of organizing and managing the services of waste collection, disposal and recovery of urban waste and the collection of related charges.

At the operational level, waste management, as well as waste collection and disposal, is jointly undertaken by public authorities (including municipal utilities) and economic actors. In particular, the most relevant economic actors are National Consortia required to pursue recovery, recycling and reuse targets, by enacting prevention strategies on specific waste streams. For example, the importance of recycling of waste packaging, the main activity undertaken by the National Consortium Conai, reaffirms the key role of economic actors in waste management for promoting the circular economy.

5.2.4 Portugal

The General Regime for Waste Management (RGGR) sets the principles for the prevention, production and management of waste, in alignment with the EU Directive 2008/98/CE (MAOT, 2011). It establishes the general principles guiding waste management, the rules for waste management planning, the technical standards of waste treatment activities, the licensing of waste management activities, the requirements for record keeping and monitoring of waste management and the economic and financial instruments of waste management.

The National Plan of Waste Management 2014-2020 (PNGR) sets the national strategic guidelines for the waste prevention and management policy and the guiding rules that assure coherence between specific waste management instruments. It implements the principles set in the General Regime of Waste Management (RGGR) (PCM, 2015). The Waste Prevention Programme is integrated within the PNGR.

Currently there are three Waste Strategic Plans: for urban waste (PERSU 2020) (MAOTE, 2014), for industrial waste (PESGRI) (MAOT, 2002), and for hospital waste (PERH) (MADR et al., 2011). However, the PNGR proposes that, in the future, non-urban waste policies should be combined into a single strategy aiming towards an integrated process-based waste management.

Urban waste management planning (up to 1100 litres per day) is established under the Urban Waste Strategic Plan (PERSU 2020) (MAOTE, 2014). The vision, principles and objectives of the PERSU 2020 are aligned with the view of the PNGR. Urban waste management is the responsibility of municipalities, and inter-municipality and multi-municipality management systems. There are 23 urban waste management systems in Portugal (12 multi-municipality and 11 inter-municipality systems) which are very diverse with regards to the number of municipalities, area and population covered, and the socio-economic conditions of the population served. Therefore, specific targets are set in the PERSU 2020 for each urban waste management system according to their specificities. The Urban Waste Prevention Programme is included in the PERSU 2020 and sets the general principles, goals and measures regarding urban waste prevention at national level. Each urban waste management system is required to prepare an Action Plan (PAPERSU 2020) with prevention and management measures and actions to be developed so as to comply with the targets set in the PERSU 2020 (MAOTE, 2014).

Due to the complexity or increasing importance of some waste streams, there is specific legislation regarding its management, which, in general, assigns the co-responsibility for prevention and management to the various actors in the life cycle. According to the characteristics of the waste, two models can be applied (PCM, 2015):

1. A model of technical-economic management based on the Extended Producer Responsibility (EPR) principle, operationalised through the adoption of individual systems or the implementation of integrated management systems (the most common). As part of an integrated system, the producer responsibility is transferred to a management operator of the specific waste stream upon payment of financial compensation (or Ecovalor) for the products placed on the market. The EPR principle, enforced in Portugal since 1997, is applied to the management of: packaging and packaging waste, tyres, mineral oil, waste electric and electronic equipment, end-of-life vehicles, and batteries and accumulators.
2. A model in which the responsibility for waste management lies with the producer/holder of the waste. In this regard, specific legislation has been developed concerning the management of construction and demolition waste and waste cooking oil, which are generically managed in a way similar to urban waste.

5.2.5 Romania

In Romanian Law 211/2011, republished in 2016, the General Regime of Waste Management ("Waste Law") is defined, as it sets the measures for environment and health protection, by preventing and diminishing the adverse effects of resource use and increasing resource

use efficiency. Responsibility for waste management is assigned to waste generators or to waste producers, for the waste streams covered by the EPR principle (batteries and accumulators, packaging, tyres, WEEE, wood). Local public administrations are responsible for the collection, transport and disposal of municipal solid waste.

The Ministry of Environment, Waters and Forests of Romania, through an EU capacity building Project, has developed a new **National Waste Management Plan** (covering the period of 2016–2025), which also integrates the **Waste Prevention Plan**. Public consultations on the National Waste Prevention and Management plan were launched in December 2016 and the approval is set for 2017.

At regional levels, **Regional Waste Management Plans** have been developed by each Regional Environmental Protection Agency in order to implement all relevant legislation and support accordingly. Eight regional waste management plans were approved in 2006 by Ministerial Order 1364/1499 and will be reviewed by the end of 2018.

The **National Waste Management Strategy** for the period of 2014-2020 has been developed in accordance with the 2008/98/EC Waste Framework Directive/WFD, with the following priorities:

- Waste prevention and reuse for more efficient use of resources;
- Development and expansion of systems for separate collection of waste;
- Development/implementation of technologies and recycling and/or recovery facilities;
- Support for energy recovery from waste for that waste that cannot be recycled;
- Reduction of the amount of waste disposed of through storage (landfilled).

Further collaboration with other Member States is achieved through the implementation of the Romanian Green Growth Strategy 2013-2020-2030 (with support from UNDP) focusing on mitigation objectives of waste prevention and minimization, increased recycling practices, reducing the amount of waste materials, increased use of composting of organic waste and energy production from waste (EfW). The target audience are Public and Local Administrations, state-owned enterprises, private companies, the local business sector, civil society, citizens, and authorities.

Romania is committed to fighting climate change and pursuing low carbon development. Therefore, the Government of Romania, through the Ministry of Environment, has requested the World Bank to provide advisory services to help meet this commitment. Completed in November 2015, the Programme on Climate Change and green economic growth with low carbon emissions was jointly implemented by the World Bank and Ministry of Environment and aimed to enable Romania to advance towards attaining the “Europe 2020 Strategy” objective, which provides EU Member States a framework and means for moving towards a greener and more competitive low carbon economy that makes efficient use of resources and is resilient to climate risk. The Action plan on climate change 2016-2020 was developed within the programme and is being implemented by the Romanian Government.

The Waste Prevention Plan takes into consideration mostly measures for municipal waste (bio-waste individual composting, pay-as-you-throw), food waste, packaging, electronic waste (WEEE), and batteries. The Regional Waste Management Plans consider mainly the prevention and management of: municipal waste, biodegradable waste, packaging waste, sludge, asbestos waste, and end of life vehicles.

At the national level, the responsibility for waste prevention and management belongs to the Ministry of Environment. According to EU Directive 2008/98/CE, transposed into the national legislation with the Law 211/2011 on Waste Management, the Ministry of Environment is responsible at the national level for the elaboration and implementation of the National Waste Prevention Plan – which can be joined with the National Waste Management Plan, as is currently the case. Taking into account the type of waste, other Ministries are responsible for different types (for example, the Ministry of agriculture is responsible for agriculture, fishing and food waste).

At the local level, the municipalities are responsible for the implementation of the Prevention Plan, as they are also responsible for the elaboration and enforcement of Local strategies for Waste Prevention and Management. When it comes to Bucharest (capital of Romania), the Municipality of Bucharest has elaborated the Plan for waste management but the 6 local sectorial municipalities are responsible for the implementation under the coordination, monitoring and control of the Bucharest City Hall. Also, correlated with the National Waste Prevention and Management Plan, can be developed and implemented waste management plans or strategies at the regional and county level can be developed and implemented

5.2.6 Spain

In Spain, waste generation has been closely related to economic growth. More than 50% of waste has been generated by the services sector, mining and construction. In 2012, still 44% of the total waste was destined for landfills, despite the progress regarding waste treatment.

The extension of the application of the 16/2002 Law of prevention and control of pollution (IPPC) to other waste treatment implies that most of the installations will launch measures to apply the best available technologies (BAT). The included activities in this extension are in Annexes I and II of the 22/2011 Law of contaminated Waste and soils.

In the field of urban waste, Law 22/2011, has delimited the competences of the local entities. Domestic waste management corresponds to the local entities and it is guided by the Regional Governments. The challenge is to establish efficient management models that allow one to fulfil the legal objectives and obligations derived from the multiple and diverse European, national, regional and local legislation.

Since 2012, Voluntary Agreements between associations, companies and private homeowners have been established in the scope of the efficient use of resources, moving beyond legal requirements. For example, in waste prevention there exist voluntary agreements with economic agents involved in the packaging and marketing chain (packaging manufacturers, packers and merchants or distributors) to promote the prevention of packaging and packaging waste.

In waste reuse, there are agreements to promote the use of reusable plastic packaging: for example, reusable bags in shops and supermarkets, glass containers for certain foods, especially in the HORECA channel and similar, as well as the promotion of second-hand markets (appliances, furniture, and clothing). With regards to waste recycling, collaboration agreements have been created, pilot projects concerning the selective collection of the organic fraction and green waste of parks and gardens in municipalities have been implemented, whilst actions involving large generators, HORECA, rural environments, and isolated and insular areas have been undertaken. In order to guarantee human health, environmental preservation and maximizing of the recovery of resources contained in wastes, an important, wide-ranging technological knowledge in different fields is required. Knowledge about waste generators industrial processes, different waste treatments, waste composition and pollutants as well as the requirements of installations or receiving environments is a key issue. Therefore, it is considered important to invest human and economic resources in the increase of studies in these fields.

The PEMAR plan, (Plan Estatal Marco de Gestión de Residuos) was created by the Spanish Ministry of Agriculture, Food and Environment for the period 2016-2022. The plan seeks to improve the perception of the economic, environmental and social importance of waste policies. In this way, the clarity of waste management information is a motivating tool to increase the collaboration between all stakeholders, including citizens. Thus, it will enhance waste management and reduce littering. The possibility of improving communication and increasing sensitivity strategies is also considered.

The recycling consolidation activities will require the development of measures that facilitate the reincorporation of recycled products to the market, as well as the technical instruments to improve the collection and processes of recycling.

As Law 22/2011 dictates, each Regional Community has elaborated a regional plan of waste management. These plans define the steps to facilitate and establish objectives for the preparation for reutilization, recycling, valorisation and elimination of waste. The same law promotes separate bio-waste collection and its treatment, domestic composting and compost use produced through bio-waste.

The regional plans approved contain information about waste source and generation as well as the systems and installations for waste collection and management. New collection systems and landfill state evaluations will illustrate the capacity of the future installations of valorisation and support the development of waste management policies. The evaluation of the need of new collection systems and the state of the landfills, establish criteria regarding the location and the capacity of the future valorisation installations and the description of the waste management policies.

Where the objectives affect municipal waste responsibilities, local entities are expected to provide the necessary means to accomplish said objectives.

Taking into account the aforementioned factors, each regional community elaborates specific strategies in order to improve waste prevention and management whilst the Spanish government defines general waste prevention and management strategies.

5.2.7 Sweden

In Sweden, the Waste management is governed by various types of rules, legislation, plans and targets across various spatial scales, from EU level to, national, regional and municipality level. Aligned with the EU framework, the Swedish legislative base of waste management is laid down by the Swedish Environmental Code (Ds 2000:61) and is developed in Waste Ordinance (SFS 2001:1063). Special requirements for waste management have been developed by the Swedish Environmental Protection Agency, and can be also expanded in guidelines by other authorities (e.g. by the Swedish Construction Federation). Sweden's Waste Plan is revised every 6 years and the plan for 2012-2017 (SEPA, 2012) has defined the focus areas and main strategies, such as, household waste, construction and demolition waste and illegal export of waste, to contribute to the achievement of the national environmental objectives and targets (Environmental Objectives, 2016; Milestone Targets, 2016).

The municipalities are responsible for the collection of any household waste not covered by producer responsibility and for its transport to waste treatment plants for recycling, energy or nutrients recovery or disposal to landfill. This applies to both waste from households and similar waste from restaurants, shops, offices, etc. Every municipality is required to have its own waste and sanitation ordinance, which consists of a waste plan and regulations for waste management. The waste plan should include details of how the municipality intends to reduce the amount of waste and the danger posed by it. Preparation for reuse is also part of the municipal responsibility. The municipalities are also working to promote the prevention of waste and its recycling, despite this not yet being their statutory responsibility. The municipalities must choose themselves how waste management is organized (Avfallsverige, 2016).

For certain types of waste, there is a producer responsibility that must ensure a suitable collection, transport, treatment and final destination systems for the specific waste in question, and also ensure that the waste is transported and recycled or disposed of in an environmentally acceptable manner. At present, there are nine regulations on producer responsibility in Sweden, including for recycled paper, packaging, electrical equipment, incandescent lamps, cars, tires, batteries, pharmaceuticals and radioactive products and radiation sources.

Businesses are responsible for disposing of non- household waste and waste that is not covered by producer responsibility.

5.2.8 Analysis from the different countries perspectives

Logically, the European regulations leads the WMS developed and implemented in all countries and regions. In particular, the general principles guiding waste management are based on the Waste Framework Directive 2008/98/EC.

The countries adopt the directive to develop the different National Waste Management Strategic Plans (WMSP) according to the needs of each country. So, despite the common goal, the strategies and WMS are different, based on their specific needs (e.g. climatic, geographic, cultural…) and hence, action mechanisms and waste streams targeted can differ.

All countries reported that national strategies are complemented by regional and, in some cases, municipality competences. In these cases, each municipality develops actions according to those regional strategies and is responsible for the elaboration of Local Plans. Therefore, the final responsibilities on waste management depends both on the state and on the Regions.

Based on the compiled information, the management of organic waste is seen as priority stream at municipal level. Again, this fits with the European priorities.

Complementary to the main WMSP, most of the countries reported specific regulations for specific streams, often to assign specific responsibilities for prevention and management. In this direction, in the assessment of Italy is reported that the number of regulations can be high in some cases (i.e. due to regional, streams, etc.) at might be reasonable in some cases, to create new regulations, valid at national level that re-organises and simplify the legal requirements.

In most of the countries the reasonability on collection of municipal waste is from the public entities. In Romania, for example municipal waste generated by population is managed by public authorities (local public administration in collaboration with sanitation companies) while packaging producers and private entities are responsible for their own municipal waste generated.

Finally, it should be mentioned that is reported some initiatives based on collaborative approaches, such as Romania with the Romanian Green Growth Strategy 2013-2020-2030, or the agreements between associations, companies and private homeowners in order to improve the use of the resources, as it is the case of Spain.

6 Recommendations and perspectives

The recommendations and perspectives presented in this section are based on the content of interviews realised to experts and relevant stakeholders in all 6 countries (section 6.1), and the analysis of financing mechanism (section 6.2) and finally, on the results of previous experiences (section 6.3). Results at presented at country level followed by analysis to compare and draw conclusions at global level.

6.1 Results achieved: Do the instruments achieve real waste prevention and answer the management needs of cities?

6.1.1 Austria

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

The strategies implemented by the public sector are not directly oriented at economic incentives but rather at maintaining and improving the waste management with the money provided. The principle of proportionality is still included as a basic principle of the Waste Management Act, meaning that the economic reasonability needs to be considered for all planned measures. As the public waste management is funded through taxes and not profit oriented, there is more incentive to improve waste prevention measures (these would

reduce the returns for private companies), yet public initiatives promoting waste prevention have a smaller budget than recycling companies meaning that they often retreat into the background of marketing campaigns claiming that recycling is sufficient. A difficulty experienced by public authorities is that private companies will only accept waste materials for recycling, when the material prices are high enough. This also means that lucrative waste streams, such as metals or wood, do not require legislative quotas in order to be recycled.

The government tries to create incentives to make waste reduction more profitable, an example of this is by creating labels or awards, the reduced cost incurred by ordering less food (and reducing food waste) is not enough incentive for a large business, yet public opinion is worth a lot, so these labels aim at creating a larger incentive for waste reduction. Measures within businesses are initiated more through public pressure than government regulations, which is indicative of the high value that public opinion has for the private sector. For waste prevention within public institutions, the social incentives also overweight the financial ones as the costs are carried by the municipality, not by the institution. In the municipalities themselves waste management measures which have the fastest pay out are most popular.

When making decisions in waste management, the public authorities need to decide how high the processing costs will be and if these are justified by the amount provided for recycling. Having a centralized waste management and processing, such as in Vienna, where each stage of the non-commercial waste management is executed by the municipality, has shown to improve the efficiency and effectiveness of measures as these can be planned along the entire material stream. In other regions in Austria where the waste management is completed by the regions, the decentralized management also leads to the selection of regional bidders with the lowest cost.

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

Public authorities invite multiple stakeholders to participate in the creation of a new waste management plan or strategic environmental assessment. These stakeholders include NGOs and numerous experts from universities. In these steps, citizens are not involved as any concrete plans are being made. During the planning of waste collection or building of new processing sites, the citizens are consulted, for example during the public consultation phase in the environmental impact assessment of a new waste incineration plant. Public participation tends to be less in niche areas where fewer citizens are confronted with the product on a regular basis. For waste management within the municipal departments, attempts are made to allow the departments to develop their own strategies to implement waste management into their daily routine as well as their operations.

Efforts are made towards determining character types of people in regions and thus providing more personalized waste collection systems and strategies. Surveys are also completed to determine different attitudes in waste separation and management. There are also measures targeted specifically at the immigrant and refugee population. These are often directly involved in waste management and are provided with information and training in order to improve communication to their local community, for example, as a local waste consultant. These waste consultants are responsible for communication waste management practices to the public, from the municipal side, as well as from private businesses. This creates a link between the administration and the general public.

For repair initiatives, social response has been very good, indicating that there is high demand in the population. Many citizens are annoyed with rapidly electronics breaking and want to learn to help themselves. Through the training of individual, they become directly involved in the repair network.

The glass recycling in Austria reaches nearly 85% due to high social acceptance. This can be in part drawn back to the successful establishment over 40 years and communication with citizens of all age groups.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

Differences in waste separation are observed between rural and urban regions as well as between different income classes within urban areas. This can be led back to the availability of waste bins, possibilities for composting, the perceived anonymity in large building complexes and the different degree of education about waste management. In urban areas, the recycling materials are collected at centralized collection points, not in individual homes. This makes it less convenient for many to separate their waste. This especially has an influence on the use of the biogenic waste as a high quality is required for the production of compost. Therefore, the processing of biogenic waste is split into compost production (from high quality collection in well off, single family home areas) and biogas production (in areas with large apartment blocks and more mixed social classes). Time and spatial factors have also been determined as important. In rural areas citizens may have more space to organize waste into different fractions whereas in a city apartment there is less room. The amount of time citizens perceive to have also plays a role in the amount of effort they are willing to dedicate to organizing waste fractions. In some cases a simpler separation guideline followed by mechanical separation may be more effective. These differences are determined through regular waste analysis and surveys.

In the different states, waste management is decentralized with each community announcing their own tenders for waste processing. This results in a more regionalized waste management system, thus this also makes it difficult to create concrete measures at the state government level. The result is that each state has its own guidelines for waste separation, often dependent on the type of processing plant located nearby.

Technologies/research-What are the most important technological barriers and research needs for the implementation of a WMS?

More knowledge about waste separation habits and attitudes is necessary to create measures directed at certain demographic groups. More information is required about some waste streams in order to generate suitable management strategies at the municipal level, for example, old electronics. Every year a waste management assessment is conducted in order to gather current data about waste streams and determine strategic plans for the next years.

Research into different material components is also necessary in order to inform about harmful components and less harmful alternatives. Especially information regarding the human toxicity of materials is lacking .Creation of a transparent database can inform various actors and place pressure on producing businesses to remove harmful substances. This sort of database already exists for some product groups but needs to be expanded. This information can then be incorporated into all steps of a production process, for example

when a new building is built in Vienna, it is already considered where the materials come from, how they impact human and environmental well-being, and how they can be reused after demolition. During demolition, methods are used, which allow the material reuse afterwards. Through these considerations, the city of Vienna is moving forward towards circular economy.

Technological limitations are given by the availability of waste processing. For instance, there is no business in Austria that offers the recycling of batteries. Therefore, they are exported to Germany.

Environmental needs and achievements - What are the priorities established for the development of a WMS based on the environmental pressures and achievements to be accomplished?

Most waste strategies are implemented through economic or social incentives. Pressure by the citizens can create the incentive to make environmental considerations a priority. Environmental considerations need to include the resource extraction, resource use and possibilities of reuse. In Vienna during new building projects attention is paid to the consideration of each step. When legislative recycling quotas are adjusted, this is always done with consideration of the environmental benefits it will incur.

Environmental pressures during the extraction process as well as the waste processing are the motivation for the creation of private initiatives such as the repair network. A reduction in raw material extraction is also the driver in initiatives towards making lighter glass products, overall reducing the required resources.

An example of where the environmental pressures outweigh the economic interests is for electronics, these are dismantled into components, yet in Austria no market exists for the reclamation of rare earth metals, so they cannot be sold.

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

There is a constant learning process for the implementation of waste collection schemes as the citizens' attitudes are constantly changing. The circulation of 'Waste Myths' often hinder a successful strategy, these need to be debunked by effective information campaigns. Constant communication to the citizens is also important to ensure that waste management is positioned as an issue of high value and priority.

The reduced value of certain products perceived by citizens is part of the reason for the generation of large waste quantities. Management strategies can target this perception in order to achieve waste reduction.

Liability regulations are often a major difficulty when considering waste prevention and reuse measures. Especially concerning food waste, many actors are hesitant to take up measures out of fear of becoming liable when something happens. This also makes difficult to create interdisciplinary measures between ministries, as the communication and cooperation are weak between them.

Incorporation of waste management and prevention measures into other parts of the government is also effective. For example, waste prevention has been included in the regulation regarding large public events. When a large event is planned, the organizers need to previously provide a waste prevention plan. This implementation has allowed waste reduction at large public events as well as the creation of reusable dish businesses. Yet

quantitative waste prevention targets have proved hard to set, as the context changes in the process of the measure, making it hard to compare to before.

Creating measures which prescribe one processing method or a quota for the amount of waste collection have proved to have little effect. Prescription of a specific processing method (e.g. specific type of incineration) has shown to increase transport costs and monopolize the industry, as there may only be one business offering that method. Specific quotas regarding the amount or percentage of waste collected fail to consider the waste quality and, hence, do not reflect the true value of waste stream. The use of variable quotas can be a solution to ensure that the use of recycling materials does not reduce the quality of the products.

There are three levels of legislation that need to be considered: European, National and Municipal. In part waste management regulations are also implemented within other regulations such as for event organization, which makes implementation a complicated matter. Often times the federal legislature dictates a certain measure, yet does not intend for a consequence when this is not completed by the businesses, this makes it difficult for the executing administration to ensure businesses keep the promises made within their waste prevention plans.

6.1.2 Italy

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

In the opinion of the interviewed public bodies the strategies are implemented to answer multiple needs: complying with the laws, public services provision, and the pursuit of the urban community interest and the economic optimization of the waste management strategies. It means that not all the strategies are economically sustainable. As far as waste is concerned, both economic and social aspects are taken in consideration, and sometimes social arguments prevail over economic ones – even if only SEAP can provide a strategic vision.

In the opinion of private institutions, the strategies described and implemented are always oriented towards the achieving of an economic advantage, which is the principal aim of private companies. From a financial and economic perspective, EU incentives are used also to undertake ordinary activities, because of the lack of public investment in sustainable waste management in Italy. After planning, implementation is reduced to what is possible with the available budget.

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

Citizens do not always want to be directly involved in waste management activities, especially in the case of strategies implying citizen cooperation (e.g. door-to-door waste separate collection). In fact, some social resistance and conflicts have emerged. Participation becomes easier after citizens receive feedback for their commitment. For example, when the feedback is direct and instantaneous (e.g. “eating plastic machines” of Pomezia), or when the “effects” of the strategy can be seen, with a reduction in taxes or with a higher life quality. However, citizen participation is widespread, and consensus on separate collection has been accepted, as is the case with door-to-door collection, thanks

to the use of an effective methodology in involving and informing inhabitants. For this reason, the use of strong communication, education and public meetings is fundamental.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

From the cultural point of view, the most difficult situations are those where social distress, often in poor neighbourhoods, with a low level of education, and with a high percentage of immigrants are important realities. In numerous developing countries, the issue of waste is not considered problematic, which may imply stronger environmental awareness focused on convincing immigrants. In parallel, also with the upper class it is difficult to overcome resistance due to a very comfortable economic situation. The middle-class families, especially with children, are more receptive to innovative/engaging WMS. In any case, the use of communication in different languages and education at school are essential. From the geographical point of view, the urban structure of Italian cities makes planning and WMS implementation complex, especially with regards to logistics and infrastructures.

Technologies/research-What are the most important technologic barriers and research needs for the implementation of a WMS?

The interviewees agree that technology is not the main barrier to the implementation of WMS. The available technologies are sufficient to implement all the required activities and, where there is a lack of technology (for example for the resolution of composite polymers), they are all confident that scientific research will find a solution in the near future. The barrier is more on the "human" side of the technology use: the attribution of responsibilities for planning all the activities related to an efficient use of technology is uncertain and is the weak point in the process.

Environmental needs and achievements - What are the priorities established for the development of a WMS based in the environmental pressures and achievements to be accomplished?

The environmental aspects are usually taken into consideration only after the economic ones, except when environmental impacts (as from landfill or incinerator) make the involved stakeholders more aware of the environmental issues. The influence of the environmental objectives stated in the legislative developments could be and should be relevant, as common objective and purpose, but there is the feeling that the existing rules and regulations are not linked to reality.

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

On the one side, there are some bureaucratic limitations which obstruct the facilitating of innovation and the rise of new products and processes. On the other side, there are many cultural barriers not yet overcome. It is difficult to keep the active participation of all the stakeholders involved in the process when the results are not immediate, and require more time to be profitable. However, this participation is necessary, as is the cooperation among the principal stakeholders of the waste management chain which is still weak.

6.1.3 Portugal

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

The reduction of the cost associated with waste management is an important driving force for the implementation of the strategies in both public and private entities. Cost reductions are expected through reducing waste generation by promoting home composting, through optimizing collection routes and increasing the efficiency of waste management in general, and by promoting the separate collection of certain waste streams, mostly through awareness campaigns, thus improving the quality of recyclables.

Strategies implemented so far at cities are built to comply with national legislation (which is derived from European waste legislation), bearing in mind the national/European funding schemes that could support their implementation. In addition, cities are always quite concerned with the collection costs (more than with waste disposal costs), investing more in collection optimization software and equipment instead of strategies devoted to waste reduction or source separation of waste.

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

Although there is no national data on reduction or reuse of waste by citizens, there are some studies that could give some information for example in the Porto Region there are several prevention indicators measured by Lipor. Concerning smartphones and tablets, a specific WEEE, Martinho et al. (2017a) found that most respondents were dedicated mostly to reuse actions, such as keeping the devices at home or giving them to a relative or friend to use. Concerning food waste, there are several initiatives at the city level like "Refood" and "DariAcordar", which intends to distribute meals from restaurants and private homes to needy families, diverting tonnes of food waste from landfills. Another national measure that had a considerable impact was the plastic bag tax implemented in February 2015. According to Martinho et al. (2017b), a reduction of 74% of plastic bags consumption with a simultaneously 61% increase of reusable plastic bags was verified in two cities in Portugal.

No matter what the waste hierarchy level – reduction, reuse or recycling – there is a need for environmental awareness campaigns to increase citizen's knowledge of existing collection and recycling programs, namely for WEEE, where there are many local and regional private NGO initiatives, which are currently not reaching citizens.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

Concerning the geographical point of view, cities with historical areas have additional issues to implement WMS, especially in terms of logistics and equipment to be used. In addition, the topography of Portuguese cities also limits the use of waste management equipment.

Most cultural barriers to WMS come from the black-market sector, immigrants and socio-demographic aspects. Concerning the black-market sector, in Portugal, people commonly store metals and other valuable wastes to give to low-class citizens and some companies, who sell them to make an extra income. There are also some social institutions are collecting paper from the citizens in order to sell it and make some profit (banco alimentar, bombeiros,...). The black market has risen with the crisis, with several thefts of

paper/cardboard from recycling containers occurring, for example. Concerning immigrants, there are no awareness campaigns addressed to these communities to teach them how to handle waste. Concerning socio-demographic aspects, people are normally not interested in source separation of waste to recycle and tend to buy new gadgets as new models appear on the market. Family size is also another issue to have in mind when applying WMS.

Technologies/research-What are the most important technologic barriers and research needs for the implementation of a WMS?

The cost of technology can be a barrier, being one of the arguments for not applying Pay-As-You-Throw (PAYT) schemes in Portugal.

Environmental needs and achievements - What are the priorities established for the development of a WMS based in the environmental pressures and achievements to be accomplished?

One main driver for the implementation of the strategies is the fulfilment of environmental legislation requirements. The efficient use of resources is also pointed out as an important driver, namely through inducing the deployment of technologies that lead to lower natural resources extraction and optimizing material recovery. In general, strategies aim to stimulate market demand for environmentally improved products and services. Also widely mentioned is the need to reduce greenhouse gas and other pollutant emissions.

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

High costs of implementation and lack of funding or subsidies were reported as important barriers to the implementation of the actions. The low involvement and cooperation between stakeholders, together with the low level of concern about sustainability were also pointed out as causes for ineffective initiatives. Lack of knowledge regarding technical possibilities for waste prevention and management as well as lack of infrastructure are also causes of unsuccessful strategies. The uncertainties associated with the innovative character of the strategies is considered a drawback. Other difficulties arise from bureaucratic barriers, namely regarding the end-of-waste status due to the time and cost of the process.

6.1.4 Romania

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

National level

Local administration authorities and all private and public organizations have the obligation to ensure separate collection for at least the following types of waste: paper, metal, plastic and glass starting in 2011 (Law no. 211/2011).

In May 2017, the first version of the Romanian National Waste Management Plan (PNGD) and the National Waste Prevention Plan (PNPGD) were issued, strategies that should have been implemented since 2013.

Delays were caused by cumbersome public procurement procedures, the lack of political coherence in waste management at the national level and the fact that waste management was not prioritized by any of the governments during recent years.

The European Commission (EC) has announced its intention to take punitive measures against Romania, given the failure to comply with the EC's obligation to review and adopt the two documents (PNGD and PNPGD) and taking into account repeated requests for a solution to this problem. Time constraints are leading to a task execution of the two documents in a precarious form, some aspects have not been adequately addressed. Besides, data is not always in line with reality and the objectives set might not have a real basis for achieving them, not being linked to a specific cost-benefit requirement.

A political decision with a major negative impact on the environment was the suspension of the decision to apply a tax to the municipal landfill. The tax will take effect from January 1st, 2019, but the information issued is unreliable, since it is already the third postponement in recent years on this tax. Despite of the benefits of this measure, it is nowadays not applied.

Other problems identified at a national level include: the lack of penalties for waste management operators, the lack of a firm attitude from public authorities regarding deforestation, the construction of waste incinerators (although at European level the construction of incinerators is avoided), the illegal construction of non-compliant landfills, and the low national funding for projects in this WM field.

Regional/local level

At this level some waste management strategies have been implemented. Some of them with mixed regional-European funding, with positive effects on the level of collection. Cities that have implemented strategies and investments in waste management equipment have seen improvements in all aspects: improving separate collection rates, attracting new private awareness campaigns, increasing the population's involvement in separate collection).

However, these centres are rather small not having the capacity to collect waste from other counties and cannot easily increase their operational capacity. They are, more than anything, pilot centres and aim to test new strategies without having a major national effect. It is necessary to analyse the way of functioning and the problems of each project in order to be able to implement such strategies in all big cities.

Town halls have different levels of involvement, generally big cities are targeting rising funds for waste management, applying for European funding, investing in awareness campaigns, and technology. Nevertheless, actual progress is not in line with the measures taken.

Objectives are often mistaken (overestimated), there are many anomalies in the waste management chain (usually at collectors level, who do not have the ability/technology to collect waste separately and in the educational areas). Although all city halls have strategies that are linked to a specific cost-benefit requirement, the level of implementation of these strategies is very small, as a result of poor waste management education, various breakages in the waste management chain, or because of the avoidance of coercive measures by competent bodies.

Private company level

Best efforts in terms of cost-benefit requirements are made by a number of private companies that have conceived and implemented strategies that work, reducing overall

generating amounts of waste and their expenses. Among the industries that have made major investments, mention can be made of the operation of waste reduction technologies such as: biogas generation, sorting and recycling stations with high performance technologies, incinerators with very low pollution levels, mandatory waste management internal measures for employees, waste management procedures concerning foreign partners, planning tangible objectives for the coming years, the use of waste generated in their flux in other processes and the acquisition of waste from the free market to be used as secondary products.

The listed measures have been implemented largely by several companies or by multinational companies, which have standardized procedures and are more often controlled by the authorities.

Small companies that tried to collect their waste separately faced the collector's refusal to move to their deposits, reasoning that transport costs were not justified for their collected quantities. In addition, collectors do not have the infrastructure required to handle large quantities of waste.

Private collection centres have been set up in the big cities, rewarding citizens who collect separately plastic recipients. Although the measure helps to reduce the amount of waste, the action at the central level is perceived as negative because of the unfair competition that these companies represent to the local waste collectors. It is competition on valuable wastes (plastic, metal, glass), while collectors are required to accumulate a larger quantity of low-rated waste.

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

There is not enough information available for the citizens, the awareness campaigns are usually small scale and do not have long-term results. They are mainly initiated by NGOs, the targeted groups being especially pupils from schools. Very few such campaigns are made by local authorities. Neither are made on a regularly basis.

Citizens are particularly dissatisfied with the collectors' attitude, in terms of the lack of provision of separate collection baskets on the four fractions of waste. In addition, most collectors, in order to reduce transportation costs, are picking up recyclable waste in the same vehicle (mixed, assuming the risk of contaminating paper and plastic), and subsequently carry out a partial separate collection.

Citizens are not happy with the idea of taxes being introduced given that the collection infrastructure is not adequate.

The population in the urban areas usually participate in large numbers in all the awareness initiatives of NGOs, companies or the Ministry of the Environment, but the results of the campaigns are limited.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

Regardless of geographical differences, the Romanian population is deficient in collecting waste separately, as a result of the inefficient policies of the last 20 years and the lack of awareness campaigns.

In the urban areas, due to the existence of common tubular columns for waste disposal in residential buildings, waste disposal is not controlled, the waste reaches the selection stations contaminated and mixed. Changing the waste disposal strategy in big cities poses serious problems in terms of building architecture, the proximity between buildings does not allow the location of collection points in the streets, buildings are usually high, making difficult to transport waste and resulting in a lack of storage spaces in apartments.

However, in urban areas an increasing number of citizens are willing to direct the recyclables to specific containers but many of them are rather reluctant, due to the fact that local authorities and sanitation companies do not explain to the citizens what happens to their waste directed to recyclable containers. Some citizens even think the waste is mixed afterwards and their effort to collect separately the recyclables is useless.

The rural population that practices "subsistence agriculture", tends to recycle organic waste for composting and throw or incinerate other types of waste. The waste management infrastructure is poorly developed in the rural area, where selective collection technologies are outdated or non-existent (there are usually no means of waste transportation on the 4 fractions or any sorting stations in rural areas).

Various campaigns which involved rewarding the population that throw waste separately have proven to be very effective, regardless of the social level, citizens responding better to financial incentives.

In developed cities, due to higher population levels and industrialization, larger amounts of waste are generated, although the infrastructure here is more advanced.

In large cities, separate collection of batteries, electronic equipment, and lighting fixtures, have a much better impact than in poor cities and rural areas, being the involvement of supermarkets in the campaigns.

Small cities have a higher level of implementation of local waste management policies, public authority and NGO campaigns have a higher level of awareness, the population being more receptive. The problems that arise here are related to the inconsistency of awareness-raising measures, the fact that investments in sustainable and reliable technologies is still low, local authorities having other priorities.

Technologies/research-What are the most important technologic barriers and research needs for the implementation of a WMS?

There are universities/research centres, public authorities and private companies who have implemented or are implementing national and European funded projects in waste management. Their objective is to develop innovative solutions for the recovery and recycling of biomass waste. Other areas of interest in the field of research, that involve both universities and industry are hazardous wastes (how to decontaminate them, final disposal, transport), industrial wastes, decontamination of groundwater and methods of dehumidification of organic waste.

However, the results of the research have been applied only by industry, while at the level of the central authorities, alternatives that have already been proved to be effective or with the lowest acquisition price are preferred.

Universities aim to develop future projects that will make the transition from fundamental research to pilot projects, and then pilot projects to market solutions, although there are financial limitations and a lack of collaboration with potential beneficiaries.

Industry has implemented internal methodologies and facilities/systems for the recovery or energy use of waste. For example, cement-making plants use all the amount of waste produced as secondary raw material in their processes, and would like to buy waste from the market. Nevertheless, municipal wastes are contaminated and have high water content, so they do not meet the minimum requirements to be used in their facilities.

On the other hand, there have been situations when new technologies in waste management faced regulations barriers. This is the case of an innovative pilot biogas station opened in November 2016 in Seini (a vulnerable area to nutrient pollution, due to intensive activity of agriculture and animal farming), which found that not only it will not receive green certificates (as stipulated by the project), but it had to pay a tax to the National Sanitary Veterinary and Food Safety Authority (ANSVSA) for polluting with manure. The issue is currently under settlement.

Environmental needs and achievements - What are the priorities established for the development of a WMS based in the environmental pressures and achievements to be accomplished?

There are debates about the prioritization of actions and real environmental needs, but we can note that the introduction of the landfill tax is especially desirable, having been postponed for a third time. Other necessary moves include the creation of selective collection centres at the local level, investments in waste infrastructure at a national level, the removal from the WM system of all sanitation units who are not able to carry out separate collection, fractional collection at source, the encouraging of citizens to collect separately and penalties for companies producing high amounts of waste.

Implementing new policies in the field of waste management represent another issue that deserves attention, while the existing policies are poorly implemented or ignored by citizens and some authorities.

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

The main problem identified and the cause of unsuccessful implementation of innovative initiatives is the lack of collaboration between all the stakeholders.

National policy makers are unable to identify and implement a long-term programme, funds are prioritized to the detriment of waste management, and they are trying not to put too much financial pressure on the population by introducing taxes and coercive measures.

Another major factor is the lack of citizen awareness campaigns at national level. The major campaigns organized so far have been initiated by private companies, with limited support/real involvement from the authorities.

Regarding the livestock farms, positive example can be observed. The government has provided funding programmes for the construction of concrete platforms to produce compost from animal waste. Accompanied by the obligation to comply with soil pollution regulations and with penalties in case of non-compliance with these rules, the programmes have had positive results.

6.1.5 Spain

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

The strategy for the interviewed public bodies is mainly concentrated on employing proper waste management in order to maintain the city's cleaning with the available budget and respecting the regulatory laws applicable. For instance, the strategies are not based specifically on demands of citizens. On the other hand, the strategies implemented by the interviewed private centres are focused on economic advantage as expected. In fact, the waste management operated by private companies is not so transparent, especially the ones that are obtaining high benefits. Both public and private bodies can demand various public Spanish grants in waste sustainable management to increase their budget and invest in new strategies (e.g. Catalan Waste Agency).

In general, there are several methodologies for waste management although the ones that are implemented are usually related to economic optimization rather than the maximum quantity of waste recycled or selective waste collection depending on each type of waste produced.

The barriers are not mainly economical, they are also consciousness. The interviewers put the highlight in sensitization campaigns.

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

There is enough available information for the citizens, whilst they are aware of the need to recycle, they are not really aware of how their rubbish is recycled and more importantly, at a general level, they do not understand nor have they heard of the 'circular economy'. Environmental campaigns to meet the citizens directly are not currently systematized or universal, i.e. only specific short campaigns are undertaken, where they could explain their problems or make suggestions. This kind of meeting would be fundamental to improve communication and environmentally educate effectively. For instance, one strategy followed is the installation of new and visually attractive containers to capture people's attention.

Usually, citizens are not too involved in the waste management process and are only affected by the tax increases, which are not as visible for the citizen as water or energy taxes. Nevertheless, there are some neighbourhood associations that are insisting on involving the citizen from the beginning of the waste management process instead of at the end, in such a way that they could have the opportunity to actively participate (i.e. household cooking oil collection, domestic compost). Moreover, it has been demonstrated that strategies of waste management work better in small villages than big cities, as better communication and confidence exists between the city hall and citizens. For example, the collection of furniture, electric domestic appliances and organic fractions is quite small compared to the rest of waste, due to a lack of understanding of the recycling system.

Neighbourhood associations insist in the importance of include the citizen participation in the very beginning of the decision process not only at the end when all the important issues are already closed, and when they do not have the opportunity of a real participation during the whole process.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

Municipal strategies are selected, however the same strategy is followed over the same city independently of the urban areas. Some interviewed people, indicate that they had observed a difference in the habits according to economic status, even mentioning that normally is more difficult to change the habits to the accommodated people, while at the same time are more exigent on the level of cleaning (no waste can be seen), which even compromise the applied WMS.

However, despite of the opinion from interviewees recovered, it is worth to mention the current situation in most developed countries around Europe as Switzerland or Belgium. In those, schemes where citizen has an intensive participation are actually adopted and indeed promoted by the middle and upper middle classes.

Differences has been seen in very touristic places indifferently of nationality, especially when comparing summer and winter seasons. When people are visiting or living for short period in other city, they are not recycling may attributed to the feeling of not being part of the place or just because they do not know where to recycle. Nevertheless, cultural differences have not been observed, although to launch environmental campaigns in various languages would certainly improve the awareness. Besides, higher awareness has been observed in younger generations than older attributed to their environmental education since primary school and media nowadays. Also, geographic barriers have not been pointed out.

Here the Neighbourhood association's representatives have different opinions:

- Some think that there are real barriers between different origin countries
- The other group think that there is a gap between different generations.

Very interesting here the response to the question "do you impulse specific waste management strategies or initiatives in specific neighbourhood?"

The different activities carried out by the contacted people have in common that they include raising and awareness campaigns:

- Facilitate the household cooking oil collection, they collected it in association facilities and they take it to the collection point
- Teach neighbours to made domestic composting, and inform what to do with the results Workshop with children related to the recycling

Technologies/research-What are the most important technologic barriers and research needs for the implementation of a WMS?

Nowadays, there are several methodologies which are very complete and efficient for their implementation, however they are also very complex as well. Thus, current methodologies should be simplified, and not create new ones, through consensus to select the most important KPIs. Moreover, the majority of strategies are more focused on research at pilot scale than at industrial scale (reality). Although there are Spanish grants for waste

management, the centres have to be self-sufficient to overcome the strategy as the grants are considered as an extra budget.

Another highly important factor to take into account is the legal regulations, which do not allow too much innovation in the waste minimization as the strategy is thought as a linear economy and not circular. For instance, if the enterprise wants to reuse waste, it need an authorization as waste manager if they want to use or treat waste from other companies while if they reuse their own waste it is not necessary. Thus, technology for raw materials recycling exists but there are economical optimization barriers from the industries, which would decrease through stronger awareness campaigns.

The communication between the stakeholders and the technological centre that develop the technology has to be improved as well to finally apply the strategy at industrial scale and later follow-up.

The opinion here is that is more an economical interest problem than a technologic barrier, the technologic exists but the industry prefer to use raw materials instead of the recycled one.

Environmental needs and achievements - What are the priorities established for the development of a WMS based in the environmental pressures and achievements to be accomplished?

The environmental issues are considered but from an economical point of view than environmental impact, which is attributed to sanctions. Normally, the objective is to minimize the waste taxes instead of raising the social awareness. In fact, the government should increase waste taxes (same national taxes of landfill) and introduce more responsibilities of citizenship (currently anonymous). In such way, the waste valorisation would highly improve guarantying the product quality (i.e. reuse as raw material for energy production).

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

The main objective is to achieve a contract of maximum time focused on waste collection but the legislation does not allow to obtain a contract higher than 4 years. Furthermore, the solutions created and implemented after the project is finished they are not later followed to validate the technologies. Also, even though some EU projects are successful at pilot scale, they have not been applied finally at industrial scale. Thus, waste management has to be adapted depending on local needs.

On the other side, before developing an environmental strategy, it has to be calculated the efficiency and economic optimization as possible to be affordable by all parts. An important aspect would be to avoid big installations (i.e. incinerators), which are expensive and may be later are not frequently used for that specific waste.

6.1.6 Sweden

Based on one interview provided by Kretslopp och vatten, the main body responsible for household waste management in Gothenburg Sweden and using additional information in the literature, the following aspects were highlighted.

Economic factors - Are the strategies implemented always linked to a specific cost-benefit requirement?

Based on the interview to the public body, it was referred that environmental aspects have a high weight on the accounting of the cost-benefit of waste management strategies. This might be true for public bodies, but for companies handling waste economic factors might play a larger role, in particular smaller single actor industries might have difficulties to make capital intensive investments. This is especially true if the discussion is centred on Industrial Symbiosis schemes and it's due mostly to the fragmented responsibility between public and private waste actors in Sweden and the existence of short term contracts (Aid et al. 2017).

Social acceptance and citizen response - How do you describe the public participation of citizens in the different stages of WM?

Municipal waste management plans in Sweden have to be available for public consultation prior to their enforcement, additionally, the waste management system includes the public through assigning responsibilities to households, in particular for separating and depositing the waste at available collection points and by following the municipality's rules for waste management.

Cultural/geographical barriers - What are the most important cultural/geographical barriers to the implementation of a WMS?

Public acceptance is clearly high since 99% of the waste in households is diverted from landfill. Among possible explanations to this the convenience of the recycling stations (300 meters radius), the fact that emphasis is put on educating children with specific communication events by municipalities. However, it is observed that different behaviour is seen from people coming from different backgrounds but the municipal waste plans don't take into consideration different population segments, but instead focus on ensuring that the plans consider diversity, equality and child perspective.

Technologies/research-What are the most important technologic barriers and research needs for the implementation of a WMS?

The waste sector has a strong capacity already in place and regarding the regular waste management solutions the technology is in place and mature. There is however, an ongoing discussion on what can be done more, being circular economy and industrial symbiosis focal points of further development (Aid et al 2017). Among the main technological barriers for this advanced development lie in the unsuitability of the materials to be reused, the lack of technical solutions in commercial scale and quality and quantity demands.

Environmental needs and achievements - What are the priorities established for the development of a WMS based in the environmental pressures and achievements to be accomplished?

The waste planning system is underpinned by the need to achieve national environmental goals that are translated to goals at the municipal level, this ensures that environmental aspects are taken into consideration. For example, in Gothenburg, the waste plan considers also the targets for the environmental plan and the climate programme. This is supported also by the set of indicators that monitor the plans, which include among others waste flows, energy and material recovery, transport efficiency, customer satisfaction, and fossil fuel based CO2 emission.

Lessons learned - Which are the causes for unsuccessful innovative initiatives?

In Sweden and according to the current national waste plan, establishing systems for sustainable waste management and the effective natural resource management represents a major challenge given rising levels of consumption and cross-border global trade (SEPA, 2012). This poses challenges due to the lack of good estimates on consumption in the future. Additionally, there is a need for reliable waste generation and composition data to further develop waste management strategies. This is due to the high uncertainties in official waste collection data. In particular, standardized methods and measurements of waste data, sufficient metadata should be developed (Dahlén, 2008).

6.1.7 Analysis from the different countries perspectives

After analysing all responses compiled by different stakeholders consulted from six European countries (Austria, Italy, Portugal, Romania, Spain and Sweden), it can be stated that:

Waste management strategies are mostly based on economic factors for both public and private sectors. However, despite being only for public actors, social aspects are also seen as important factors, but only in few cases become the decision factor. Although environmental factors are not reported as a decision factor yet, in Sweden they need to be addressed directly due to the national and local environmental targets and in Austria, citizens claim for more weight on environmental balance, and in fact, citizen pressure can be a stronger driver for private companies than just regulations.

Lack of funding or legislative loopholes has a decisive limitation in the adoption of the (especially innovative) strategies. For example, if an innovative solution or technology for waste management doesn`t have a legislation standard it cannot be implemented, as it is beyond the law. Regarding economic factors in waste management system, strategies are focused on waste collection taking into account the economic sustainability of the process. Usually, the economical aspect is the main problem found for implementation assigned to inexistent public funds or initiatives in this area (i.e. Italy, Romania) or because the quantity received is not high enough and has to be considered as an extra budget for the enterprise, which should be auto-sufficient (i.e. Spain). Therefore, waste management implementation is normally linked to economic sustainable process in both public and private sector.

There is a clear agreement that communication, awareness and information campaigns are key elements to improve waste management, despite most of the interviewees mention that the positive effects of previous campaigns are not clear. In some countries, people reported the necessity to set clear and periodic campaigns. Overall, there is available information for the citizens (leaflets, advertisements in media), although there is still lack of knowledge for some waste recycling materials among the population (e.g. WEEE) or the truly importance of reusing their wastes as raw materials (a part of the circular economy approach). Multiple stakeholders, including NGOs and experts, are invited for the creation of new strategies, however population is not directly involved in this process. Efforts towards effectively educational environmental campaigns taking into account the character's types and local needs in different languages for understating improvement would improve the social awareness.

Cultural and demographics barriers are encountered mainly assigned to non-environmental education, upper class comfortable status, character types of people, tourism and city's architectures, especially the ones that are ancient. Hence, waste methodologies must be

implemented taking into account the sociodemographic characteristics of the regions where strategies aim to be developed.

Currently, there are several technologies available, but they could be very complex. Furthermore, the response of the population is normally not as high as expected due to low social awareness or non-understating of the process. Another key barrier for technology development is the economic optimization as well as is stated above (i.e. Portugal). Moreover, in some countries waste recycling is not even considered a main problem to deal with by the national government (i.e. Romania), and then national investments are not consequently focused in WMS.

Generally, the environmental priorities are focused on strategies that aim to stimulate market demand for environmentally improved products and services, although these priorities are firstly orientated to the accomplishment of legal regulations (sanctions) or minimize the process costs as much as possible. Besides, waste taxes are currently not clearly reported to cityzen in most European countries, making invisible this kind of tax for the population (i.e. water and energy taxes are not anonymous). It has been already proved that social awareness would improve through personal incentives and environmental campaigns. In addition, face-to-face door waste selectively collection methodology has had also positive results (e.g. Belgium).

Besides the relative low concern about sustainability, the main causes identified for unsuccessful innovative implementations of advanced technologies are the poor involvement, collaboration and communication between stakeholders. Other key aspect is the communication with the technologists (universities, consulting firms, research centres, etc.) that develop or support technology development. Other important drawbacks for new implementations are the uncertainties associated with the innovative character of the strategies and the inexistence of national facilities for some specific waste processing (e.g. in Austria batteries are transported to Germany). Furthermore, once the process has been applied and proved its functionality at pilot scale, later industry scale application and follow-up for technology validation is not frequently reported. Finally, it's reported the difficulties to implement some WMS due to logistics and restrictions in old towns and due to regulations, which either can limit the implementation of innovative actions, add tax penalties for the implementation of circular economy approaches or even, in case of over regulations, can limit the competence and might led to the creation of monopolies.

Although there is enough potential and expertise along Europe to continue developing new technologies for WMS improvement, some pilot initiatives with satisfied results are not implemented at large scale. This is mainly due to the non-collaboration and lack of communication between stakeholders, which is fundamental, and may be attributed to the lack of fully understanding of the process or insufficient waste recycling awareness. With that whole approach, it seems that instruments promoted have not achieved real waste prevention and did not answer the management needs of cities.

Overall, current waste management processes implemented in the European countries satisfy the Environmental Normative. However, it has been detected some limitations. These strategies only cover in many cases minimum requirements of cities and referred only for waste recycling. And in many regions, waste management is not perceived as a key problem addressed by governments.

In this manner, strategies should be more orientated to environmental needs rather to be limited to economic optimization, being enchained and reinforced with higher population compromise through stronger education environmental campaigns and involvement taking into account sociodemographic characteristics. So, clear regulations to promote the circular economy principles coupled to innovative actions to increase the citizen and stakeholder compromises during the creation of new WMS and to enhance their cooperation (e.g. surveys) during their implementation should be key elements at municipality level.

6.2 Available resources match the aims of the policies?

6.2.1 Austria

The initiative RESET2020 contains provisions for efficient resource use. It was designed to support the implementation of the EU Circular Economy Package. It should concern production as well as consumption for achieving a sustainable and a more resource efficient society with minimization of influences on the environment. The fields of action are supported through existing and new environmental political agendas of the ministry in charge, using different instruments and provisions, funding, consulting, management and balancing systems, information and networks. The main objective is to decouple the development of the economy in Austria and the use of resources, e.g. raise resource efficiency by 50% by 2020 in relation to 2008 (BMLFUW, 2017a).

Central to Austria's activities in waste management are the Federal Waste Management Plan (BMLFUW, 2017b) and plans for the individual federal states within Austria. In addition, there are many different initiatives led by motivated individuals in the public and private sectors who are not content with simply meeting guidelines prescribed by the EU or the State of Austria. E.g. re-use platforms are being developed, also by initiatives and supported by funding of the public administration. This is further enabled through the close relationship between the public administration and universities as innovative ideas are fostered at the universities and implemented with the help of the public administration. Initiatives by the private sector, for example in Supermarkets, are also not legally prescribed but originate from the management of these businesses.

Waste analyses are regularly prescribed, financed and conducted in order to ensure the "picture" of the waste quality and waste streams be current and reliable and further steps for the improvement of the waste management can be tailored based upon that up-to-date knowledge. Those responsible for waste collection are encouraged to complete surveys with the citizens to determine more effective methods of waste collection. There is also a 6 year renewal of the Federal Waste Management Plan ensuring its relevance to the current situation. These informational resources allow for a flexible and near-term adaptation and development of more suitable measures if those in place are found to be suboptimal.

If for certain recycling paths no technology in a given federal state or even Austria is at hand, for the time being the material has to be recycled in neighbouring federal states or countries. Depending on the state-of-the-art in general and the expected trends of the waste streams regarding amount and composition in particular, financing of research and/or technology development is critical. The Austria Wirtschaftsservice (aws, i.e. Austria economy service) has funding available for a range of economic framework conditions, e.g. investment guarantees allowing small to medium sized businesses to obtain up to 25 Million

Euros for investment in new technologies or upgrades (Austria Wirtschaftsservice, 2017). Without these funding opportunities, the allocation of the ministerial budget for research is often a political decision.

The European Regional Development Fund allocated 646 million Euros of funding to Austria during the period of 2007-2013, which is just below 1% of total government expenditures. Focus of funding was on innovation, RTD and enterprises (EC, 2017). The new funding period of this structural fund is going to last from 2014 to 2020 and a global (European) budget of 183, 2 billion Euros will be made available (Welcomeurope, 2017). Part of this funding is available for projects within the scope of research and investments related to waste and environment.

Austrian projects that receive public funding must determine indicators that measure the impact as well as making a clear cost analysis. There is also a consulting and assistance service offered to businesses that want to improve their environmental footprint. Many thousand businesses are a part of this initiative. For some economic branches such as catering, businesses can do an online self-assessment to determine waste streams and the ministry will pay 50% of the price for a professional evaluation of waste reduction possibilities if a need is determined through the assessment.

6.2.2 Italy

The Economic and Financial Document 2017 (DEF) (COM, 2015) is a key document produced by the Italian Ministry of Economy and Finance. It offers the opportunity to evaluate the activities implemented and the results achieved at national level, and it represents the basis to design the future choices of economic policies. In the "Report of the Minister of the Environment, Land and Sea on the status of implementation of commitments for reduction of greenhouse gas emissions. L.39/2011, art. 2, c. 9" (EC, 2017), it is clearly explained how Italy is positioned in the right pathway to meet mandatory annual targets set out in the Decision no. 406/2009/EC of the European Parliament and the Council of April 23, 2009 (updated by following Decisions 162/2013/EU and 634/2013/EU), which regulates GHG emissions in sectors outside the EU ETS (transports, civil, small industry, agriculture and wastes) by setting binding annual GHG emissions targets for each Member States (MS) for the period 2013-2020. The actions implemented by the Italian government are consistent with the new objectives for 2030 according to the Paris Agreement and in accordance with the objective to de-carbonize the economy by 2050.

The Economic and Financial Document 2017 includes for the first time a section on "BES – *Benessere equo e sostenibile*" ("Fair and sustainable wellbeing") with a set of 4 indicators on the life quality of citizens and on society. Italy is thus the first State in the European Union and in G7 where the Government includes, in its own economic planning, not only GDP but also 4 indicators significant for the life quality of citizens and the society:

- Average disposable income
- Inequality index
- Labour market missed participation rate
- CO_2 and other GHG emissions

Another relevant document is the "*Programma Operativo Nazionale Governance e Capacità Istituzionale 2014-2020*", The National Operational Programme (NOP) on Governance and Institutional Capacity for the 2014-2020 period, adopted by Commission implementing Decision C (2015) 1343 of 23 February 2015 approving the support of the ESF and ERDF funds under the "Investment for growth and jobs" goal in Italy, for the period between 1 January 2014 and 31 December 2020.

In the NOP Governance, the "Axis I - Building administrative and institutional capacity for modernizing the Public Administration", co-financed by ESF, addresses the modernization of the PA by implementing the reforms with regard to management and organization and by simplifying processes, to reduce the costs and length of the procedures. Furthermore, it foresees investments in the development of digital skills, to improve transparency and access to data and public services, within the framework of open-government policies and it envisages actions for enhancing the efficiency of the judicial system and promoting legality in the Public Administration.

Within Axis I, the "Action 1.3.3 – actions for the improvement of the administrative capacity, national and regional, for the integration of environmental sustainability" foresee financing lines for activities related to Green Public Procurement (GPP) promotion and communication. One of the three environmental objectives of the National Action Plan for Green Public Procurement (GPP NAP) is the reduction of waste produced and the adoption of minimum environmental criteria defined within the framework of GPP NAP became compulsory for Italian public administrations after the approval of Law no. 221 of 28 December 2015, the so called "Environmental annex" and of the new public procurement code (Law Decree N. 50 of 18 April 2016 and Corrective Decree n.56 of 19 April 2017).

Finally, at regional level, all the regions where the pilot cities are located have foreseen activities for the promotion and the financing of home composting, door to door waste collection and for the information, education and involvement of citizens.

6.2.3 Portugal

Funding for research and development (R&D) in the waste sector is provided under the Portugal 2020 program PO SEUR - Operational Programme for Sustainability and Efficiency in Resource Use, *Axis III – Protecting the environment and promoting resource efficiency.* This program aims to support investments in the waste sector to meet or surpass EU environmental requirements. About 306 M€ are available from the European Structural & Investment Funds to finance R&D projects directed to the recovery of waste by promoting the reduction of waste production and landfilling, and the increase in selective collection and recycling. 41 projects have been approved until July 2017, corresponding to about 122 M€ financed by European funds.

The Environmental Fund, created through Decree-law nº 42-A/2016 of 12 August, aims to support environmental policies that foster sustainable development and contribute to fulfil national and international goals, namely regarding climate change, water resources, waste, and conservation of nature and biodiversity. It gathers the resources of existing national funds (the Portuguese Carbon Fund, the Environmental Intervention Fund, the Water Resources Fund and the Fund for Conservation of Nature and Biodiversity) and finances entities, activities and projects that aim to fulfil national and European objectives and targets of urban waste management, the transition to a circular economy, mitigation of climate change, among other objectives.

Under the Environmental Fund, the "Sê-lo Verde" Program aims to encourage the adoption of environmental practices that are innovative and have positive social and economic impact through the financing of green measures to be adopted at music festivals. The main goals are: (i) to encourage the adoption of environmental criteria that contribute to the reduction of impacts and promote the efficient use of material and energy resources; (ii) to encourage the adoption of innovative approaches, such as new technologies, integration of renewables, promotion of collaborative economy, eco-design; and (iii) to contribute to the education and environmental awareness of the stakeholders involved.

The Environmental Fund is also promoting a program to support the shift towards a Circular Economy. The first phase will fund studies and analysis, consulting and other activities that aim to identify the opportunities, promote the involvement of entities and make a pre-assessment of economic, environmental and social gains of circular economy strategies. These preliminary studies should lead to implementation or business plans that could be supported by the Environmental Fund in subsequent phases.

The Strategy for Waste-Derived Fuels (Order n. º 21295/2009, of 26 August) promotes energy recovery of refuse from organic recovery and screening units and aims to improve the sustainability of urban waste management systems based on mechanical and biological treatment. This strategy advocates a set of market incentives to waste-derived fuels, namely regarding optimization of production processes, strengthening of economic and fiscal instruments, restrictions on landfilling, streamlining administrative licensing of production units, and awareness and information of potential users, particularly in the industry and energy sectors.

Mercado Organizado de Resíduos (MOR) (Organized Waste Market) is an electronic platform to trade waste and by-products, licensed by the Portuguese Environmental Agency. MOR online aims to facilitate and promote industrial symbiosis, reduce waste generation and consumption of virgin resources, and foster waste recovery and recycling as well as its reintroduction into the business cycle. MOR provides a direct communication channel between the players in the sector, bringing together waste producers and waste operators, and facilitates and promotes trade of various types of waste.

6.2.4 Romania

In order to reach the objectives set by the EU Commission by 2020, Romania has started to take strategic steps. A Government approved Waste Prevention and Management Plan that integrates the priorities, objectives and general measure directions towards reaching EU goals is the key element in the process of a comprehensive integrated programme. So far, the second National Waste Management Plan is in the phase of public consultation and its approval timeframe has been negotiated with EU and postponed a number of times.

The national plan is comprised of objectives, indicators, and actions, and sets the general framework for the next EU funded projects on Big Infrastructure (Operational Programme Big Infrastructure – priority axis 3 – allocated budget 3 billion euros). The official enforcement of the NWMP is an EU condition for the launch of the EU funded projects on Big Infrastructure. The National Plan (Waste EAC, 2017) is developed in order to meet the unfulfilled criteria 2-4 of the ex-ante conditionality "6.2 Waste sector: Promoting economically and environmentally sustainable investments in the waste sector particularly by the development of waste management plans consistent with Directive 2008/98/EC on waste, and with the waste hierarchy".

Therefore, the EU funds for big infrastructure on waste management will only become available after the Romanian Government approves the National Waste Management and Prevention Plan (based on the prior approval from the EU Commission).

Thus the most important financial resources for waste management programs and policies will hopefully be available starting 2018 (with a couple of years delay) and will have a shortened timeframe to be developed, approved and implemented.

Other EU funds are available through The Regional Operational Programme (total budget allocation for 11 priority axes: 8.2 billion euros, out of which 1.5 billion national contributions and 6.7 EU support), that supports among others the transition towards a low carbon emissions economy and the sustainable urban development, including improving the energy efficiency.

Additional resources for waste management related project/policy implementation that involve external funding include the EEA (European Economic Area) and Norway Grants, such as Environmental Monitoring and Integrated Planning and Control, Reduction of Hazardous Substances, Energy Efficiency, Renewable Energy, Adaptation to Climate Change, research in relevant fields or Green Industry Innovation Programmes.

Moreover, the Romanian Government finances an extended number of programmes through the Environment Fund – renewing the auto park, financing the acquisition of electric and hybrid cars and building the infrastructure, green homes, awareness campaigns on environment issues, rebuilding the contaminated sites etc.

Local authorities have financial allocation for waste management and prevention projects, including for supporting NGOs activities in schools and public areas, building infrastructure for bicycle transport – priority lines. Of course, many campaigns are implemented with private funding and lately private-public partnerships are being developed. Some of the private funding comes from CSR programmes, other are aiming at reaching the recycling objectives when it comes to the transfer of responsibilities companies (packaging, WEEs).

6.2.5 Spain

In order to reach the objectives for 2020, the Ministry of Environment will develop "The Spanish Strategy of Circular Economy" to create a more sustainable production model. The strategy will include all sectors Regions (Comunidades Autónomas), municipalities, foundations, NGOs ...), in accordance with the circular economy package prepared by the European Union to boost competitiveness, create jobs and generate sustainable growth (Waste EAC, 2017).

In Spain there are many initiatives (private and public) to promote and finance circular economy, waste management and sustainable development.

On the public sector, most of the regions (Comunidades Autónomas) have defined strategic programs for financing actuations on the field of waste management planning and prevention, selective collection improvement and transport, promoting recovery, recycling and final treatment of waste. For example, the government of Catalonia and the Basque Government have many plans for city councils or private companies to develop waste management, recycling and circular economy projects. Not only the (Comunidades Autónomas) finance projects, also the Provincial Councils (Diputaciones Provinciales), which finance projects for small cities, towns and companies. One of goals of the Spanish State is

to prepare a directory with information on all the aids and subsidies aimed to the circular economy, recycling and sustainable development.

On the other hand the Spanish Federation of Municipalities and Provinces (Association of Local Entities from the whole state) signed in March 2017 the Seville Declaration (Seville, 2017). Municipalities are the first step to develop strategies to promote circular economy, zero spillage, recycling, waste reduction, etc.

Part of these initiatives are directly financed by European Funds, such as ERDF reported in other countries.

6.2.6 Sweden

In Sweden, several public, private and mixed type initiatives are being developed, ranging from European to National initiatives, for example to support the development of Circular Economy, Industrial Symbiosis and other resource efficiency based strategies. For example, RE:Source is Sweden's leading research and innovation investment within the resource and waste area. It is a national innovation arena and supports the development of innovations that can contribute to a more efficient use of resources in both society and business.

In line with the need to achieve environmental goals, several economic instruments are also available, of which, taxes for producer responsibility are enforced, charges to fund disposal of nuclear wastes, landfill tax, municipal waste disposal charges, among others, but also grants for disposal of oil waste, ecological building, deposit (refund)drinking containers (SEPA 2005).

6.2.7 Analysis from the different countries perspectives

All countries mention the positive effects from the European Funds to support R+D projects and initiatives to be implemented at local level. Austria and Portugal shown strong national programs to support the implementation of new waste management strategies; while Romania shown a range of initiatives, sometimes, based more on international cooperation; and finally, in Spain and Italy, regional and local financed actions are mentioned. In the case of Italy, the Green Public Procurement and the definition of KPI is reported as relevant and supporting issues for the improvement of WMS.

Additionally, five countries mention specific actions to support the implementation of circular economy related initiatives after that the European Union approved a package of Circular Economy in December 2015. For example, Austria has implanted a National initiative "RESET2020" on Circular economy and responsible consumption of resources or Spain that is developing the National strategy "The Spanish Strategy of Circular Economy". Portugal has a national Environmental Fund to promote Circular Economy projects, among other initiatives. Romania and Italy also have National plans for establishing waste management policy programs. Again, the European drivers and regulations promote further actions in terms of financing and/or improving the WMS at national, regional and local level.

6.3 Results achieved by the strategies

6.3.1 Austria

Information gained through the interviews was primarily regarding the social impacts of measures, only few comments were made about environmental improvements or economic gains, this information is added from previous and further research.

The desired results vary between the public and private sectors. The waste management in Austria is a combination of private and public ventures, which are administered by each region. While public institutions are financed through public funds, their main aim is the provision of waste management services as well as increasing the social wellbeing, this at minimal costs. Large private companies, which are financially independent of the government, are commonly profit oriented and will process certain materials as long as the resource prices allow, based on current contracts and given settings. Small private initiatives have been founded in Austria with the aim of creating socially integrative cooperatives; these often have more holistic goals in mind.

Social gains have been achieved both in the public and private sector through the strategies mentioned in previous sections. Through the reuse initiative by the municipal waste management in Vienna, financial as well as material donations have been made to various charities in the region. Through the integration of individuals from immigrant and refugee communities in Styria it was possible to integrate them into the waste management programs and substantially improve the waste collection and separation in these specific communities.

The repair centre in Vienna (RUSZ) was founded as a socially integrative business and employs long term unemployed individuals offering them the opportunity to re-enter the job market. The R.U.S.Z. (BMLFUW, 2011) also has an established rental service for home electronics, which offers the possibility for consumers to obtain products of a higher quality with an included reliable repair service. As stated in the Federal Waste Management plan there is a focus laid on the provision of a 'service instead of a product' (BMLFUW, 2017c) as a measure for waste reduction.

The repair network in Austria has been expanded to include multiple repair businesses in the city and also offers advice for individuals to take repair measures into their own hands. The multitude of similar measures has allowed for collaboration and mutual reinforcement of actors in waste management and social initiatives leading to increased social wellbeing and substantial steps towards a circular economy and resource efficiency.

Social considerations are also important when planning measures to reduce food waste. The coupling of food processing, trading and distribution businesses with social institutions has proven to be an important, yet difficult, measure to achieve the desired food waste reduction of 50% by 2030 (based on the 2017 value) (BMLFUW, 2017c) as stated in the Food waste reduction agreement between the ministry and private businesses such as REWE (A German trade corporation). The coordination of this trade is difficult, especially in rural areas. Another measure to reduce the food waste within supermarkets is the use of remaining bread and baked goods as animal feed.

Through the awarding of the VIKTUALIA Award (BMFFUW, 2015) numerous initiatives targeting the reduction of food waste are distinguished. Out of 100 nominations in 2015, 24

were awarded the prize in categories ranging from social involvement, personal dedication, regional initiatives, and industry.

The Austrian glass recycling system has been successfully established and communicated through effective measures starting 40 years ago. This results in a collection quota of over 80% of the glass on the market and through this a reduction in the energy requirement for glass production (Grünbuch, 2014).

Through detailed regulations targeting multiple material streams, improvements have been achieved across the country regarding the environmental impact of waste management processes. A reduction in greenhouse gas emissions of 52% (VÖEB, 2015) has been achieved through the Waste Management Act and Landfill Regulation prescribing the treatment of all municipal waste before final deposition. The municipal waste is incinerated allowing for the provisioning of district heating to surrounding areas. The composting regulation has allowed the production of high quality compost, which can be used by farmers in the region free of cost, as well as the sale of peat free potting soil. These measures are in compliance with measures of the EU Circular Economy Action Plan.

Through a continuous revision of the waste management plan every 5-6 years, the relevance to the current situation is ensured. In this renewal process the public is involved and stakeholders are given the opportunity to comment as the draft is published on the website.

6.3.2 Italy

The interviews, addressed both to pilot cities and to other public/private relevant stakeholders, were aimed at understanding, first off all, if the strategies implemented could guarantee their efficiency, both on the economic side and in the social/cultural side.

For what concerns the economic sustainability of the strategies, a distinction has to be done between public and private interviewed bodies. From the public bodies' point of view, the strategies are implemented to answer to multiple needs: the respect of laws, the public services provision, the pursue of the urban community interest or the economic optimization of the waste management strategies. It means that not all the strategies are economically sustainable. As far as waste, both economic and social aspects are taken in consideration, and sometimes social arguments prevail the economic ones – even if only SEAP can provide a strategic vision. From the private bodies' point of view, instead, the strategies described and implemented are always oriented to the realisation of an economic advantage, which is the main scope of private companies. In a financial and economic perspective, EU incentives are used also to realise ordinary activities, because of the lack of public investment in waste sustainable management in Italy. In the end, after planning, implementation is reduced to just what is possible with the available budget.

For what concerns the public participation in the different stages of waste management, the interviews show that in Italy citizens do not always want to be directly involved in the waste management activities, especially in case of strategies implying citizen's cooperation (e.g. door-to-door waste separate collection), in fact some social resistance and conflicts have emerged. The participation becomes easier after citizens receive feedback for their commitment: for example, when the feedback is direct and instantaneous (e.g. "eating plastic machines" of Pomezia), or when the "effects" of the strategy arises, with a reduction in the taxes or with a higher life quality. However, the citizen participation is large, and consensus on the separate collection has been accepted, also in case of door-to-door, thanks

to the use of an effective methodology in involving and informing inhabitants. For this reason, it is fundamental the use of strong communication, education and public meetings.

From the cultural point of view, the most difficult situations are the ones with social distress, that often are diffused in poor neighbourhoods, with a law education level, and with a high percentage of immigrants: in numerous development countries, the issue of waste is not considered problematic, that makes the deal with immigrants one of the most relevant challenges. In parallel, also with the upper class it is difficult to overcome the resistances due to a very comfortable economic situation. The middle-class families, especially with child, are more receptive to innovative/engaging WMS. In any case, the use of communications in different languages and the education at school are essential. From the geographic point of view, the urban structure of Italian cities makes planning and WMS implementation complex, especially for logistics and infrastructures.

Over the investigation of the economic/social/cultural aspects linked to the strategies implemented, the interviews had also the purpose to analyse the gaps, the barriers, the needs emerging from the description of the strategies, and their connection with the general framework of waste management and prevention strategies.

Talking about the barriers, the interviewees agreed that technology is not the main barrier in the implementation of waste management strategies. The available technologies are sufficient to implement all the needed activities and, where there is a lack of technology (for example for the resolution of composite polymers), they are all confident that the scientific research will find a solution in the near future. The barrier is more on the "human" side of the technology use: the attribution of responsibilities for planning all the activities related to an efficient technology use is uncertain and is the weak point in the process. This is also the reason and the causes for unsuccessful innovative initiatives: on the one side, there are some bureaucratic limits not facilitating the innovation and the raise of new products and processes. On the other side, there are many cultural barriers not yet overcome: it is difficult to keep the active participation of all the stakeholders involved in the process when the results are not immediate, and require more time to be profitable. However, this participation is necessary, as well as the cooperation among the main stakeholders along the waste management chain is still weak.

The environmental aspects are usually taken into consideration only after the economic ones, except when environmental impacts (as from landfill or incinerator) make the involved stakeholders more careful to the environmental issues. The influence of the environmental objectives stated in the legislative developments could and should be really relevant, as common objective and purpose, but there is the feeling that the existent rules and regulations are not linked to the reality.

6.3.3 Portugal

A range of strategies were reported, covering informational, promotional and regulatory actions. Most strategies, particularly from public bodies, have been applied to contribute to the compliance of 2020 targets and are ongoing; therefore, in most cases, only expected results are presented.

Most initiatives lack clearly defined indicators and/or targets, which makes the evaluation of those actions very difficult. When available, organizations tend to use quantitative indicators to measure the success of the strategies implemented, usually related with the

achievement of specific targets. Different indicators are used, depending on the type of strategy, such as: reduction of organic waste sent to landfill (target achievement); mass of waste collected separately per capita (target achievement); mass of waste collected separately (e.g., batteries and accumulators); reduction of waste generation, and number of stakeholders involved (particularly for awareness campaigns).

Reported strategies have a clear focus on organic/food waste and separate collection of different waste streams. On organic waste management, a common strategy is the promotion of home composting. In general, home composting is done on a voluntary basis, without any financial reward or direct incentive, and the number of households with a composter is still reduced. Free-of-charge, door-to-door collection of green and garden waste provided in some municipalities also does not incentivize home composting. A reduction of the waste tax for householders that actually deliver less residual waste for treatment could promote citizens' participation in this type of actions. Home composting is also an activity that has not been widely explained (e.g. in schools; institutions); therefore, citizens have little practical knowledge on how to treat organic waste except in the Porto region, here are over 11000 home compost bins and over 18000 citizens in awareness courses. Workshops and other educational actions have been promoted recently to circumvent these issues and encourage the use of household composters.

Prevention of food waste in restaurants and canteens has also been the goal of several actions. Successful initiatives include socially-oriented actions to divert food goods still proper for consumption from being disposed of to feed low-income people. Despite these actions, food waste avoidance is still entangled with cultural habits ("restaurants in Portugal are usually expected to serve large portions") and lack of real incentives to reduce waste. Residual waste from restaurants is mixed with domestic waste and tariffs are very low, which does not incentivize these businesses to act on waste reduction or separation. Additionally, bio-waste collection is still a niche activity lacking scale economy. Myths ("the country is too hot to have bio-waste collection"; "the Portuguese are not ready for bio-waste collection") and negative opinion from the public and decision makers impairs the process and slows its implementation.

Concerning source separation, the Portuguese cities are still not reaching higher rates, especially for packaging waste and WEEE. A possible strategy to increase source separation rates would be by implementing Pay-As-You-Throw (PAYT), which is foreseen in the national strategy. However, in Portugal, no municipality has fully operational PAYT system. Only pilot, restricted PAYT systems have been tested until now and, politically, it has been difficult to introduce tariffs according to the polluter pays principle. On the other hand, several campaigns and initiatives have been promoted to encourage separate collection of different waste streams (e.g., plastic caps, batteries and accumulators). These campaigns are generally well perceived by citizens, particularly when there is a social objective. However, results (in kg/year) are not known to the public, and consumers get little or no feedback on how waste is managed after collection, or what are the positive impacts of such actions, hampering further progress.

6.3.4 Romania

In Romania, the main strategies implemented are regulatory (by public authorities to comply with EU rules) and technological (mostly by private companies). They are also a few

promotional and informational strategies (awareness campaigns run mainly by private companies and NGOs).

While public authorities have delays and numerous difficulties regarding the development and implementation of regulatory strategies, best efforts in terms of developing strategies are made by a number of private companies that have conceived and implemented strategies that work properly, reducing overall generating amounts of waste and their expenses. Among the industries that has made major investments, we can mention operation of waste reduction technologies such as biogas generation, sorting and recycling stations with high performance technologies, incinerators with very low pollution levels, mandatory waste management internal measures for employees, waste management procedures concerning foreign partners, planning tangible objectives for the coming years, the use of waste generated in their flux in other processes, the acquisition of waste from the free market to be used as secondary products.

The listed measures have been implemented largely by large companies or by the multinational companies, which have standardized procedures and are more often controlled by the authorities.

In Romania there are some important waste management companies using advanced technology. Their major problem is not necessarily the lack of new technology, but the poor implementation of separate collection system at the population level. In case the waste would be separate at least into 2 fractions (recyclables and biodegradable waste), the recycling rate could rise up to 50%. Otherwise, even the most performing equipment can fail trying to separate the fractions, not mentioning that this is inefficient.

The companies and public institutions have to pay different fees to waste collectors in order for them to collect different types of waste. Most collectors either have high collection fees or impose a minimum quantity of waste for picking up the waste. From the point of view of a company/institution, it is cheaper to throw all types of waste together with the household waste, in comparison with collecting it separately.

As concerns the households, in major cities, the separate collection is possible for the population only through the street "bell" containers (separate for each of above mentioned waste types), but in smaller cities and villages this is rather difficult or impossible, as these containers are few or located far from citizens' home. So far, no pay –as-you-throw (PAYT) system has been applied to population. There are few cities with municipal waste collection centres (in Iasi is already operational, and in Oradea will be operational in September 2017).

An excellent solution (so far, available only for citizens and at a small scale) is the implementation of smart collecting machines (SIGUREC), available within or outside some hypermarkets. These machines offer vouchers usable for shopping in related hypermarkets. Unfortunately, due to Romanian regulations, small companies generating small quantities of waste cannot bring their waste to these machines, as the voucher given in return for bringing the recyclable waste is not recognized as a supporting document for accounting and environmental purposes.

An increasing number of citizens are willing to direct the recyclables to specific containers. However, many of them are rather reluctant, due to the fact that local authorities and sanitation companies do not explain the citizens what happens to their waste directed to recyclable containers. Some citizens even think the waste is mixed afterwards and their

effort to collect separately the recyclables is useless. Obviously, more informational and promotional strategies are needed.

6.3.5 Spain

The strategies developed in Spain are directed at both the public sector and the private sector, and also involve the participation of the citizens, different cultural and leisure organizations, commerce, social entities, industrial activities, universities and all kind of sectors. There are three main types of strategies developed on waste prevention and management; ones focused in regulatory issues, others in promotional and promotional matter.

The regulatory strategies are made in order to accomplish the European legislation and improve the environmental quality. In this way there are actions like application and monitoring of Environmental Management Systems, the environmental control on different activities, application of REACH legislation or the elaboration and application of different programs with the objective to reduce waste generation and disposal.

The promotional and informational are focused on the raising awareness of the population and different entities. It is made through prevention days, promote green attitude (domestic composting, ecological agriculture, etc.), organizing working groups, making campaigns to reduce the waste generation and promoting local prevention plans.

6.3.6 Sweden

Sweden has proven a track record in achieving targets for waste, most notably for household waste, which has caused the shift to tackling more complex issues related to waste, such as, circular economy, industrial symbiosis and sustainable consumption. Analysing new waste prevention initiatives in Sweden, it can be seen that they are mainly for raising awareness about the need to prevent waste, increasing material efficiency, and developing sustainable consumption, while not considering so much the other steps in the life-cycle, such as, design, transport. Initiatives are also mostly small or medium scale and there are no examples of National action that can impact waste management as drastically as past experiences in Sweden. Finally, waste prevention is not proved in a quantified way but more as an aspiration (Corvellec 2016).

6.3.7 Evaluation of the results achieved by the strategies

The results of the strategies are quite different because the strategies developed in the different countries are arranged to their necessities, and within the country, there are very different realities.

One common point between Austria and Italy is that there are differences in the results between public and private institution. While public agent offers the service and wellbeing and sometimes they are not economically sustainable, the private take economic advantages. In Austria the small private sector has created social integrative cooperatives. Through these initiatives they have had large social gains. The municipal waste in Austria is partly incinerated, but the composting regulation has allowed the production of high quality compost that can be used for farmers free of cost.

In Italy, the incentives from EU are used for the developing of ordinary activities. There is a trouble with citizens because they don't want to be directly involved in management actions and it have emerged social resistances and conflicts. Although the separate collection has been accepted, the social distress is affecting because poor neighbourhoods are considered problematic, but the upper class are also problematic due to their comfortable economic situation. There is also "human" factor problem in terms of who are taking the responsibilities. The environmental preferences are behind the economical preferences. The general feeling is that the rules and regulations are not linked to the reality.

Reported strategies in Portugal are mostly focused on organic/food waste and waste collection. Most initiatives lack clearly defined indicators and/or targets, which makes the evaluation of these actions very difficult. Moreover, most of the reported strategies implemented by the public sector are still ongoing and only preliminary results have been presented so far. Nonetheless, there are some successful initiatives regarding food prevention in restaurants, even though they clash with cultural habits. In general, socially-oriented strategies are well received by citizens, but these are usually not continuous, long-term actions. Direct incentives for waste reduction and separate collection are lacking. The rate of separate collection is still not high enough, and one of the proposed measures is to implement Pay-As-You-Throw schemes. Nevertheless, politically, it has been difficult to introduce tariffs according to the polluter pays principle. There are delays on the implementation of regulatory strategies in Romania, while strong the efforts on developing strategies come directly from private companies. In the waste treatment, there are companies with very good technologies but the problems are often derived from the low rate of waste separation. Is very difficult to promote the separation because companies and public institutions have to pay different feeds in order for them to collect different types of waste. There is needed more information and communication of waste generation and separation.

Finally, in Spain the strategies are focused in three main directions; regulatory, promotional and management. The strategies are developed at both the public and private sector, but also involves the citizens and other organizations participation.

7 The social vector: Analysis with the DPSIR framework

The DPSIR model developed in the framework of the Urban_Wins project has been configured with the aim to:

1) Help us to better connect and shape the different components of UrbanWINS, i.e.

- Urban metabolism
- Strategic planning
- Waste prevention and management

2) help end-users (i.e. urban policy makers, technicians, stakeholders) in placing their actions in a wider framework and in taking into account the different variables/factors that affect those actions and on which the latter can have an impact (causal relations).

In the sections below, detailed explanation about the methodology itself and the work developed until the definition of the main determinants of the WMPS and policies are described.

7.1 DPSIR model for waste management and prevention strategies and policies

7.1.1 DPSIR: a system approach to address environmental issues

More often environmental problems in urban areas are treated in the same manner despite they are complex and different in every suburb. A single department in the municipality with a limited number of technicians is dedicated to adopt decisions having into account only a specific and a unique economic concern. Lack of extra time for these purposes, limited acknowledge of the new trends or an insufficient analysis in a short and a long term about the implications of adopting determined decisions may bring unsuccessful results.

This biased adoption of determined decisions is more often due to a lack of relationships between stakeholders involved. Very often, they have to deal with an absence of instruments for exchanging experiences, needs and demands.

The conjunction of these circumstances avoids to adopt a holistic approach once a WMSP is implemented. Individual actions can be addressed but effects and relations of all are interconnected and cross effects cannot be neglected. At the end, efforts and results might be completely non-aligned.

The system thinking approach (STA) may be a source of solutions to these concerns. That procedure is based in the idea that only individual elements fend for itself never can be part of a integrated system. STA focuses on analyse the area under study to understand the interactions happened between the different components which is divided. Only a depth analysis of these relations could bring the best assessment of alternatives and make decision-process more profitable.

In that context, many different methodologies have intended to guide this process in a systematic way and help users. However, the high number of issues, management options and unclear related information represent a drawback to start.

In order to overcome all these issues, the DPSIR framework was developed by the European Environmental Agency (EEA, 2009) and has been used by the United Nations, (UNEP, 2007). It is an extension of the pressure-state-response model developed by OECD which is defined as a causal framework who describes the interactions between society and the environment. The components of this model are:

- **Driving Forces** are the factors that motivate human activities and fulfil basic human needs: the necessary conditions and materials for a good life, good health, good social relations, security, and freedom

- **Pressures** are defined as human activities, which induce changes in the environment, or human behaviours that can influence human health.

- **State** refers to the state of the natural and built environment (e.g., the quantity and quality of physical, chemical, and biological components), and human systems (e.g., population level and individual attributes).
- **Changes** in the quality and functioning of the ecosystem have an Impact on the welfare of humans, including the production of ecosystem goods and services and ultimately, human well-being
- **Responses** are actions taken by groups or individuals in society and government to prevent, compensate, ameliorate or adapt to changes in the state of the environment; and to modify human behaviours.

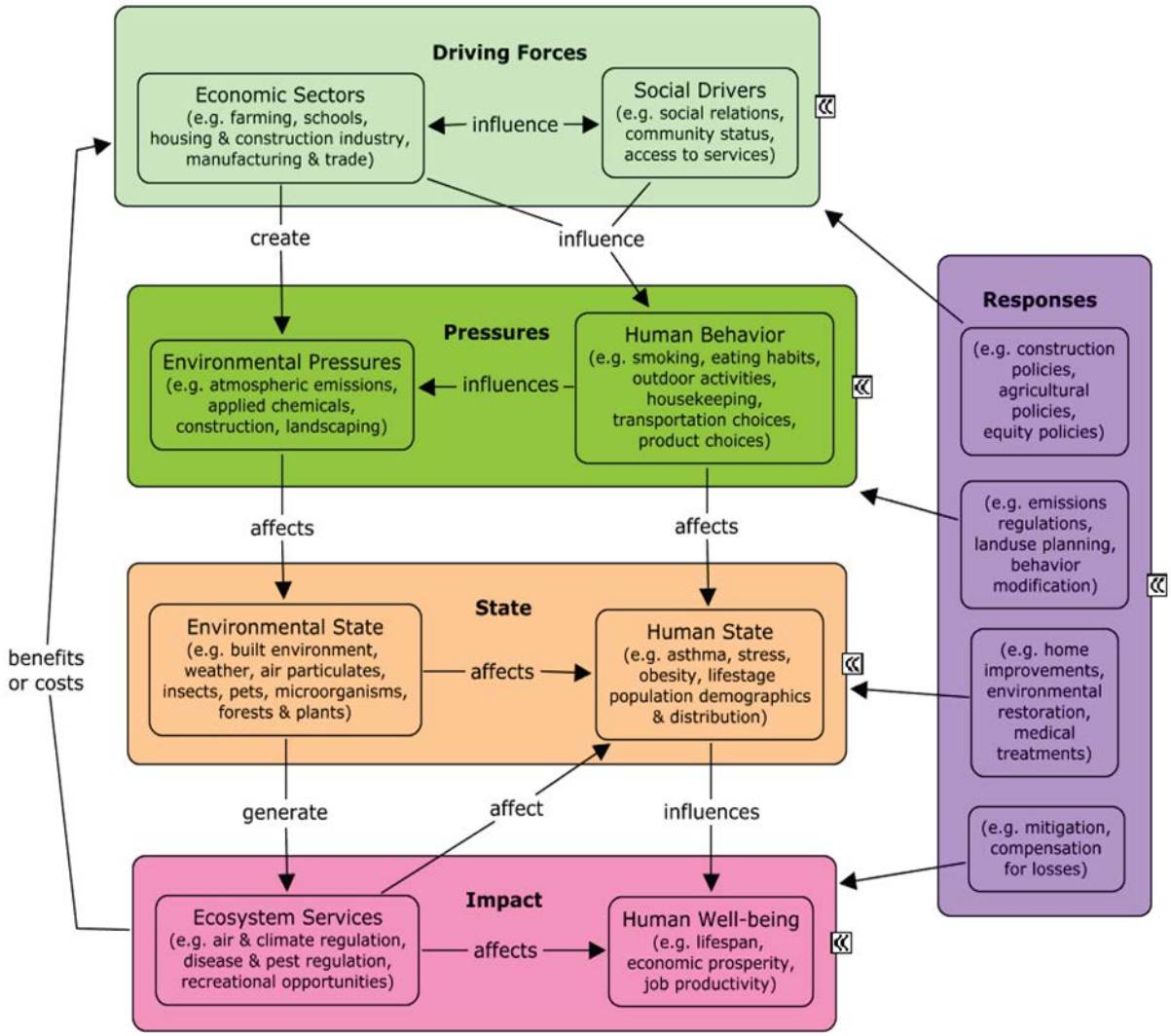


Figure 7.1 The Eco-Health DPSIR framework. Source: Bradley and Yee, 2015

Seems very reasonable that within the process to plan a waste management action plan, this approach helps to understand and have into account different aspects and relationships. The Urban_Wins consortia followed the Eco-Health DPSIR framework proposed by Bradlee and Yee (2015) for the United States Environmental Protection Agency. The approach

proposed is especially interesting for the aim of the project, considering that the interrelation between all the elements defined above are referred for the ecosystem health (left side) and human health (right side) as well is presented in Figure 7.1.

In the section below is described how the elements of the model have been defined for the Urban_Wins case: waste management in an urban context.

7.1.2 DPSIR within Urban_Wins

As starting point, urban activities have been identified as the DRIVING FORCES and corresponding outputs represent the PRESSURES, and this under the umbrella of urban metabolism. If it is considered that cities "live" from material, energy and non-material inputs, and at the end, generate waste, all activities related within their limits have to be considered as potentially source of waste.

The understanding of pressures has begun with the identification of the activities that characterize urban areas, i.e. what activities are determining the material flows (input/outputs) happening in the cities, and then at how/if these activities are shaped and managed from a material/waste point of view.

Apart from this, and according to the intensity and the composition of those PRESSURES related, changes occur in the STATE of city environment with consequential IMPACTS on urban ecosystems and society. At the end of this interrelated process, waste prevention and management policies and strategies will represent the RESPONSES. They can aim at:

- Changing determinants (prevention)
- Reducing pressures (prevention/management)
- Mitigating changes in the state of the environment and impacts or adapting to them (management)

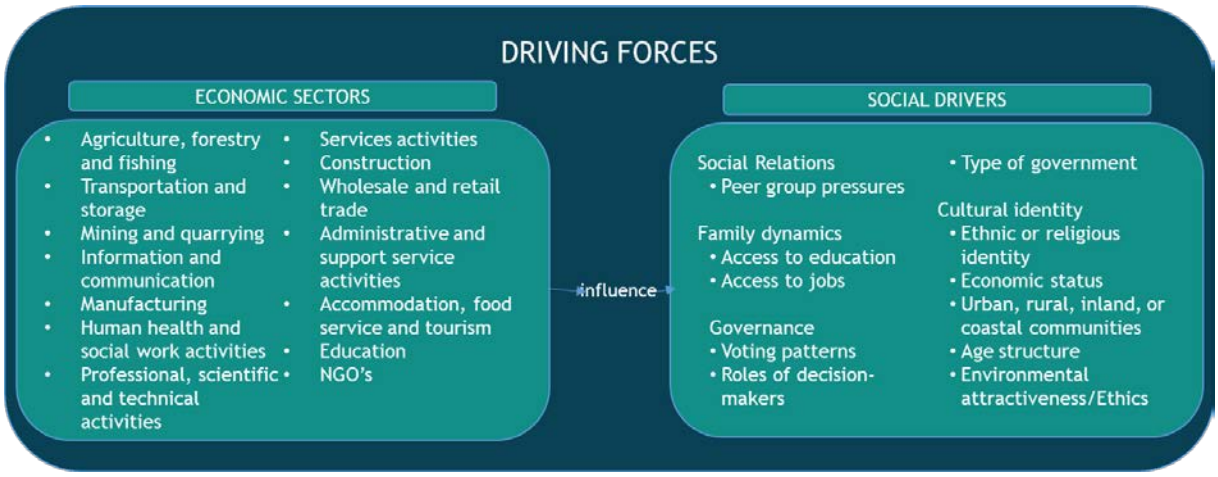
Once stated this general framework, the conceptualization of the model was developed in a collaborative manner by following the guidelines stated by Bradlee and Yee (Bradlee et el., 2015). Hence, the understanding of waste management system dynamics, the appreciation of the diversity of information needed to construct the model and at the end, the selection of elements defining each step were conducted within a collaborative learning process.

Through different workshops held in the project (see Figure 7.2), different representatives of the stakeholders involved (decision-makers and scientists) which have been part of Urban_Wins (partners, follower cities, EAB members, etc) have been in charge of the three key elements that must be addressed in a conceptual mode: the understanding of the system processes and dynamics, the identification of linkages of processes across disciplinary boundaries and the identification of the bounds and scope of the system of interest.

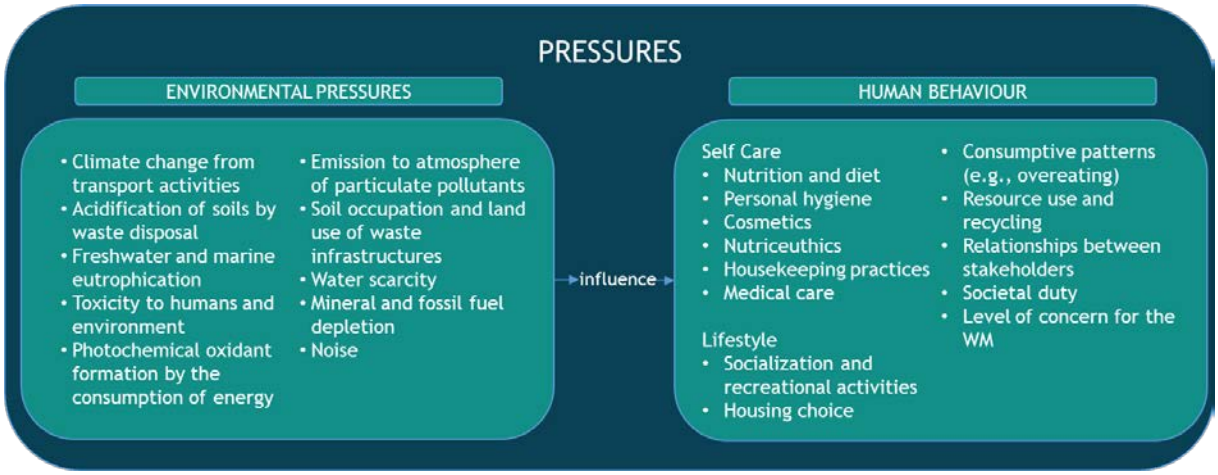
Figure 7.2 One of the workshops held for the conceptualization of the URBANWINS-DPSIR framework

With that whole approach, results for all the different elements in the DPSIR are detailed in the next sections. Possible connections between these different aspects are in this terms, postulated. Thanks to the use of the DPSIR modelling framework, the effectiveness and sustainability of responses put in place can be better assessed. The framework defined (see Figure 7.3) for Urban_Wins contributes to the urban analysis with an environmental approach including economic and social factors.

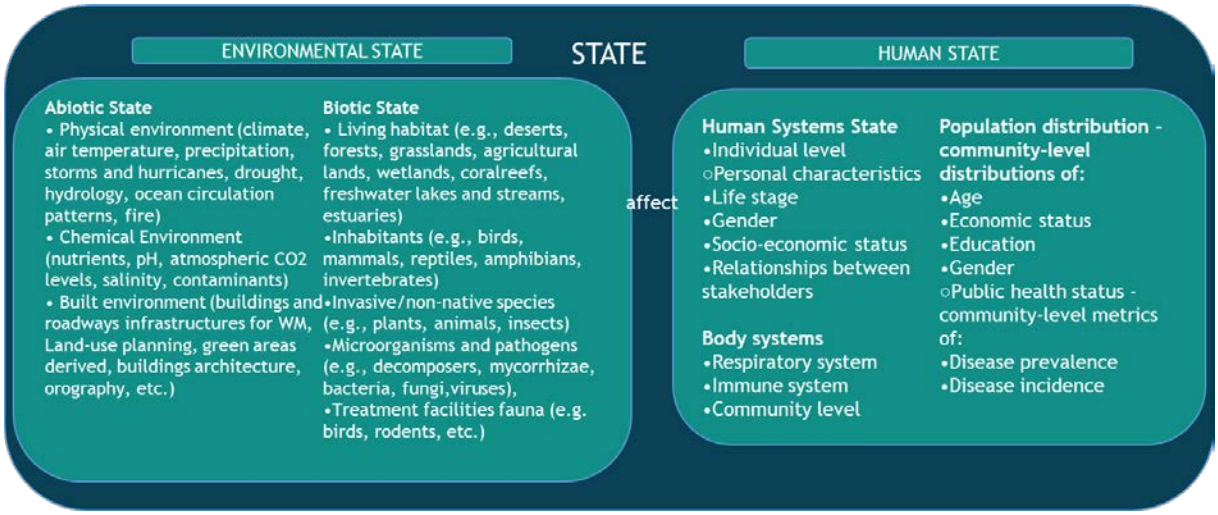
Driving Forces



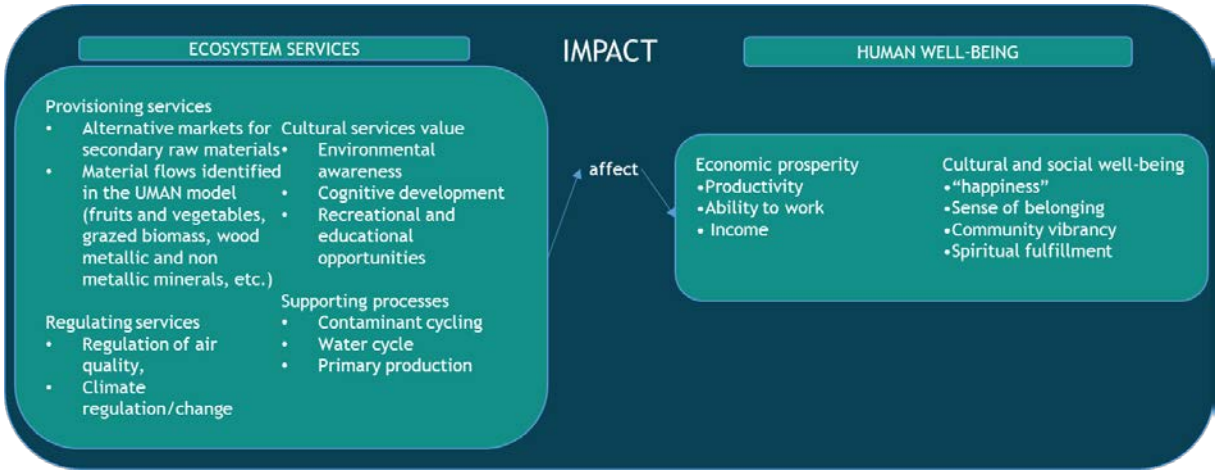
Pressures



State



Impact



Responses

RESPONSES

DRIVING FORCES-BASED RESPONSES

WM policies, legislation, restrictions, and guidelines that allows to minimize waste generation, and or a proper treatment, including:

- Best waste management practices
- Environmental education and outreach - including training, demonstrations, or brochures
- Manufacturing and trade policies to control the transport of waste
- Equity policies seek to improve fairness and access to waste services among populations through:
  - Elimination of barriers to access
  - Programs and actions to enhance diversity

Decision support tools

- Development or application of models, websites, and other tools related to waste planning and management
- Statistical analysis of waste generation
- Visualization and geospatial analysis of waste generation points, treatment infrastructures, etc
- Cost-benefit analysis for waste management
- Trade-off evaluations for waste and sub-products (industrial symbiosis and circular economy approach)

PRESSURE-BASED RESPONSES

Land-use management which seeks to plan and control development of needed infrastructures for waste management:

- Land-use zoning
- Building permits
- Designation of restricted areas

Discharge limitations which place limits on and monitor pollution derived for waste disposal, treatment and valorization:

- Non-point source discharge regulations
- Point or mobile source discharge regulations

Technological innovations, which involve research and development to improve the use of technology applied to the life cycle of waste planning, treatment and management

- Improved technology
- Alternate energy sources - such as solar or wind power

Resource use management in regulations, policies, and actions designed to control the use of natural resources

- Setting new uses for waste
- Designating protected areas

Responses may be designed to modify individual human behaviors that contribute to health risks:

- **Human behavior modification** is an attempt by an individual to modify their own behavior, which may be negatively contributing to increase impact derived from uncontrolled waste generation or inadequate disposal
- **Outreach and Education** attempts to get an individual or group of individuals to modify their behavior by providing materials and information through presentations, brochures, and other promotional tools that encourage a responsible attitudes to waste

STATE-BASED RESPONSES

Environmental responses which seek to control the physical, chemical, and biological environment affected by the waste management practices including:

- Water quality monitoring
- Air quality monitoring
- Setting water or air quality criteria
- Biological monitoring
- Scientific research
- Setting biological criteria

Restoration, remediation, and revitalization activities-

- Community planning seeks to modify the state of the community by promoting and implementing actions

Expanded economic opportunities derived by waste activities: circular economy business models

IMPACT-BASED RESPONSES

Monitoring involves tracking the success of implemented decisions related to waste management on one or more indicators measuring environmental or human well-being impacts derived throught:

- Surveys and opinion polls
- Field observations

Ecosystem Services Valuation is the process of estimating the monetary or non-monetary merit of potential or implemented decisions, including:

- Market valuation
- Non-market valuation

Mitigation is an effort to alleviate burdens on persons or the environment caused by some action by compensating for the loss of environmental benefits, including:

- Compensatory mitigation
- Mitigation banking
- Pay by generation schemes

Compensation for losses is an effort to alleviate burdens on individuals caused by some action or offense by compensating for economic, social, or emotional losses with money or other things of economic value, and includes:

- Financial compensation
- Statutory environmental damage insurance

Human Well-being Index is an effort to quantify the condition of humans and society, defined in terms of the basic material and other natural resource needs for a good life, freedom and choice, health, wealth, social relations, and personal security

Figure 7.3 Summary of URBANWINS-DPSIR framework

7.2 Main determinants of the WMPS and policies (based on DPSIR)

The main determinants that affect and define the adoption of the policies and strategies have been evaluated from the extensive analysis developed in the definition of the DPSIR model. These factors are the elements that identify and define the social nature of many different issues related to the whole management of waste. Determinants fix and outline not only the quantity generated of waste, but also nature, sources of generation, and all inherent social aspects.

These factors have to be considered in the development of the strategies and consequently, in the planning of the Strategic Planning Framework. And this is not an easy feat. The determinants as are described can affect the success of the strategy, but does not affect in the same way for all instruments and in the same grade.

Having into account these facts, within the Urban_Wins project, a deep analysis will result once the DPSIR model will be applied for the priorities established by the different pilot municipalities. Each city has to define and explain the main factors leading to these definitions. And after that, determinants will be deeply analysed. In that moment, the effect of these factors will be checked and the mechanism of actions revealed. Afterwards, the identification and some insights would be stated.

Finally, with the info recovered until now, determinants have been identified. Below the most relevant that affects the implementation of WMPS and policies are described.

7.2.1 Industrialization

The finance dictionary of the MBA SKOOL initiative defines industrialization as a systematic process of production that arises from development, study and advancement in science. It states how the different industry and economic activities are being developed in a regional context. Industrialization depends on some factors, like the level of automated mass production, the use of technological innovations and the efficient division of labour. It is strongly depending on the economic growth and also have direct relation with waste generation.

In one hand, it is well demonstrated that societies with the highest industrial production indexes show the highest production of waste. And this is obvious having into account that industrialization index shows the output and activity of the industry sector. That ratio measures changes in the volume of output on a time basis. Hence, if at the end the industrialization level in an urban context defines the input and output flows within the city, it has direct relation of waste generated.

On the other hand, the industrialization also means a higher degree of developed policies and strategies to minimize the adverse effects of waste. That counterbalanced effect is reflected by the fact that with the industrialization advancement, the development of remediation technologies has emerged to a great degree.

7.2.2 Governance

More often governance is referred to in a simplistic way and it is identified only as the act of govern. People have the perception that only covers the implementation of policies and standards without taking into account strategic and participatory approaches. One of the

aims of Urban_Wins is to leave behind that not-participatory approach that, as it was well demonstrated, is generally not successful and ignores issues from social, financial, environmental as well as technical fields. In this sense, the United Nations through the declaration "The importance of coherence between competition policies and government policies" under the framework of the United Nations Conference on Trade and Development (2011) state that:

- Many opportunities exist to improve effectiveness in waste reduction and management in less developed cities
- Coordination has to be explored between governments, state organizations and other sectors of the society
- Win-win (eco-eco) situations exist, but there are institutional obstacles

All these issues that reflects the importance of governance determinant have been revealed during the construction of the DPSIR model. From the different sessions held, the idea emerged that waste services are in many terms ineffective. A "bad governance" approach needs to be redirected by the application of strategies that have to be definitively aligned in order to increase the capacity to manage finances and services in an effective and transparent manner, streamline management responsibilities and work effectively with communities.

As a "sub-determinants" two relevant aspects were also identified: the voting patterns and the roles of decision-makers.

On one hand, voting patterns affect the implementation of strategies for two relevant reasons. First, the timeline to adopt effective strategies is a medium-long term. More often, mandates of political parties are limited in time (4 years in some cases) and all their efforts are focused on the accomplishment of citizens' perception instead of implementing strong strategies that help to solve the identified problems of waste management. Secondly, there is often a lack of policy continuity and it is not possible to implement the long term vision. With all this, when it comes to EU countries, the national legislation and trends in national economic development are guided by the fostering European umbrella and must be aligned.

On the other hand, the role of decision makers is limited or concentrated only on the financial issues. Subcontracting of waste services is a solution that avoids the adoption of complex models and users exclude the implication of environmental quality and public health considerations.

7.2.3 Cultural barriers and the linked geographic context

Migration phenomena in developed countries have radically changed the radiography of urban areas: societies are in constant development and foreign-born population are strongly contributing to the creation of a multicultural society. In many cases suburbs with a concentration of a determined ethnic or religious community that is different from the one that is predominant in the city/country have appeared. This might affect waste management (either positively or negatively), insofar that awareness and cultural approaches might differ from one community to the other.

A determined strategy must take these phenomena into account in order to be successful. It is well recognized that these issues affect the recovery of waste and the people engagement to adopt good habits and luckily in most cases the cultural issues are being addressed by the planning process, also in relation to the geographical distribution of minorities within cities. And this is extremely relevant where the population coming from other countries and with different habits and behaviours are increasing day by day. Hence, if the multiculturalism is the legal approach of a society that encourages the difference of backgrounds by promoting different cultures (Vitiello, 2017), that approach must be considered also in the planning strategies of waste management.

7.2.4 Environmental Impacts

It is obvious that waste generation is one of the most important environmental paradigms of new societies. Its importance has been addressed by a large number of standards, polices, strategies etc., whose efficacy is well known, however the environmental implications of the adoption of measures and policies to remediate the adverse effects of waste generation are rarely based on a scientific approach.

This is an extremely important issue that has to be addressed and may influence the implementation of these measures. If the aim to adopt standards is the reduction or the elimination of an environmental problem, the translation to a specific environmental vector can bring unexpected additional problems.

That fact is coupled by the cities' environmental resilience and it has to be aligned with the development of WMPS and policies: in order to become key elements toward minimizing of environmental impact these two elements need to be thoroughly planned. Also, in the construction of DPSIR model, two interrelated effects have been identified as not directly addressed in recent years: gentrification and "urban living".

These two aspects have increased environmental pressure on cities. And it is especially important in city centres where the generation of waste is usually higher. The adoption of the proposed strategies will firmly affect the generation and nature of waste. In such a context, as stated by Dobson & Jorgensen (2014), urban fabric renewal, the quality of public realm, and the densification of development in the declining city centre, have been undertaken with the primary aim of attracting inward commercial investment.

This has been developed through structural and aesthetic improvement and it has been reflecting the continuous increase of waste generation and nature. Some of the engaged stakeholders, conformed this scenario and they identified this item as a key element of the environmental impact determinant. Hence, environmental sustainable design and actions that consider negative impacts will deliver environmental outcomes that minimize the gentrification phenomenon.

7.2.5 Human behaviour

Environmental concern and human behaviour are influenced by many factors. Some authors focused their research into the variables that affect these factors. For instance, Gifford & Nilsson (2014) split and listed them into 18 personal and social factors. The personal factors include childhood experience, knowledge and education, personality and self-construal, sense of control, values, political and world views, goals, perceived responsibility, cognitive biases, place attachment, age, gender and chosen activities. The social factors include

religion, urban– rural differences, norms, social categories, proximity to problematic environmental sites and cultural and ethnic variations.

How each factor gains or loses relevance, in relation to the others, is still unclear. Also, how this factors affect citizen's behaviour in relation to WMPS and policies should be further investigated. However they certainly do affect the relation between citizens behaviour and waste production and management, and therefore they have been taken into account when developing DPSIR model, even though it is well known that citizenship has gradually adopted more active and participatory conducts. Their concern with environmental problems in the recent years has unequivocally increased. So, why their attitudes concerning waste and all activities directly related are in spite of that an unsolved environmental problem?

A possible answer can be found in the opinion of many of the stakeholders that have joined in the workshop sessions during the construction of the model. They agree that policies designed to solve environmental problems are unlikely to succeed unless they have broad public support, underlying that motives for public support are poorly understood. In that sense, and after questioning the "bad habits" associated to waste management, some related problems that represents the most common human behaviour have been identified:

- Preference for more basic priorities reinforced by a palpable system mistruth
- Disaffection and decoupling with the objectives of the policies and instruments proposed
- A non-effective bidirectional communication that would reinforce the "win-win" perception of the strategies
- A poor environmental consciousness in some population segments that did not received environmental education prior to 90's decade
- The negative (odour, non-value…) perception of waste sometimes hides its value as a resource
- An unknown or non-value return for good praxis by means of positive behaviour reinforcement programs
- A more comfortable and an aesthetic insight of the practices directly linked to the citizens action

To overcome these statements behavioural scientists, such as Gagne and Skinner (Curzon, 2003), state that *"…behaviours, opinions, and attitudes that are rewarded and reinforced are likely to be repeated and, ultimately, incorporated into our personal value set and routine behaviour…."*.

It seems clear that human behaviour plays an important role in the adoption of people practices concerning prevention, generation, and management of waste. And this behaviour has a higher role in the adoption of poor practices. Solutions have to be definitively linked to the reinforcement of positive messages instead of the negative sense of their attitudes.

In conclusion, the mechanism of human behaviour determinant can be explained by an example: the general thought that identifies the "pay by generation" schemes as the future of waste management strategies. It would be more helpful to turn around this underlying message into a "benefit for prevention" strategy. Hence, the use of rewards and reinforcements of positive behaviour may increase the willingness of citizens to replicate the desirable attitude, generating a positive domino effect. In brief: let the reinforcement of "positive attitudes" emerge, instead of highlighting "bad habits".

8 Interpretation of data concerning the explanatory variables of urban metabolism

8.1 Introduction

Currently, the number of people living in urban areas amounts to over a half of the total world population. In Europe and Central Asia, this figure has already exceeded the seventy percent threshold, and the growth of urban population still goes on (World Bank, 2016). As it was stated in Brundtland Report on urban economy, "*this system, with its flows of information, energy, capital, commerce, and people, provides the backbone for national development*" (UN, 1987), and, hence, there is no doubt that the transition of such system to a sustainable one is paramount in order to match global sustainable development goals.

City urban metabolism is a unique system of consumption, transformation, accumulation and discard of materials and energy, which flows are interconnected and predefined by a variety of factors. However, material and energy streams, basically, refer to physical consequences of the economy and society development that can become substantial determinants or explanatory variables of urban metabolism indicators.

The main goal of this section is to review determinants reported in the literature for the explaining urban indicators and suggest other variables that can be used for defining urban models. At the current stage, the research carries a mostly qualitative character, while mathematical correlation between variables and indicators will be established at a later project phase within WP2 that is aimed to account, inter alia, for the numerical values of urban metabolism indicators. This approach, initially, focuses on the drivers of material intensity, and then considers possible variables with their impact on waste management system.

Due to its highly heterogeneous character, the review is performed with regard to different fields of possible determinants: economic, sociodemographic, geophysical variables, as well as those referring to technology and infrastructure development and urbanization. Variables considered in this report are coupled with related urban metabolism indicators defined in D2.1 "Model architecture". In the majority of cases, the numerical values of variables are provided for NUTS 3 level that, in accordance with Eurostat, corresponds to small regions. If the data is not available for the NUTS 3 level, it is provided for NUTS 2 or a country level (the latter provides only one explanatory variable), where, in accordance with the Eurostat classification, a NUTS 2 spatial unit corresponds to basic regions for the application of regional policies. The relation of the pilot cities to NUTS 3 and NUTS 2 territorial units can be derived from Table 8.1.

Table 8.1 Relation of pilot cities to NUTS 2 and NUTS 3 territorial units

Country	NUTS 2	NUTS 3	Pilot city
Romania	București – Ilfov (RO32)	Bucharest (RO321)	Bucharest
Italy	Lombardia (ITC4)	Cremona (ITC4A)	Cremona
	Piemonte (ITC1)	Torino (ITC11)	Torino
	Lazio (ITI4)	Roma (ITI43)	Pomezia
			Albano Laziale
Portugal	Centro (PT) (PT16)	Região de Leiria (PT16F)	Leiria
Spain	Cataluña (ES51)	Barcelona (ES511)	Manresa
			Sabadell

Given a complex structure of interconnections, the coupling of variables, as well as the pairing between urban metabolism indicators is being also put to analysis (Sections 8.2.5 and 8.3, respectively).

8.2 Material flow indicators and determinants

The section analyses explanatory variables with regard to the main material flow indicators, determined in WP2 (Deliverable 2.1), that are as follow:

- *Domestic extraction (DE)* is the input of raw materials (except for water and air) from the natural environment that is used in an economy.
- *Domestic material consumption (DMC)* measures the total amount of material directly used in an economy (i.e. excluding indirect flows). DMC can be measured as follow:

$$DMC = DE + Imports - Exports$$

- *Direct material input (DMI)* - measures the direct input of materials for use into the economy, i.e. all materials which feature economic value and are used in production and consumption activities. DMI is calculated as follow:

$$DMI = DE + Imports$$

- *Net Additions to Stock (NAS)* provide information about the quantity (weight) of new construction materials used in buildings and other infrastructure, and materials incorporated into new durable manufactured goods, such as cars, industrial machinery, and household appliances. NAS can be calculated as follow:

$$NAS = DMC - DPO$$

- *Material discard (MD), as a part of Domestic processed output (DPO[1]),* measures the total weight of materials released back to the environment as waste (with or without aim for further processing).
- *Physical import (Imp) and physical export (Exp)* include goods entering or leaving a territorial unit, respectively.
- *Physical trade balance (PTB)* is defined as a difference between physical imports and physical exports:

$$PTB = Imports - Exports$$

Additionally, given its determinant character, material productivity (MP), i.e. an indicator of economy dematerialization is also considered among material flow indicators (Steinberger et al., 2010), where the term "dematerialization of economy" underlines the fact that lower amount of materials is required to serve the same economic function in a society.

MP is a reverse of material intensity, and it is calculated as GDP output per a unit of material consumption:

$$MP = {}^{GDP}/_{DMC}$$

Since, at the economy level, MP is calculated as a ratio of GDP to material input or consumption, this indicator can measure material intensity of the overall economy or a selected economy sector. MP can correspond also to the generation of some types of waste. More explanation about coupling between MP and MD (i.e. waste generation) can be found in the Section 2.3.

Where it is reasonable, the correlation of explanatory variables and material flow indicators is analysed with regard to specific material categories, namely: fossil fuels, metals (ferrous and non-ferrous), non-metallic minerals, fertilizers, biomass (forestry, crops and animal products). Otherwise, the review for corresponding material flow indicators was performed on the overall basis.

8.2.1 Explanatory variables

8.2.1.1 Economic variables

8.2.1.1.1 Gross Domestic Product Purchasing Power Parity

Gross domestic product purchasing power parity (GDP PPP) was approved to be a good explanatory variable for a variety of material flow indicators in different categories, including DMC. GDP was found in a good linear fit with the consumption of non-ferrous metals, such as copper and zinc (Binder et al., 2006), construction materials, chemicals and ores (Weisz et al., 2006; Kalmykova et al., 2016), although GDP alone is not able to provide

[1] DPO measures the total weight of materials which are released back to the environment after having been used in the domestic economy.

satisfactory correlation for all material categories in DMC. It exhibits also a good correlation with fossil fuel consumption (Steinberger et al., 2010).

As it was observed by Binder et al. (Binder et al., 2006), the use of metals correlates directly to such category as the prosperity of a society measured mostly via per capita GDP. Countries with high GDP exhibit a considerably higher amount of zinc, copper, construction mineral consumption (Binder et al., 2006; Weisz et al., 2006). Another observation indicates that PTB, especially material import balance, is in a good relation with GDP.

Presumably, given the dependence between GDP PPP and DMC, material discard might also be affected by this variable (Binder et al., 2006). For instance, Thogersen (Thogersen, 1996) discussed correlation between GDP PPP and MSW, both on the per capita basis. However, no evidences have been found concerning a link between GDP and such constituents of DPO as emissions into the air, dissipative flows, etc. In fact, this link can be complicated by other relatively independent variables (e.g. environmental budget, availability of waste recycling facilities, etc.). The latter will be studied based on data obtained from the UMAn model in WP2.

Figure 8.1 demonstrates GDP PPP per capita for NUTS 3 territory units for the period 2000 - 2011.

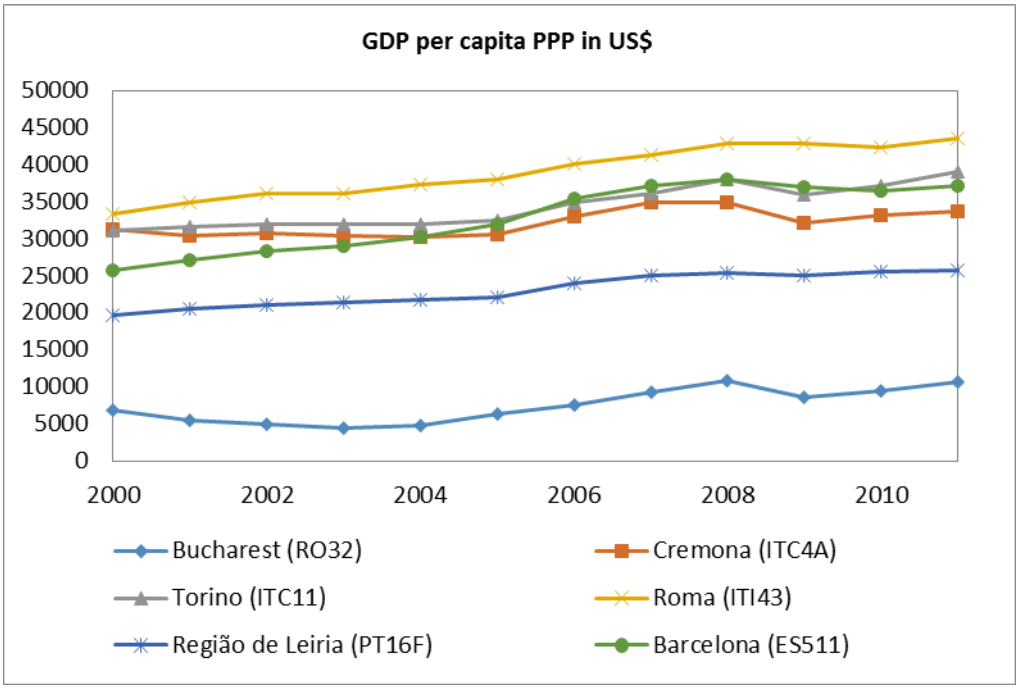


Figure 8.1 GDP PPP per capita for NUTS 3 territory units

While compared with the country average, PPP adjusted GRP per capita of the cities under review is, basically, considerably higher, implying the key role that cities use to play in a national economy. For instance, in 2011, NUTS 3 PPP adj. GRP exceeded country average by 7.8% (Torino), 17.3% (Roma) and 13.6% (Barcelona), although Bucharest, Cremona and Região de Leiria revealed a lag of 69.7%, 6.6% and 4.4% behind the resp. country's GDP. Additionally, GRP of Bucharest features the lowest figure among peers (the average of 7436 US$ per capita for the period 2000 – 2011), while the average GDP on PPP basis of Italian cities was 35179 US$ per capita for the same time span. The latter can be explained by the

extremely high population density of the Romanian capital, though other economic factors can be also relevant.

8.2.1.1.2 Income

Income, expressed as an average income on the per capita basis, can be in a high correlation with DMC of fossil fuels, construction materials, ores and industrial minerals (Steinberger et al., 2010). This variable is also found to be a good determinant for material trade, especially for the imports of ores and industrial minerals, as well as biomass. A generally moderate impact of a personal income at the per capita DMC was observed for the Swedish cities Stockholm and Gothenburg (Kalmykova et al., 2016). Additionally, similar to GDP, higher income would contribute to the increase of household material discard (Sterner et al., 1999). However, the countertrend might be also expected, if consider personal income to be predetermined by the level of education (Kalmykova et al., 2016), where the latter would allow to reach a lower amount of waste generated by a household (Sterner et al., 1999).

Data of average income by NUTS 2 region for the period 2000 - 2011 is shown in Figure 8.2.

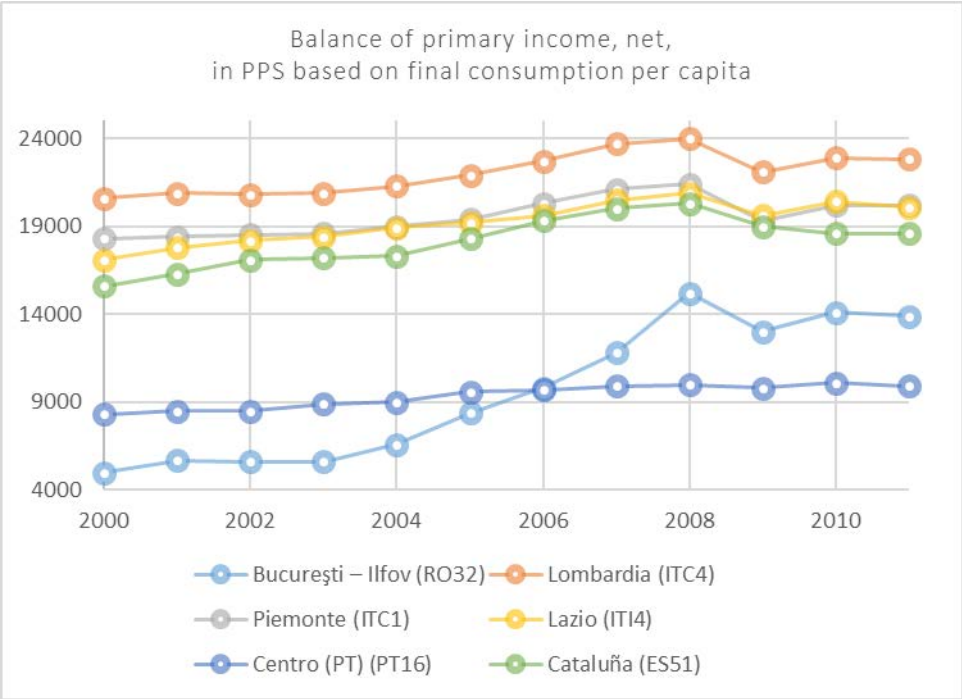


Figure 8.2 Average income by NUTS 2 region (Comment to the figure: PPS - purchasing power standard)

8.2.1.1.3 Value added in different economic sectors

It was shown that value added in the manufacturing of machinery and transport equipment features a good linear correlation with copper and zinc consumption (Binder et al., 2006), while value added in construction is in a good fit with DMC of construction minerals (Weisz et al., 2006). Due to a high energy intensity, we can also expect the impact of value added in heavy industries, including the manufacturing of machinery, on the final energy consumption (FEC).

Table 8.2 provides information on gross value added in main economic activities (agriculture, forestry and fishing, industry, manufacturing, construction and other) of eight pilot cities (by NUTS 3 regions, year 2014).

Table 8.2 Gross value added (GVA) at basic prices by NUTS 3 territory units (year 2014)

NUTS 3	Pilot city	Economic Sector (NUTS 3), % of the total GVA					GVA total (NUTS 3) in million EUR
		A	B - E	C	F	Other	
Bucharest (RO321)	Bucharest	0.6	16.7	9.2	7.9	65.6	32229.83
Cremona (ITC4A)	Cremona	5.7	26.2	24.6	4.1	39.4	9129.27
Torino (ITC11)	Torino	0.6	20.2	17.4	4.1	57.7	61122.75
Roma (ITI43)	Pomezia **Albano Laziale**	0.4	8.9	3.9	3.8	83.1	134609.57
Região de Leiria (PT16F)	Leiria	2.7	28.5	24.4	7.1	37.3	4229.36
Barcelona (ES511)	Manresa Sabadell	0.5	21.0	18.6	4.4	55.5	131798.5

Comments to the table: A - Agriculture, forestry and fishing; B – E - Industry (except construction); C – Manufacturing; F – Construction.

Based on the year 2014, it can be observed, from Table 8.2, that agriculture plays an insignificant role in the cities' economy, with a certain exclusion of Cremona (5.7% of the total GVA) and Região de Leiria (2.7% of the total GVA). At the same time, industry and manufacturing play a prominent role in the economies of those two regions (50.8% and 52.9% of the total GVA, respectively). Industry and manufacturing are also important parts of economy in Barcelona (21.0% and 18.6% of the total GVA) and Torino (20.2% and 17.4% of the total GVA), though they were found less valuable for the capital of Romania (16.7% and 9.2% of the total GVA), and even considerably smaller for the Italian capital city (8.9% and 3.9% of the total GVA, respectively). In Rome, other economic sectors, such as public administration and defence, social security, social work activities, entertainment, professional, scientific and technical activities, administrative and support service, etc. influence the economic structure to a larger extent (39.5% of the total GVA). To compare, the same sectors account for just 29.0% (Torino), and 28.8% (Bucharest) of the total GVA.

Wholesale and retail trade, transport, accommodation and food service are also important for the cities' economies, and account for 29.2% of the total GVA (Bucharest), 26.9% (Rome), roughly 26% in Torino and Região de Leiria.

The leadership in the share of construction sector is held by a city with the largest population, i.e. Bucharest, and, surprisingly, by Região de Leiria, with the said shares of 7.9% and 7.1%, respectively.

8.2.1.2 Sociodemographic variables

8.2.1.2.1 Population density

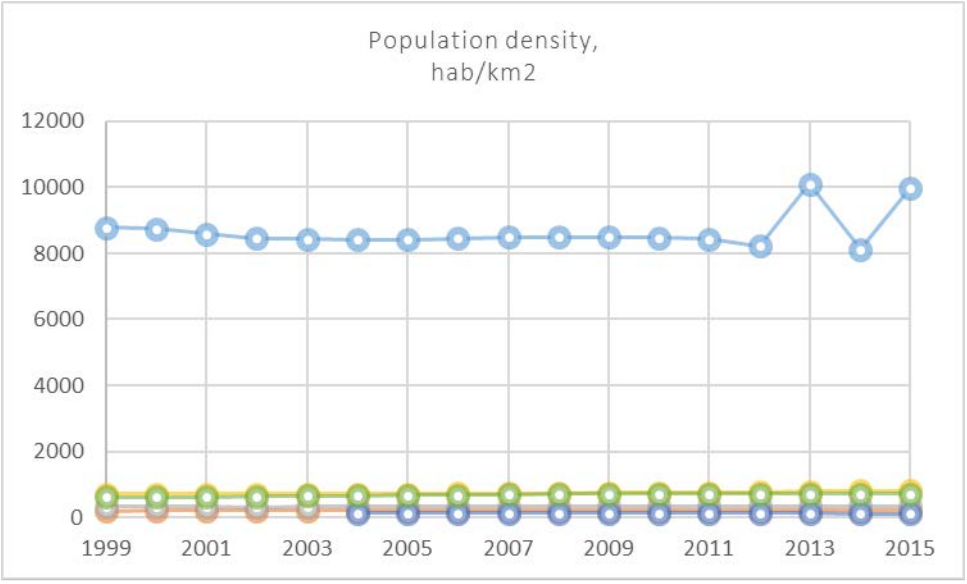
Population density is the reverse of land availability on the per capita basis. Given the widespread development of agriculture across the European countries, it can be assumed that population density should correlate with DE and DMC of biomass, though there are still a lot of factors, such as climate, the use of biomass in energy sector, as well as people's diet that can also affect these indicators.

Weisz et al. (Weisz et al., 2006) showed that land availability is highly related to DE and DMC, rather than to other indicators.

The impact of population density is also evident in DMC of construction sector. Namely, as it was observed, a low density results in a higher DMC of bulk construction materials on the per capita basis (Weisz et al., 2006). The latter might be the result of a larger need for the construction of a vast network infrastructure. Another issue is that a higher residential density would most likely result in a more intensive importation of construction materials that might be the outcome of both resource depletion and environmental strategy. In a broader context, higher land availability results in a larger amount of ores and industrial minerals consumed (Steinberger et al., 2010).

Another observation regarding waste management indicators revealed that the amount of materials discarded from the residential sector appeared to be in a positive relation with population density (Sterner et al., 1999) that, basically, implies that more MSW on the per capita basis can be expected in cities compared to rural areas.

Figure 8.3 demonstrates population density for pilot cities (by NUTS 3 level) for the period 1999-2015.



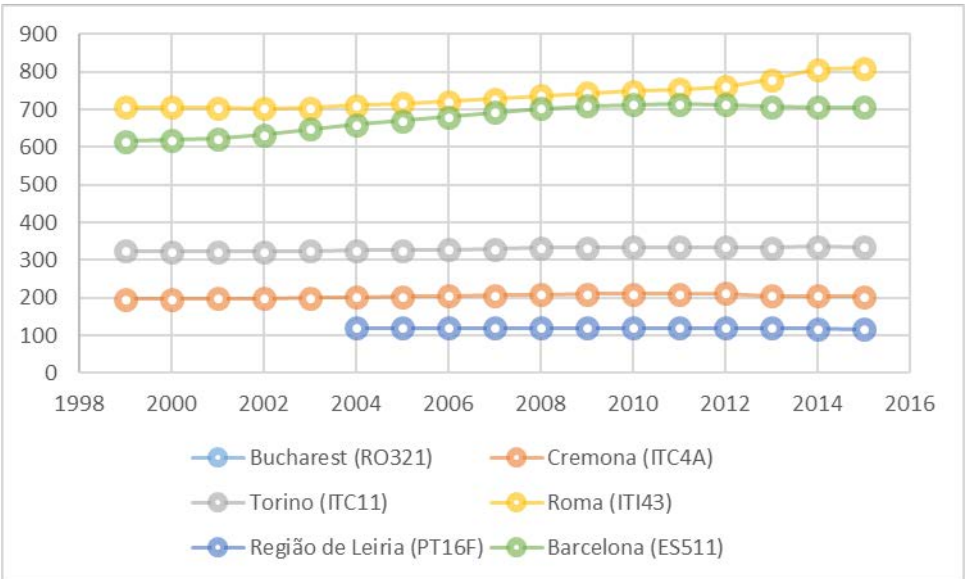


Figure 8.3 Population density by NUTS 3 territorial unit

8.2.1.2.2 Population growth rate

Presumably, the growth of urban population should be accompanied by an increase in housing construction and, consequently, the use of construction materials, mainly non-metallic minerals, as well as ferrous and non-ferrous metals.

The annual population growth rate (PGR) for a certain period can be calculated via an equation:

$$PGR = \frac{(V_{present} - V_{past})}{V_{past}} \times 100\% \Big/ N \quad (1)$$

Where: $V_{present}$ and V_{past} – present and past population, respectively;

N – number of years.

Due to its common use in galvanization process, zinc might be a proper representative within the group of non-ferrous metals, while non-metallic minerals and ferrous materials can be presented by different kinds of them (sand, cement, clay, stone, iron, steel alloying metals, etc.).

Another indicator that, as it is supposed, could be explained by PGR is NAS. NAS reflects the addition to stock of durable materials that are involved mainly in construction and machinery manufacturing. Given its considerably high value, it might become an issue to analyse the correlation between PGR and the stock of metals (both ferrous and non-ferrous) in the aforementioned economic sectors.

Data on the growth of population in eight pilot cities for the period of 1999 – 2014 is provided in Table 8.3.

Table 8.3 Annual PGR between 1999 and 2014 by NUTS 3 region

NUTS 3	Pilot city	Annual PGR for NUTS 3 in 1999 – 2014, %
Bucharest (RO321)	Bucharest	-0.49
Cremona (ITC4A)	Cremona	0.63
Torino (ITC11)	Torino	0.45
Roma (ITI43)	Pomezia	1.28
	Albano Laziale	
Região de Leiria (PT16F)	Leiria	0.23
Barcelona (ES511)	Manresa	0.96
	Sabadell	

8.2.1.2.3 Age

Age would most likely refer to the variables defining people lifestyle, including, for instance, diet preferences, attitude to waste collection, etc. As it was discussed, multi-family dwellings with a higher number of elderly people feature low amounts of waste generated per a resident compared with the amount of waste produced by the same types of dwellings with younger generation living in them (Sterner et al., 1999; Beigl et al., 2008). Due to a specific lifestyle, it can be also expected that younger generation contributes more to specific types of waste (e.g. packaging waste).

Figure 8.4 demonstrates the share of people of different age groups by NUTS 3 region. As it can be seen, basically, the share of people who are 65 years old and above increases during a considered period, while the share of middle-aged category (15 - 64) declines, although the latter still prevail significantly over other age groups. Bucharest features the highest share (over 70%) of the age group of 15 – 64 years, and is followed by other cities with the share of around 62 – 70% of that age category. On the contrary, in the older age group (over 65 years), Bucharest shows the lowest proportion of about 14 – 16%, followed by Barcelona (16 – 19%), Rome (18 – 21%), Região de Leiria (17 – 22%), while the highest value for this group can be observed in Cremona (20 – 23%) and Torino (20 – 24%).

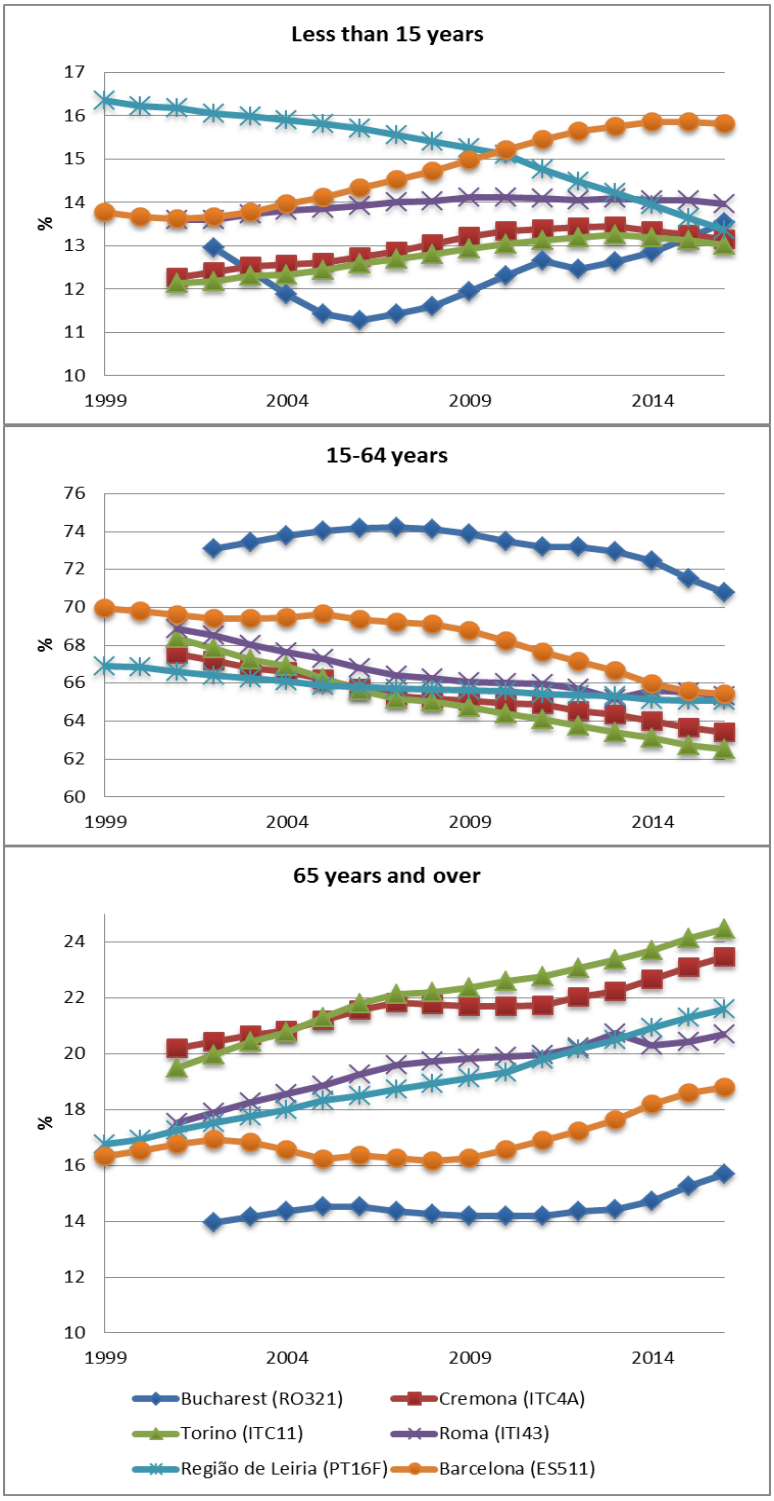


Figure 8.4 The share of population by age group by NUTS 3 region

8.2.1.2.4 Education

A moderate impact of literacy on DMC was observed by Kalmykova et al. (Kalmykova et al., 2016) for Stockholm and Gothenburg. However, the trends found were similar to the function of income vs. DMC. This allowed to suppose that the level of education may also define personal income.

In some studies it was shown that the level of education, basically, would negatively affect the amount of waste generated by households and would positively affect the recycling quality (Sterner et al., 1999; Sidique, et al., 2010).

The level of education for the eight pilot cities (by NUTS 2) in accordance with ISCED[2] is laid out in Figure 8.5, where ISCED 0 – 6 corresponds to the educational levels starting from early childhood education and finishing with the level of bachelor (or equivalent).

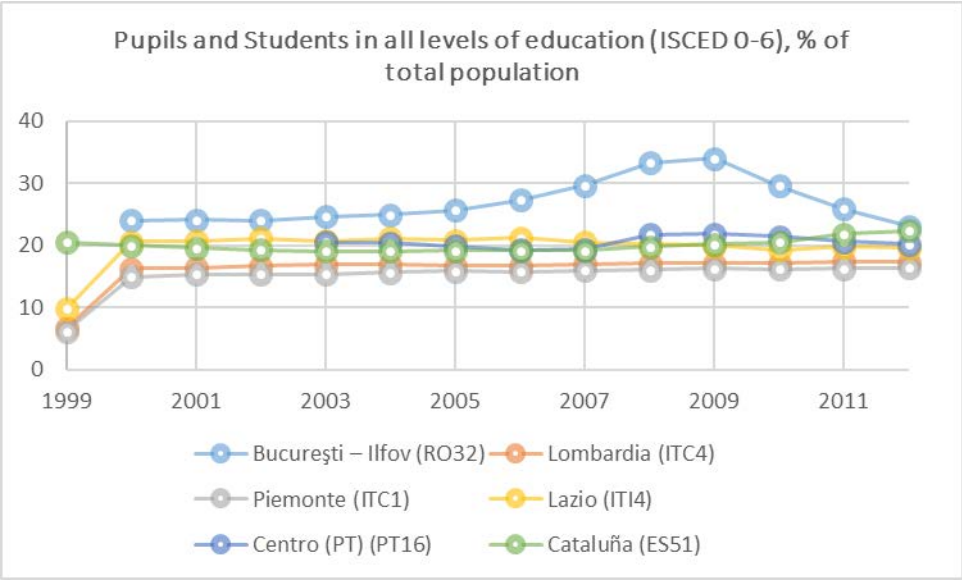


Figure 8.5 Pupils and students in all levels of education (ISCED 0-6), as % of total population at regional level by NUTS 2

8.2.1.3 Geophysical variables

8.2.1.3.1 Climate

Moderate temperatures and humidity, as they appear in countries located mainly closer to the north of the EU, e.g. Belgium, Ireland, The Netherlands, Germany, might allow for a higher biomass productivity than, for instance, in the Mediterranean region, though the natural productivity is dependent also on agricultural technologies applied (Weisz et al., 2006).

Another indicator related to climate conditions is the consumption of fossil fuels. This dependence is well-defined for countries located to the north, because those areas require more energy for heating needs (Steinberger et al., 2010).

City latitude can be a suitable determinant for climate zoning. However, since on the per capita basis DE of biomass will be affected by population density, the two explanatory variables, climate and population density, shall be considered together.

Concerning waste management indicators, climate temperature was found to be in relation with household waste: higher temperature may influence positively on the amount of materials discarded from households (Sterner and Bartelings, 1999).

[2] International Standard Classification of Education

Information about climate conditions for the eight pilot cities is provided in Table 8.4.

Table 8.4 Climate characteristics

Pilot city	Latitude, N	Average temperature, °C	Average temperature range, °C	Precipitation, mm
Bucharest	44°25'57''	10.8	-4.8 - +29.8	620
Cremona	45°08'	12.8	No data	810
Torino	45°04'	12	2.1 – 22.4	981
Pomezia	41°41'	15.3	8.2 – 23.4	784
Albano Laziale	41°44'	14.8	7.3 – 23.4	801
Leiria	39°45'	15.9	+7 - +15	790
Manresa	41°43'	15	No data	600
Sabadell	41°32'55''	15.8	+3.8 - +27.6	611

8.2.1.4 Technology development, urbanization and infrastructure variables

8.2.1.4.1 Stock of passenger cars

The fleet of passenger cars is expected to be a satisfactory explanatory variable for the use of non-ferrous metals. For instance, Binder et al. (Binder et al., 2006) observed a good linear correlation between the consumption of zinc and the number of cars, though this variable was found also in interdependence with GDP on the per capita basis.

Another dependence can be expected between the stock of cars and fuels consumed. Indeed, higher adherence to use a private car may lead to higher fuel consumption on per capita basis. However, continuous penetration of biofuels on the fuel market split this consumption by fuel origin – biobased (e.g. bioethanol, biodiesel) and conventional fossil fuels.

Information about the fleet of cars by NUTS 2 region for the period 1999 - 2015 can be derived from Figure 8.6 and Table 8.5. As it can be observed, the total amount of vehicles on the per capita basis (except trailers and motorcycles) does not differ too much from the number of passenger cars.

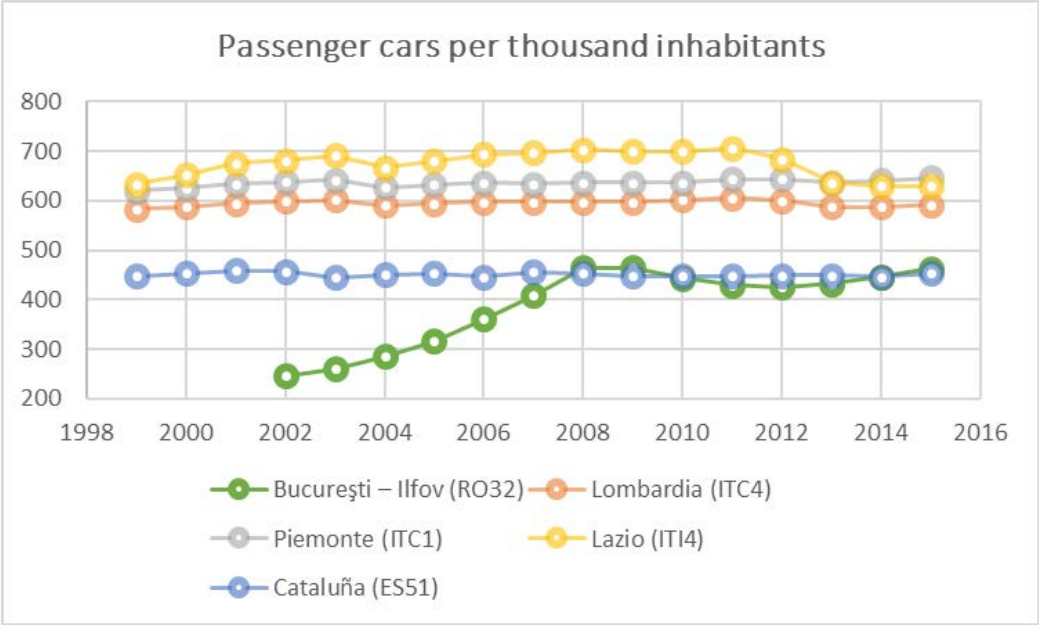


Figure 8.6 The number of passenger cars per thousand inhabitants by NUTS 2 region (Comment to the figure: no data was found for NUTS 2 "Centro (PT) (PT16)")

Table 8.5 The number of total utility vehicles and passenger cars per NUTS 2 region for the year 2014

NUTS 2	Pilot city	Number of cars per thousand inhabitants (NUTS 2)	
		All vehicles (except trailers and motorcycles)	Passenger cars
Bucureşti – Ilfov (RO32)	Bucharest	530	450
Lombardia (ITC4)	Cremona	660	590
Piemonte (ITC1)	Torino	730	640
Lazio (ITI4)	Pomezia	700	630
	Albano Laziale		
Centro (PT) (PT16)	Leiria	No data	No data
Cataluña (ES51)	Manresa	560	450
	Sabadell		

8.2.1.4.2 Electric and electronic industry, electric lines

Since the electric and electronic industries account for over 30% of the global copper consumption, it can be supposed that the network of telephone lines and electric power consumption on the per capita basis might serve a proper explanatory variable for DMC and NAS of non-ferrous heavy metals (Cu). A considerable interference can be expected from

the consumption of copper in construction, for the general consumer needs, in transportation and industrial machinery sectors that consume about 25, 17, 12 and 10 %, respectively (LME, 2017). Binder et al. (Binder et al., 2006) observed a high convergence between the use of copper and such variables, as telephone mainlines, the ownership of television sets and personal computers.

Data on telephone mainlines and percentage of households with computers at country level can be found in Table 8.6.

Table 8.6 Telephone mainlines and percentage of households with computers

Country	Telephones - mainlines in use per 100 people (2014)	Percentage of households with computers (2015)
Italy	35.35	
• Households, living in densely-populated area (at least 500 inhabitants per km^2)		75
• Households, living in intermediate urbanized area (between 100 - 4999 inhabitants per km^2)		72
Portugal	42.28	
• Households, living in densely-populated area (at least 500 inhabitants per km^2)		77
• Households, living in intermediate urbanized area (between 100 - 4999 inhabitants per km^2)		72
Romania	21.42	
• Households, living in densely-populated area (at least 500 inhabitants per km^2)		81
• Households, living in intermediate urbanized area (between 100 - 4999 inhabitants per km^2)		72
Spain	40.86	
• Households, living in densely-populated area (at least 500 inhabitants per km^2)		80
• Households, living in intermediate urbanized area (between 100 - 4999 inhabitants per km^2)		76

8.2.1.4.3 Access to the Internet

Given the wide use of the Internet technologies, it can be assumed that this variable corresponds to the number of computers in the European residential sector. Indeed, for instance, while the average percentage of Italian households with computers (for Households, living in densely-populated and intermediate urbanized areas) amounts to 72 - 75%, the percentage of households with access to the Internet is equal to 77, 73 and 74% for Italian provinces Lombardia, Piemonte and Lazio, respectively. The similar correspondence can be observed for the other countries.

Hence, pairing this determinant with indicators, a satisfactory correlation might be expected between it and DMC of Cu, especially when it refers to the electronics sector (Shigetomi et al., 2017). Additionally, based on the study of electric and electronic equipment lifespan (Kalmykova et al., 2015), an essential interdependence can be expected between this variable and Cu stock and its discard with WEEE.

Figure 8.7 shows the percentage of households with access to the Internet at home by NUTS 2 for the period 2006 - 2016.

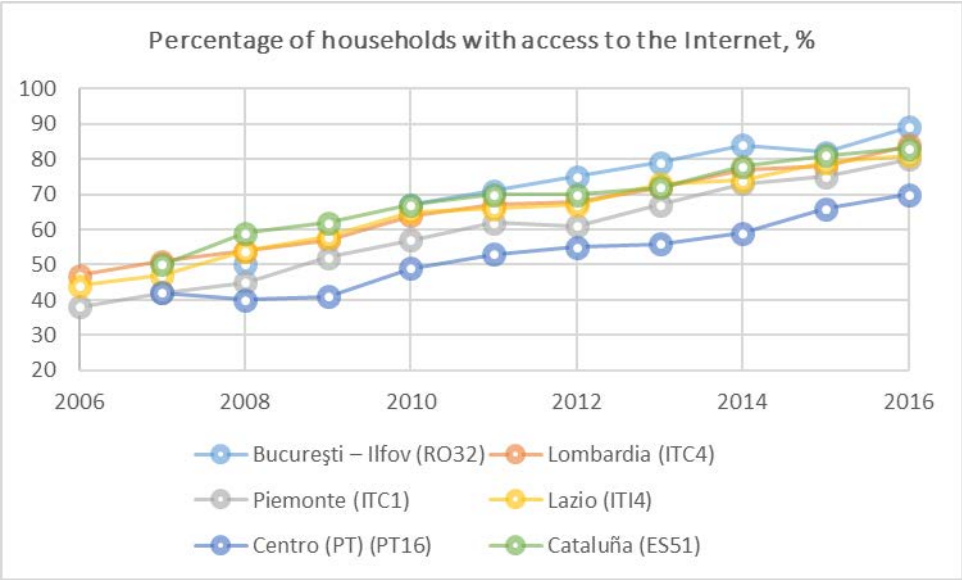


Figure 8.7 Households with access to the Internet by NUTS 2

8.2.1.4.4 Other variables affecting waste management

Undoubtedly, the number of determinants for explaining waste generation can be quite extensive and may depend on a variety of factors like e.g. the development of industrial sector, waste prevention and management policies and such strategies set at a country or city level, the availability of a proper waste management system infrastructure, environmental budget, environmental awareness, available living area in households, the time of staying at home, etc.

The majority of those variables is either qualitative or are not reflected in basic statistical reports. Those factors should be assessed individually at a city level based on the participatory approach of citizens, businessmen, authorities and other stakeholders.

8.2.2 Coupling between variables

In complex systems, it is a quite common situation where an indicator is affected by a set of partially independent parameters, so their contribution to a model that describes the indicator in a better way becomes a specific subject of study. There are several examples of such pairing in the current section, though the real system of determinants coupling is rather more complicated.

In DMC of non-ferrous metals on a country level, Binder et al. (Binder et al., 2006) showed that the model for describing the consumption of copper on the per capita basis was highly sensitive to three factors in total, namely: GDP per capita (PPP-adjusted), % of value added in the manufacturing of machinery and transportation and the percentage of people living

in urban areas (equation 1), while the model of Zn consumption can be defined via GDP per capita (PPP-adjusted) and % of value added in the manufacturing of machinery and transportation (equation 2).

$$\ln(DMC_{Cu}) = (-2.07 \pm 0.412) + (9.12 \cdot E-5 \pm 1.73 \cdot E-5) \times GDP + (0.042 \pm 0.01) \times M + (0.016 \pm 0.0064) \times U \quad (1)$$

$$\ln(DMC_{Zn}) = (-1.26 \pm 0.25) + (1.14 \cdot E-4 \pm 1.52 \cdot E-5) \times GDP + (0.04 \pm 0.01) \times M \quad (2)$$

Where:GDP is GDP per capita (PPP);

M is % of value added in manufacturing of machinery and transport;

U is urban population, %.

In the same manner, a better suited model was found for copper NAS per the per capita basis (Binder et al., 2006):

$$\ln(NAS_{Cu}) = (-1.76 \pm 0.371) + (5.12 \cdot E-5 \pm 1.59 \cdot E-5) \times GDP + (4.76 \cdot E-2 \pm 9 \cdot E-3) \times M + (1.56 \cdot E-2 \pm 6 \cdot E-3) \times U \quad (3)$$

Where:GDP is GDP per capita (PPP);

M is % of value added in manufacturing of machinery and transport;

U is urban population, %.

Keeping in mind the correlation between residential density and DMC in construction sector, another variable can be introduced in order to enhance this connection. A high population density along with mild climate conditions result in the reduction of DMC of construction materials (Weisz et al., 2006).

As it was discussed previously, there is another complimentary example of interconnection between such explanatory variables as climate zone and population density. While considered together, these two variables will most likely determine DE of cereal biomass on the per capita basis (Weisz et al., 2006). At the same time, since those two determinants are linked to DE in the agricultural sector, they might predefine the use of fertilizers for agricultural biomass growing.

Material productivity (MP) is a reverse of material intensity, and it is calculated as GDP output per a unit of material consumption. It was found in a good correlation with income for a variety of categories except for fossil fuels, ores and industrial minerals (Steinberger et al., 2010).

Another example of coupling between variables “literacy” and “income” with regard to DMC was suggested by Kalmykova et al. (Kalmykokva et al., 2016) in their study of resource consumption drivers for Gothenburg and Stockholm. The cross impact of education and income and their correlation with the rates of e-waste recycling was noticed by Milovantseva and Saphores (2013).

8.2.3 Summary of explanatory variables for urban models

The list of explanatory variables and their relation to material flow indicators are summarized in Table 8.7.

Table 8.7 Explanatory variables

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
Economic variables																					
GDP per capita (PPP)						X	X (Cu, Zn)	X	X				X	X (Cu, Zn)	X		X		X	X	
Income								X	X						X (O, IM, Bio)					X	
% of value added in manufactur							X (Cu, Zn)		X												

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
ing of machinery and transport equipment																					
Growth of value added in construction								X													
Sociodemographic variables																					

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
Population density	X	X (GA)		X	X			X		X						X				X	
Population growth rate						X	X (Cu, Zn)	X					X	X (Cu, Zn)							
Age																				X	
Education												X								X	
Geophysical variables																					
Latitude			X (GA)	X (E)	X (E)				X											X	

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
Technology development, urbanization and infrastructure variables																					
Stock of passenger cars				X (Bio-f)	X (Bio-f)		X (Zn)		X (D, G)				X	X (Cu, Zn)							
Percentage of households with computers							X (Cu)							X (Cu)							
Electric lines							X (Cu)							X (Cu)							

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
Access to the Internet							X (Cu)							X (Cu)							X (Cu)
Coupling between variables																					
Climate zone (latitude) and Population density		X						X			X										
GDP and % of value added in manufactur							X (Cu)							X (Cu)							

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
ing of machinery and transport and % urban population																					
GDP and % of value added in manufacturing of machinery and transport							X (Zn)														

Explanatory variable	Material Flow Indicator																				
	DE			DMC									NAS		PTB			MP	Material discard		
															Imp		Exp				
	Biomass			Biomass		Metals		NMM	FF	O, IM	F	DMC *	Metals		Tot	CM	Tot	Tot	Tot	MSW **	Metals
	F	AS	AS	F	GA	Ferrous	Non-ferrous	BCM	-	-	-	-	Ferrous	Non-ferrous	-	-	-	-	-	-	Non-ferrous
	t/cap	t/cap	Abs. value	t/cap	t/cap	t/cap	t/ cap	t/cap	t/cap	t/cap	kg/km^2	t/cap	t/cap	t/cap	t/cap	t/cap	t/cap	USD/t DMC	t/cap	t/cap	t/ cap
Income and GDP																		X (excl. FF, O and IM)			
Income and literacy												X									

Comments to the table: NMM - Non-metallic minerals , F – Forestry, AS – Agricultural sector, GA – Grassland based agriculture, E – for energy purposes, BCM – Bulk construction minerals, FF – Fossil fuels, O - Ores, IM – Industrial minerals, Bio – Biomass, Bio-f – biofuels, MP – material productivity, D – Diesel, G - Gasoline; * - the category is not defined; ** different types of MSW are not separated.

8.2.4 Coupling between material flow indicators

There are several examples of interrelated material flow indicators.

Correlation between DMC and DE can be found in different material categories (biomass, construction materials, ores and industrial minerals), but with the exception of fossil fuels (Steinberger et al., 2010). However, FEC was observed as a satisfactory explanatory variable for overall DMC (Weisz et al., 2006; Steinberger et al., 2010).

Imports appear to be the driver for DMC of fossil fuels, ores and industrial minerals, while exports were found to be in a correlation with DMC of ores and industrial minerals (Steinberger et al., 2010).

Given an intrinsic connection of DMI, DE and imports, high correlation can be expected between these indicators in specific economic activities.

Predictably, the extraction of agricultural biomass might be in a connection with the livestock number. For instance, as it was observed by Weisz et al. (Weisz et al., 2006), the two European countries with the highest agricultural biomass production on the per capita basis, namely Ireland and Denmark, feature the largest livestock population.

In the agricultural sector, especially in livestock breeding and forestry, there is also a strong correlation between PTB and DMC of corresponding category (Weisz et al., 2006). Even more correlation can be found between different categories within the agricultural sector, for instance, between PTB in highly processed fodder and the number of livestock.

Due to high transportation costs for the majority of construction materials and their natural abundance, there is a significant correlation between DE and DMC. However, this correlation can be affected significantly by population density, especially when it refers to densely populated cities. The impact of this determinant has been discussed above.

Concerning material intensity of the city economy, it is obvious that at a given level of GDP (most likely GDP PPP would be the most appropriate variable to be used), one more correlation can be found out, namely the correspondence between MP and DMC. Higher DMC in this case will result in lower MP.

Another correlation can be predicted between MP and MD (again under a certain level of GDP). If MD follows the low of the Weibull probability density function, as it was shown for WEEE (Kalmykova et al., 2015), MD in future will be defined by the current DMC and, hence, by the current MP. However, it should be noticed that time here that is defined by a product lifespan is an independent variable to be taken in consideration.

The summary of interrelations between material flow indicators is provided in Table 8.8.

Table 8.8 Coupling between material flow indicators

Indicator	DE					DMC						PTB										MD
												Import					Export					
	B	CM	FF	***	Tot	B	CM	FF	O, IM	***	Tot	B	CM	FF	O, IM	Tot	B	CM	FF	O, IM	Tot	***
DE																						
B	X*					X*						X*					X*					
CM							X**															
O, IM									X													
Tot											X										X	
DMI																						
***				X						X												
DMC																						
B	X*					X*																
FF											X			X								
O, IM															X					X		
Tot					X											X					X	
***																						X

Indicator	DE					DMC						PTB										MD
												Import					Export					
	B	CM	FF	***	Tot	B	CM	FF	O, IM	***	Tot	B	CM	FF	O, IM	Tot	B	CM	FF	O, IM	Tot	***
Import																						
B	X*					X*											X*					
FF								X														
O, IM									X											X		
Tot											X											
Export																						
O, IM									X						X							
Tot					X						X											
MP																						
***						X	X	X	X	X	X											X

*Comment to the table: B – Biomass, CM – Construction materials, FF – fossil fuels, O – Ores, IM – Industrial minerals, Tot – total; * - refers to specific sub-categories (details are provided in the text); ** - other variables can also affect significantly (details are provided in the text); *** - by specific sector of economic activity..*

9 Conclusions and recommendations

The general conclusions and recommendations from the different analysis are briefly summarised below. Together with the developed DPSIR model and the assessment of the main determinants from MFA regarding each pilot city, these outputs will feed the innovative WMS that are being developed in WP4 under the framework of the UrbanWINS project.

- Participatory approach is considered to be a key factor to improve the success of WMS.

The participatory approach must have three different goals: to integrate citizens and other stakeholders in the development of WMS; to integrate and synchronise waste management practices in all types of neighborhoods and differing social status; and, to establish clear, regular awareness campaigns, appropriately adjusted to the identified target groups.

- The consumer driver.

As expected, the economic driver is the most relevant aspect for private companies and WM techniques and solutions. While public agents also consider the economic driver, in the sense of providing the desired services at a minimum cost, the social dimension can, depending on the situation, be considered as of even greater significance. In contrast, environmental drivers are not considered to be a priority either by public or private companies. However, as observed in the case of Austria, through consumer pressure, private companies are willing to change their attitude. Therefore, the development of new WMS can benefit from the power of citizens as consumers who in turn become proactive lobbyists by virtue of their spending habits.

- Simple and clear regulations

Current regulations are seen as a limiting factor for the efficient implementation of new WMS. Limitations are described as technical (e.g. limiting the implementation of some practices), economical (e.g. through taxes) or bureaucratic (e.g. number of regulations, local, regional and national standards).

- Need to test and implement new innovative solutions at real scale.

In some countries/municipalities it has been observed that innovative practice, even thoguht tested at pilot scale as part of financed R+D projects, are not eventually fully implemented and the theoretical benefits are thus lost. This is due to restrictions made by regulations as described in the previous point or to economic limitations. Green public procurement, is seen as a promising solution to overcome this issue.

Based on the DPSIR model, the five main determinants are: Industrialization, Governance, Cultural barriers and the linked geographical context, Environmental Impacts and Human behaviour. As the effect/response of each determinant is specific for each reality (i.e. national, regional, local and even at a neighbourhood level), the WMS that will be developed later in the project must reflect an analysis of such effects.

- The main determinants based on the UMAN model are established for each pilot city. These determinants are grouped into economic, socio-demographic, geophysical, technology development, urbanisation and infrastructure variables.

The identified economic variables: GDP and income have an effect on the consumption, accumulation and discard of materials, while determinants related to the production sector mostly affect the consumption of materials. Increase in GDP and income tend to indicate more consumption and accumulation of metals, construction materials and chemicals in cities. Analysing the data for the 8 cities it can be seen that Bucharest deviates significantly from the other 7 cities. The share of different economic sectors also plays an important role in terms of a city's metabolism, namely the existence of heavy industry indicates more consumption of materials and energy. In the 8 pilot cities, it means that the city of Leiria and Cremona consume more, while Pomezia and Albano Laziale show the cities that consume less. Torino, Manresa, Sabadell and Bucharest appear somewhat in the middle, suggesting three different types of metabolisms of cities when considering the economic sectors structure.

In terms of sociodemographic characteristics that affect the metabolism of cities density of population, age and education play a role. While the increase in density reduces the need for construction materials and biomass and increases the amount of waste discarded, hence allow for a better waste management system. In the 8 pilot cities Bucharest shows the largest density, while cities in the Rome and Barcelona areas are inbetween, while Leiria, Cremona and Torino show very low densities.

The population growth rate however indicates that an increase in construction materials is likely to happen. Again, the 8 pilot cities show very different behaviours. Bucharest is reducing their population, Rome and Barcelona areas have a higher increase and Leiria, Cremona and Torino are increasing in a lesser proportion. This indicates that despite differences, cities in this case might be able to be clustered when considering density and population growth.

The age of the population might also play a role, and older people might tend to producing less waste. When analysing the trends in all the 8 cities, it can be seen that people aged above 65 are increasing during the last 15 years in all of them. Finally, when looking at the education of people and how it affects the metabolism of the city it can be observed in the literature that there is a strong correlation with income and therefore this likely will follow the same trend and impact on the cities' metabolism.

Another variable that have an impact on the metabolism of cities is the climate, for which it can be seen that cities located in the north of Europe might have higher biomass productivity than Mediterranean but also consume more fossil fuels due to heating requirements, therefore, the use of the city's latitude can be used has a variable to define different metabolisms. In the case of the 8 pilot cities however, they are very similar.

Finally, the technological determinants are also important to consider, such as, stock of cars, stock of electric and electronic equipment, access to internet among others. All cities indicate trends towards high levels of stocks of technology, which indicate that due to this, cities might consume more metallic materials and are hubs where this materials are concentrated, which facilitate there management when reaching the end of life.

The number of determinants for explaining waste generation can be quite extensive and may depend on a variety of factors like e.g. the development of industrial sector, waste prevention and management policies and such strategies set at a country or city level, the availability of a proper waste management system infrastructure, environmental budget,

environmental awareness, available living area in households, the time of staying at home, etc.

Furthermore, in complex systems, it is a quite common situation where an indicator is affected by a set of partially independent parameters, so their contribution to a model that describes the indicator in a better way becomes a specific subject of study. There are several examples, though the real system of determinants coupling is rather more complicated.

10 References

http://ec.europa.eu/environment/waste/ (Date of online access 10th April 2017)

AÄllgemeines zur Abfallwirtschaft. 2017. Bundesministerium für Land und Forstwirtschaft, Umwelt und Wasserwirtschaft. https://www.help.gv.at/Portal.Node/hlpd/public/content/379/Seite.3790060.html (Date of online access 12th May 2017)

Aid, G., Eklund, M. Anderberg, S. and Leenard, B, 2017. Expanding roles for the Swedish waste management sector in inter-organizational resource management. Resources, conservation and recycling 124, 85-97.

Austria Wirtschaftsservice. 2017. https://www.aws.at/foerderungen/aws-garantien-fuer-investitionen-in-oesterreich/ (21/07/2017)

Avfallsverige. 2016 Swedish waste management 2016. Retrieved from http://www.avfallsverige.se/fileadmin/uploads/Arbete/Remissvar/swm_2016.pdf (Accessed on 26.06.2017)

AWG.2002.https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=Bundesnormen&Gesetzesnummer=20002086

Beigl, P., Lebersorger, S., & Salhofer, S. 2008. Modelling municipal solid waste generation: A review. Waste Management, 28, 200–214. https://doi.org/10.1016/j.wasman.2006.12.011

Binder, C. R., Graedel, T. E. and Reck, B. (2006), Explanatory Variables for per Capita Stocks and Flows of Copper and Zinc. Journal of Industrial Ecology, 10: 111–132. doi:10.1162/108819806775545475

BMLFUW "Bundesabfallwirtschaftplan". 2011. https://www.bmlfuw.gv.at/greentec/bundes-abfallwirtschaftsplan/bawp2011.html (21/07/2017)

BMLFUW. 2017c. Vereinbarung 2017-2030 zur Vermeidung von Lebensmittelabfällen bei Lebensmittelunternehmen.https://www.bmlfuw.gv.at/service/presse/land/2017/170531Lebensmittelsindkostbar.html (21/07/2017)

BMLFUW. 2015. VIKTUALIA 2015- Die besten Projekte. https://www.bmlfuw.gv.at/land/lebensmittel/kostbare_lebensmittel/viktualia/viktu2015.html (21/07/2017)

BMLFUW. 2017a. https://www.bmlfuw.gv.at/umwelt/nachhaltigkeit/ressourceneffizienz/aktionsplan_ressourceneffizienz_reset/reset2020_initiative.html (21/07/2017)

BMLFUW. 2017b. https://www.bmlfuw.gv.at/greentec/bundes-abfallwirtschaftsplan/BAWP2017.html (21/07/2017)

Bradley, P., Yee, S. 2015. Using the DPSIR Framework to Develop a Conceptual Model: Technical Support Document. US Environmental Protection Agency, Office of Research and Development, Atlantic Ecology Division, Narragansett, RI. EPA/600/R-15/154.

Bußjäger P., Kroneder-Partisch, C. 2004. Übersicht über die Bundes und Landes Kompetenzen.

COM . Closing the loop – An EU action plan for the Circular Economy. 2015. 614 final. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

Corvellec, H. 2016. Waste prevention in Sweden 2008-2015 - An analysis of key waste prevention initiatives. The Department of Service Management and Service Studies, Lund University. Retrieved from http://www.ism.lu.se/sites/ism.lu.se/files/wastepreventionsweden_v3.pdf (Acessed 27.06.17)

Curzon, L.B. 2003. Teaching in further education: an outline of principles and practice. Cornwall: MPG Books Ltd.

Dahlén, L. 2008. Household Waste Collection. Factors and Variations. Doctoral thesis. Department of Civil, Mining and Environmental Engineering. Division of Waste Science and Technology. Luleå University of Technology. Luleå. Sweden

Desa, A., Kadir, N. B. Y. A., Yusooff, F. 2011. A study on the knowledge, attitudes, awareness status and behaviour concerning solid waste management. Procedia-Social and Behavioral Sciences, 18, 643-648.

Directive 2008/98/CE, of the European Parliament and of the Council, 19 November 2008, on waste and repealing certain Directives.

Dobson, S., Jorgensen, A. 2014. Increasing the resilience and adaptive capacity of cities through entrepreneurial urbanism. International Journal of Globalisation and Small Business, 6(3-4), 149-162.

EC.2017.http://ec.europa.eu/regional_policy/sources/docgener/evaluation/pdf/expost2013/wp1_at_report_en.pdf (21/07/2017)

European Environment Agency (EEA). 2005. Sustainable use and management of natural resources. EEA Report No 9/2005, Copenhagen: European Environment Agency, 72 pp.

Gifford, R., Nilsson, A. 2014. Personal and social factors that influence pro-environmental concern and behaviour: A review. International Journal of Psychology, 49(3), 141-157.

Grünbuch – Nachhaltiges Recycling von Glasverpackungen in Österreich“ Austria Glas Recycling (2014) Page 38.

Kalmykova, Y., Patricio, J., Rosado, L., & EO, B. P. 2015. Out with the old, out with the new - The effect of transitions in TVs and monitors technology on consumption and WEEE generation in Sweden 1996-2014. Waste Management, 46, 511–522. https://doi.org/10.1016/j.wasman.2015.08.034

Kalmykova, Y., & Rosado, L. 2016. Resource consumption drivers and pathways to reduction: economy, policy and lifestyle impact on material flows at the national and urban scale, 132, 70–80. https://doi.org/10.1016/j.jclepro.2015.02.027Martinho, G., Magalhães, D., Pires, A. 2017a. Consumer behaviour with respect to the consumption and recycling of smartphones and tablets: An exploratory study in Portugal. Journal of Cleaner Production, 156, 147-158.

LME, 2017. URL: https://www.lme.com/en-gb/about-us/ (accessed 23.05.2017)

Martinho, G., Balaia, N., Pires, A. 2017b. The Portuguese plastic carrier bag tax: The effects on consumers' behaviour. Waste Management, 61, 3-12.

MADR (Ministry of Agriculture Regional Development and Fisheries), MAOT (Ministry of the Environment and Planning), MS (Ministry of Health). Portaria (Decree-Order) n.o 43/2011 de 20 de Janeiro. Diário da República. 2011;1a série(14):377–466.

MAOT (Ministry of the Environment and Planning). Decreto-Lei (Decree-Law) no 73/2011 de 17 de Junho. Diário da República. 2011;1a série(116):3251–300.

MAOT (Ministry of the Environment and Planning). Decreto-Lei (Decree-Law) n.o 89/2002 de 9 de Abril. Diário da República. 2002;1a série-A(83):3350–82.

MAOTE (Ministry of the Environment Planning and Energy). Portaria (Decree-Order) n.o 187-A/2014 de 17 de setembro. Diário da República. 2014;1a série(179):5004–(2–4).

MBA Skool. Date accessed: 15/06/2017 http://www.mbaskool.com/business-concepts/finance-accounting-economics-terms/12159-industrialization.html

Milovantseva, N., Saphores, J., 2013. E-waste bans and U.S. households ' preferences for disposing of their e-waste. J. Environ. Manage. 124, 8–16. doi:10.1016/j.jenvman.2013.03.019

PCM (Presidency of the Council of Ministers). Resolução do Conselho de Ministros (Council of Ministers Resolution) n.o 11-C/2015. Diário da República. 2015;1a série(52):1610–(8–50).

SEPA. (2012). From waste management to resource efficiency. Sweden's Waste Plan 2012–2017. Report 6560, May 2012. Retrieved from http://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6560-7.pdf (Accessed on 29.10.2016)

SEPA. (2005). Economic instruments for the environment. Retrieved from https://www.naturvardsverket.se/Documents/publikationer/620-8221-3.pdf?pid=3947 (Accessed on 29.06.2017

Seville. 2017. "Municipios y economia circular" HTTPS://www.municipiosyeconomiacircular.org/comunicados-de-prensa-economia-circular-sevilla/2017/3/15/la-declaración-de-sevillla-por-la-economia-circular-recibe-el-apoyo-de-60-ayuntamientos-espaoles-y-europeos

SFS 2001:1063. The Swedish Waste Ordinance (2001:1063).

Shigetomi, Y., Nansai, K., Kagawa, S., Kondo, Y., Tohno, S., 2017. Economic and social determinants of global physical flows of critical metals. Resour. Policy 52, 107–113. doi:10.1016/j.resourpol.2017.02.004

Sidique, S.F., Joshi, S. V, Lupi, F., 2010. Resources , Conservation and Recycling Factors influencing the rate of recycling: An analysis of Minnesota counties. Resour. Conserv. Recycl. 54, 242–249. doi:10.1016/j.resconrec.2009.08.006

Steinberger, J.K., Krausmann, F., Eisenmenger, N., 2010. Global patterns of materials use: A socioeconomic and geophysical analysis. Ecol. Econ. 69, 1148–1158. doi:10.1016/j.ecolecon.2009.12.009

Sterner, T., Bartelings, H., 1999. Household Waste Management in a Swedish Municipality: Determinants of Waste Disposal, Recycling and Composting 1. Environ. Resour. Econ. 13, 473–491.

Thogersen, J. 1996. WASTEFUL FOOD CONSUMPTION: TRENDS IN FOOD AND PACKAGING WASTE, 12(3), 291–304.

UN, 1987. Report of the World Commission on Environment and Development: Our Common Future.

United Nations Environment Programme (UNEP). 2007. Global Environment Outlook GEO4, Nairobi and Valletta. www.unep.org/geo/geo4/ (21/07/2017).

Vitiello, A. (2017) "Immigration: a Multilateral Phenomenon. What makes immigration such a debated issue nowadays?" Articled available at: http://one-europe.net/immigration-a-multilateral-phenomenon

VÖEB. 2015. Kreisläufe schließen Ressourcen schonen Wirtschaftsstandort Europa stärken. (21/07/2017)

Weisz, H., Krausmann, F., Amann, C., Eisenmenger, N., Erb, K., Hubacek, K., Fischer-kowalski, M., 2006. The physical economy of the European Union : Cross-country comparison and determinants of material consumption. Ecol. Econ. 58, 676–698. doi:10.1016/j.ecolecon.2005.08.016.

Waste EAC. 2017. Annex 6.6.2. Detailed action plan for waste_EAC 6.2. Waste management available at: http://www.fonduri-ue.ro/poim-2014 (02/2017).

Welcomeurope. 2017. http://www.welcomeurope.com/eu-fonds/erdf-1-european-regional-development-fund-815+715.html#tab=onglet_details (21/07/2017)

11 Annexes

11.1 Annex A – List of Abbreviations

DE - Domestic extraction

DMC - Domestic material consumption

DMI - Direct material input

DPSIR –Drive Pressure State Impact Response methodology

Exp - Export

FEC - Final energy consumption

GDP - Gross domestic product

Imp - Import

ISCED - International Standard Classification of Education

MD – Material discard

MP – Material productivity

MSW – Municipal solid waste

NAS - Net additions to stock

PGR - Population growth rate

PPP - Purchasing Power Parity

PPS - Purchasing Power Standard

PTB - Physical trade balance

WMS – Waste Management Strategy

WMSP - Waste Management Strategy Plans

11.2 Annex B - DPSIR model

11.3 Annex C - Summary of Strategic Plans analysed for each pilot city

State	ITALY			
Region	LAZIO			
City	ALBANO LAZIALE			
	Name of the Plan/Programme	**Type of plan/ programme/ Tool**	**Legislative Framework**	**Type of flow/resource**
	P.A.E.S Piano di Azione per l'Energia Sostenibile(Sustainable Energy Action Plan)	Action Plan	EU level	energy,water,CO2 production
	Ordinance for the activation of the service door to door of municipal solid waste N. 187 DEL 14-09-2016	Regulation tool	Metropolitan level	Municipal Waste
	Saving water ordinance, drinking water use norms	Regulation tool	Metropolitan level	Water resource
	Regulation of the municipal collection point for separate waste collection of Albano Laziale	Regulation tool	Local level	Municipal Waste
	Regulation for the establishment and application of the municipal tax on waste and on services	Regulation tool	Local level	Municipal Waste
	Air Quality Restoration Plan	Monitoring Plan	Regional level	air pollution,CO2

City	POMEZIA			
	P.A.E.S Piano di Azione per l'Energia Sostenibile(Sustainable Energy Action Plan)	Action Plan	EU level	energy,water,CO2 production
	Regulamentation of municipal waste collection and cleaning services	Regulation tool	Local level	Municipal Waste
	Municipal composting regulation	Regulation tool	Local level	Municipal Waste
	Cultural heritage promotion and touristic development of the city of Pomenzia (2016-2018)	Promotional strategic plan	Local-Metropolitan level	Economic development
Region	LOMBARDIA			
City	CREMONA			
	Waste Prevention and Management Guidelines	Action plan guidelines	Regional level	Waste management and production
	S.E.A.P. Sustainable Energy Action Plan (Piano di Azione per l'Energia Sostenibile)	Action Plan	EU level	energy,water,CO2 production
	Air pollution Cooperation protocol & supra-municipal agreement for air pollution	Cooperation tool	Regional level Supra-municipal level	Air pollution
	Historic centre mobility action Plan	Action Plan	Local level	Air pollution - economical development
	Bicycle mobility plan of Cremona	Action Plan	Local level	Air pollution

	Supra-municipal park of Po river & Agreement	Cooperation tool	Regional level Supra-municipal level	Water resource
Region	PIEMONTE			
City	TORINO			
	Regulation for municipal waste management	Regulation tool	Local level	Waste management
	Energy action plan of Torino	Action plan	Eu level	energy/water/CO2 production
	Regulation of water service	Regulation tool	Local level	Water resource
	Municipal action plan: Structural measures to air pollution reduction	Action plan	Local level	Air pollution
	Torino's urban mobility sustainable plan	Strategic action plan	Eu level	Air pollution/CO2 reduction/
	Action plan for tourism in Turin and province	Strategic development plan	Regional- provincial level	Economical development

State	SPAIN			
Region	CATALONIA			
City	SABADELL			
	Name of the Plan/Programme	**Type of plan/ programme/ Tool**	**Legislative Framework**	**Type of flow/resource**
	Waste Plan (draft)	Strategic action plan	Autonomous community level	Urban waste
	Agenda 21+10 Sabadell	Action Programme	EU level	Energy / Water / GHG emissions / CO2 production
	Pla D'acció Per L'energia Sostenible (Sustainable Energy Action Plan) 2016-2020	Action Plan	EU level	Energy / GHG emissions / CO2 production
	Estratègia Municipal per a la Mitigació del Canvi Climàtic de Sabadell (Sabadell Municipal Strategy for Climate Change Mitigation 2008-2012)	Strategic action plan	EU level	Energy / Water / GHG emissions / CO2 production
	Estratègia de desenvolupament Urbà Sostenible i Integrat (Sustainable and Integrated Development Strategy)	Strategic action plan	Local level	Energy / Water / GHG emissions / CO2 production
	Pla de Mobilitat Urbana de Sabadell (Mobility plan of Sabadell)	Strategic action plan	EU Level	GHG emissions / CO2 production

	Pla Especial de Desenvolupament i millora del parc agrari de Sabadell (Agricultural Sector Strategic Development Plan)	Sectorial plan	Local level	Food production and consumption
	Ordenança Reguladora De La Neteja Pública I De La Gestió Dels Residus De Sabadell (Regulating ordinance of public cleaning and waste management of Sabadell)	Regulating tool	Local level	Water / Urban waste
	Taxa Per La Prestació Dels Serveis De Prevenció I Gestió Dels Residus Municipals I Assimilats A Aquests (Services for the prevention and management of waste tax)	Financial Tool	Local level	Urban waste
	Ordenança reguladora dels usos i l'estalvi d'aigua a Sabadell (regulating ordinance for use and saving of water in Sabadell)	Regulating tool	Local level	Water
	Ordenança Municipal D'abocaments A La Xarxa De Clavegueram (Municipal Ordinance for the use of sewage network	Regulating tool	Local level	Residual Water
City	MANRESA			
	Pla D'acció Per L'energia Sostenible (Sustainable Energy Action Plan)	Action Plan	EU level	Energy / Water / GHG emissions / CO2 production
	Pla De Mobilitat De Manresa (Manresa Mobility Plan)	Strategic action Plan	EU level	GHG emissions / CO2 production
	Pacte De Ciutat 2015-2019 (City Agreement 2015-2019)	Development strategic plan	Local level- political mandate	-

	Pla Director Manresa 2022 (Touristic development Plan Manresa 2022)	Development strategic plan	Local level	Economical development
	Pla Industrial Del Bages (Industrial Plan Of Bages County)	Industrial sector development	Autonomous community level	Industrial Waste/ Energy consumption / Water
	International expansion strategic plan 2015 - 2022 (Plan de projecció exterior de Manresa)	Strategic Plan for innovation	EU Level	Economical development
	Proposal for a Green belt Strategic Plan 2017-2020	Strategic action Plan	Local level	Food Production and consumption
State	PORTUGAL			
Region	LEIRIA REGION			
City	LEIRIA			
	Name of the Plan/Programme	**Type of plan/ programme/ Tool**	**Legislative Framework**	**Type of flow/resource**
	PAPERSU 2020 – Multi-council system	Action Programme	Supra-municipal level	WP&M
	Regulation of urban waste	Regulation tool	Local level	Waste management
	Municipal strategy to the Climatic Changes (EMAAC)	Strategic action plan	Eu level	Climate change
	Strategic Plan for Mobility and Transport (draft)	Strategic action plan	Local level	Air pollution

State	ROMANIA			
Region	BUCHAREST REGION			
City	BUCHAREST			
	Name of the Plan/Programme	**Type of plan/ programme/ Tool**	**Legislative Framework**	**Type of flow/resource**
	Medium and long-term development and operation Strategy of public sanitation in the City of Bucharest	Strategic action plan	EU level	Waste management
	Integrated air quality plan for the city of Bucharest	Action Plan	EU level	Air pollution
	Project of Municipal Waste Treatment plant and Incineration Plant in Bucharest	Waste management facilities project	EU level	Waste treatment/ energy production
	Local Environmental Action Plan (LEAP)	Action Plan	EU level	Air/water/ energy

11.4 Annex D - Transcription of the Stakeholders consultation processes

Transcription are covered by the data protection law and cannot be published here. Please contact the project coordinator for further details.