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Systems Thinking Applied to Municipal Solid Waste Management: A Case Study of Italy

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Masters in Social Studies of the Environment and Sustainability

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CIÊNCIAS SOCIAIS
E HUMANAS

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Abstract

Municipal solid waste management is a complex issue that can be described as a ‘wicked problem’, due to the interconnections of environmental, economic, technological and social aspects. Simple solutions that don’t address the complexity of the system remain a significant hurdle in the development of sustainable waste management. This study aims at identifying and understanding the problem of municipal solid waste management through a system thinking perspective and addresses the role of collaboration in its management. It identifies the main processes and dynamics within waste management and how these interactions affect collaboration efforts. Italy is used as a case study, where stakeholders that represent the system are interviewed and the data is analysed through coding from a system thinking perspective. The findings suggest that systems thinking is effective in creating a comprehensive understanding of a complex problem such as waste management. By mapping out its flows, stocks, variables and complex dynamics, system thinking offers a clearer picture of the ‘wicked problem’, highlighting potential solutions, such as multilevel governance approaches and systemic collaboration. These insights offer long term solutions to the complex problem of waste management, not only for Italy but for other nations pursuing Circular Economy and sustainable development goals.

Key words: Municipal Solid Waste Management, System Thinking, Wicked Problems, Systemic collaboration

Resumo

A gestão de resíduos sólidos urbanos é uma questão complexa que pode ser descrita como um '*wicked problem*', devido às interconexões entre os aspectos ambientais, econômicos, tecnológicos e sociais. Soluções simples que não abordam a complexidade do sistema continuam a ser um obstáculo significativo para o desenvolvimento de uma gestão sustentável de resíduos. Este estudo tem como objetivo identificar e compreender o problema da gestão de resíduos sólidos urbanos a partir de uma perspectiva de *system thinking* e aborda o papel da colaboração em sua gestão. São identificados os principais processos e dinâmicas da gestão de resíduos e como essas interações afetam os esforços de colaboração. A Itália é utilizada como estudo de caso, onde foram entrevistadas partes interessadas que representam o sistema, e os dados foram analisados através de codificação sob uma perspectiva de *system thinking*. Os resultados sugerem que *system thinking* é eficaz em criar uma compreensão abrangente de um problema complexo, como a gestão de resíduos. Ao mapear seus fluxos, estoques, variáveis e dinâmicas complexas, o *system thinking* oferece uma visão mais clara do '*wicked problem*', destacando possíveis soluções, como abordagens de governança multinível e colaboração sistêmica. Esses insights oferecem soluções de longo prazo para o problema complexo da gestão de resíduos, não apenas para a Itália, mas também para outros países que buscam alcançar objetivos de Economia Circular e de desenvolvimento sustentável.

Palavras-chave: Gestão de Resíduos Sólidos Urbanos, *System Thinking*, *Wicked Problems*, Colaboração Sistêmica

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Acronym Glossary

CE- Circular Economy

EU - European Union

ISPRA- Italian Institute for Environmental Protection and Research

ISWM- Integrated Solid Waste Management

MSWM - Municipal Solid Waste Management

PNGR- Italian National Programme for Waste Management

ST - System Thinking

WM – Waste Management

Introduction

Global solid waste production has surged to unprecedented levels, surpassing two billion tons annually. A significant portion of this waste is either incinerated, illegally disposed of at sea, or buried in unregulated landfills (The World Bank, 2022). The United Nations Environment Assembly has officially labelled the current waste situation as a "global crisis" and projections indicate that this crisis will worsen significantly by 2050. The generation of municipal solid waste is anticipated to rise to 3.4 billion tonnes by 2050, based on current consumption and disposal patterns (Walters & Loreiro, 2020).

The rise in the generation of waste can be attributed to rapid urbanization at a scale never seen before, resulting in two consequences: an increase in the usage of resources for manufacturing products which generates higher amounts of waste whenever users discard these products (Chen et al., 2022). In conjunction with the rise of waste amount, there has also been a rise of complexity in the composition of waste, due to the existence of new substances that are difficult to manage in treatment and disposal. Therefore, inadequate handling of waste leads to various consequences to human and animal health, as well as to the environment, due to contamination of soil and water by leachate, methane in the earth, and presence of insects and diseases. Additionally, it increases social unrest as a result of sanitation issues and odor in neighbourhoods (Nanda & Berruti, 2021).

Waste Management (WM) is considered a basic need and is also regarded as a human right (Walters & Loreiro, 2020). Proper waste management and clean cities contribute to the principles of provision of water, shelter and food (United Nations Environment Programme, 2015). Until the 1960s, WM was just the act of disposing waste so that it didn’t pose a threat to human health (Singh, 2014). The first WM models appeared during the 1970s, which were optimization models that concentrated on individual issues, such as vehicle transportation and routes (Morrissey & Browne, 2004). By the 1980s these models further broadened their system contexts to include the Municipal Solid Waste Management (MSWM) at the system level. This meant that they not only focused on individual issues, but also took an interest in how the factors in the system are connected (MacDonald, 1996, as cited in Morrissey & Browne, 2004). In the course of the 1990s, waste planning expanded its scope to the level beyond landfilling and embraced integrated strategies.

Current strategies include prevention of waste at the source through designing out waste, avoiding its generation, and reducing the usage of dangerous substances (Meidl,2021). This change from “waste disposal” to “waste management” and from “waste” to “resources” is part

of the general evolution towards the circular economy. In this case, proper WM is viewed as a key factor for sustainable development, addressing about half of the high-level SDGs (United Nations Environment Programme, 2015). Nevertheless, the above milestones remain shadowed by continued challenges in WM, such as poor infrastructure and resources, lack of prioritization, and social inequities (Walters & Loreiro, 2020).

Challenges involve impact not only on environment, but also on communities and individuals, especially in underserved areas (Walters & Loreiro, 2020). The growing concern for the impact of toxic wastes and pollution has led to what is known as environmental justice, a concept that entails the right of every individual to enjoy a safe and healthy environment (Walters & Loreiro, 2020). According to the environmental justice concept various civil movements have emerged, such as the "Not in My Back Yard" movements in the United States that opposes the establishment of waste facilities (Walters & Loreiro, 2020). These led to many movements across the world, including the Italian movement, whereby postcards of children who succumbed to cancer due to inefficient waste management were sent to the President of the Italian Republic and Pope Francis in order to raise awareness and seek direct intervention (Iengo and Armeiro, 2017, as cited in D'Alisa et al., 2017).

There is also an extricable link between growth of economies and waste amount, related to how products are consumed in society, with the rise of consumption and prevalence of "throw away culture". Therefore, enormous amounts of new waste are entering into the streams. Consequently, even countries with a relatively developed infrastructure for WM face challenges to manage waste sustainably (Singh et al., 2014). In addition, products that have complex material compositions are impossible to categorize and sort, leading to complicated waste treatment processes (Singh et al., 2014). Lack of citizen participation also plays an important role, where poor waste-sorting behaviour among people directly hampers recycling activities (Agovino et al., 2017).

There are also various barriers towards prioritizing WM in policy implementation, and constantly policy interventions fail due to economic reasons or competition with existing approaches (Singh et al., 2014). In addition, not all costs of WM are internalized, where many interactions, cross-scale dynamics and phases of the process are not accounted for. This lack of comprehensive cost accounting reduces the incentive for waste reduction and eco product design (Singh et al., 2014).

Therefore, WM is considered as a wicked problem, because it is composed of parts that are so interconnected that it becomes difficult to identify clear causes or find simple solutions (Salvia et al., 2021). Some of the characteristics that make WM complex are its

multidimensional nature, which involves complex interactions among various stakeholders and contextual factors such as social norms, political influences, and financial resources (Salvia et al., 2021). These complexities call for innovative solutions that transcend reductionist methods, resulting in a holistic view of WM. Systems thinking (ST), a common approach to unravelling complex issues, considers all processes and actors involved, as well as their interactions (Salvia et al., 2021). Addressing the challenges of WM, ST presents a new approach that challenges traditional strategic management.

Systemic cooperation is also significant in this regard and includes all stakeholders, such as waste processors, governmental organizations, non-governmental organizations, and financial institutions (Vasconcelos et al., 2022). In this way, all participants are included in decision-making, which makes collaborative models more likely to use problem-solving or conflict-solving when making a decision. Therefore, this study has the goal of understanding how ST can enhance WM, by identifying processes and dynamics involved, while analysing the role of collaboration.

In order to do so, Italy's MSWM system is used as a case study, because of its unique qualities, since unlike other countries that have a constant waste problem, Italy is a developed country with high standards especially because of its membership to the European Union (EU). However, Italy has certain cultural and social indicators that reveal regional inequities and 'hotspots' of waste issues (D'Alisa et al., 2017). Known as a wicked problem, WM in the Italian context is a complex phenomenon threatening health of citizens through inefficient management, and further complicated by the lack of emphasis from governments.

Consequently, this study explores the role of ST in addressing the complex challenges of WM, highlighting the importance of collaborative approaches. In the first chapter, the literature review defines ST, WM processes, and collaborative methods. Afterward, a brief review of the Italian case is made in order to illustrate the context of MSWM and the relations among the social, technological, economic, and governance aspects. This iss followed by the development of themes based from interviews conducted with stakeholders of the Italian MSWM. The study concludes with a discussion of the findings and their implications, as well as recommendations for future policies.

CHAPTER 1

Literature Review

1.1. Theoretical Lens: System Thinking

1.1.1. Systems and System thinking

It is undeniable that intricate systems are rapidly expanding and emerging, with globalization playing a significant role in making systems more interconnected. These systems feed into each other to produce highly intricate and unpredictable consequences. Put simply, systems are groups or combinations of interrelated, interdependent, or interacting elements forming collective entities and ST is a skill set or lens used to detangle and understand complex webs of systems (Arnold & Wade, 2015). With the growth of systems worldwide there is a need for system thinkers and "this need stretches far beyond the science and engineering disciplines, encompassing, in truth, every aspect of life" (Arnold & Wade, 2015, p.670).

In the 1920s, organizational scholars contributed greatly to the creation of ST. Organizational strategy and ST were a seamless match as experts regarded organizations as 'organisms' that change in response to their environments (Dooley, 1997, as cited in Grewatsch et al., 2023). Albeit introduced with much enthusiasm, ST did not embed itself within the wider landscape of management research; more specifically, it did not become an important domain in the field of strategic management research. Over time, ST was viewed as a paradigm, belief system, methodology, viewpoint, and a theory (Grewatsch et al., 2023).

ST aimed as a theory to incorporate all sciences, substituting the classical mechanic worldview. As it failed to give casual explanations, ST as a paradigm was developed, presenting assumptions that gave meaning to the world, forming knowledge and uniting interdisciplinary practices. As a belief framework ST changes behaviors and thought patterns, bringing about desired transformations. Indeed, this is how ST explains the issue of theory and practice in a precise manner. It is not about analyzing the world as a system, it is about taking affirmative actions before that system and inquiring about those constructive and realizable activities (Checkland and Scholes, 1990, as cited in Grewatsch et al., 2023). As for the last, but not least perspective, ST as a research method, it is strategically designed to concentrate on particular research levels of investigation. According to Grewatsch et al., (2023), there are various perspectives of ST that include system dynamics (Forrester, 1994; Sterman, 1994), multi-level analysis (Hitt et al., 2007) and historical socio-technical analysis (Geels, 2004).

As a belief framework, ST influences behaviour and mental models, which changes actions and attitudes, thus causing systematic changes (Grewatsch et al., 2023). Like this, ST as a perspective involves both theory and practice to tackle problems effectively. It not only looks at the world as a system but attempts to intervene in this system in order to figure out what actions are desirable and achievable (Checkland and Scholes, 1990, as cited in Grewatsch et al., 2023). Finally, there is ST as a research method, that encompasses multiple levels in order to grasp large scale issues. According to Grewatsch et al., (2023), ST has several streams, including system dynamics (Forrester, 1994; Sterman, 1994), multi-level analysis (Hitt et al., 2007), and historical socio-technical analysis (Geels, 2004).

Despite different interpretations of ST, Grewatsch et al., (2023) provides some core principles: in line with its determinant worldview, ST believes that the world is a web of relationships and networks. In addition, systems are permeable and engage with other systems resulting in patterns of behaviours and systemic change. Consequently, the goal of ST is to determine how constituents form a collective whole. ST frames the world as a set of feedback loops or control mechanisms, through circular arrangements of casual connections (Meadows, 2008 cited in Grewatsch et al., 2023). These systems are hierarchical and divided along higher hierarchies, for instance social norms and laws; they respond slowly, but rapidly emerging lower hierarchy systems, often firms or individuals, can modify those upper levels. The requirement for ST includes the identification and depiction of system dynamics, in which behaviour is emergent as components constantly adapt and learn from experience (Grewatsch et al., 2023).

Arnold & Wade (2015) propose a new definition of ST, where they analyse ST as a system itself. This definition includes (1) interconnections, (2) feedback loops and how they impact system behaviour, (3) understanding system structure, (4) differentiating types of stocks, flows and variables (stocks being any type of resource such as physical, like fishes in a bucket, or emotional, like trust; flows being the changes in these levels; and variables the changeable parts of the system that affect stocks and flow), (5) identifying and understanding non-linear relationships, (6) understanding dynamic behaviour, (7) reducing complexity by modelling systems, such as reduction, transformation, abstraction, and homogenization and finally (8) understanding systems at different scales. The authors consider that all these elements work in a feedback loop system and claim that this is a complete definition of ST to be used in educational efforts and systems sciences.

Mirzaie Daryani et al., (2012), have raised the idea of ST as one of the organizational theories and management systems that expand beyond traditional paradigms in terms of

feedback, complexity management, chaos theory, and environmentalism. The theories of ST include contingency theories, dynamic capabilities, and open systems. The development of Von Bertalanffy's open systems theory in the biological sciences in 1968 recognized that any living entity can only survive if it is capable of exchanging materials with its environment, that is, as an open system (Zarghami, 2024). This particular theory has been used in management as well as in other fields. The basic concept of the theory is that a system has three dimensions: the components of the system, the interaction between such components, and the environment (Zarghami, 2024).

Additionally, contingency theories in organizations evidence the importance of the environment, especially the different environments in which organizations are located. Hence, as per the theory the best management will be contingent with the environment and situation. According to Lawrence & Lorsch (1967), there is not one best solution that can be applied to all. Alternatively, dynamic capabilities represent an organization's ability to discern what it is capable of doing and the effectiveness with which it can enact changes, especially in requiring that changes in one sector conform to the overall system, functioning as a healthy organism (Teece, 2018).

In climate studies, ST encourages scholars to expand their view, analysing behaviours in a longer time horizon, as well as their feedback effects and delayed outcomes, instead of short-term effects. Exploring process characteristics, instead of solely measuring outcomes, which entails considering a broader spectrum of variables, including values, identity, and beliefs. These aspects, often overlooked in strategic models, are essential for gaining deeper insights (Meadows, 2008, as cited in Grewatsch et al.,2023).

1.1.2. Systems Thinking in Sustainability

The enhanced understanding of sustainability management requires researchers to have a multidisciplinary systemic perspective which helps them understand complex interactions of the economic, political, social, and environmental systems across various temporal and spatial settings (Williams et al., 2017). As highlighted by Meidl (2021), a comprehensive understanding of the impact on the overall system and of any potential risk shifting is needed before an action, policy, or product is deemed sustainable. Through the application of ST to sustainability management researchers may be able to "identify the points at which a system is capable of accepting positive change and the points where it is vulnerable" (Holling, 2001, p. 392, as cited in Williams et al., 2017).

In Williams et al. (2017) study, a literature review was conducted pertaining to ST in sustainability management. According to the authors between 1990 and 2000 few articles were published averaging less than one article per year, but since 2000 the numbers grew considerably, and in their review of 96 articles 67 were from after 2010. The authors present core theoretical concepts that have been used to understand sustainability from a ST perspective: interconnections, feedback loops, adaptive capacity (which is the ability of actors to maintain structure and resilience), emergence (when something new appears in the system that arise due to interaction of system variables), and self-organization, which is the ability of a system to structure itself (Williams et al., 2017).

According to Meidl (2021), ST challenges the traditional systematic approach to management and policymaking, wherein systems are dissected into constituent components and analysed in isolation. This approach, when applied to sustainability, tends to oversimplify the complexities inherent in holistic systems. Consequently, the adoption of a limited perspective on sustainability hampers the attainment of systemic equilibrium, focusing solely on individual parts can inadvertently transfer risks elsewhere in the system, resulting in unsustainable and undesirable outcomes. Understanding the behaviours and dynamics of systems is complex due to interconnections that are constantly changing and emerging, which can lead to difficulty in decision making, making ST essential.

As mentioned above, ST offers a different paradigm, challenging the notion that research can only investigate parts of the system, it also challenges concepts such as unlimited growth and endless resources. ST is essential to deal with complex problems, not giving simple and short-term solutions, it seeks for significant solutions. As stated by Grewatsch et al., “with the rise of oceans, loss of natural resources and extinction of species, the stakes become too high to continue with strategy management research as usual” (2023, p.729).

1.1.3. Systems thinking in Waste Management

ST focuses especially on participatory methods and can be very effective at solving complex problems, particularly those beset by disagreements over perceptions (Vennix 1999, as cited in Salvia et al., 2021). In situations involving wicked problems such as heightened inequity and accumulation of waste, complex components are linked and, as a result, it is hard to identify a specific cause or effect (Grewatsch et al., 2023). The nature of waste generation and treatment constitutes a wicked problem, because it involves several systems where the formulation of the problem is contingent upon interactions among numerous participants, and insight into the challenges relies on external aspects such as social expectations, political processes, and

financial resources (Salvia et al., 2021). Thus, the elaborate interactive networks between stakeholders and systems characterize WM as a wicked problem, which seems unredeemable due to its complexity, social dynamics, and what appears to be an endless nature (Churchman, 1967; Rittel and Webber, 1973, as cited in Salvia, 2021).

To address wicked problems, scholars need to recognise that they "have no definite boundaries, exhibit non-linear dynamics, and require new ways of thinking" (Grewatsch et al., 2023, p. 722). Grewatsch et al. (2023) argues that when addressing wicked problems, many strategists try to reduce complexity and observe isolated variables, which is not effective because it takes the problem out of its context. There is a necessity to examine the larger context, an example would be firm-enforced emissions reduction practices; such strategies seem reasonable for each individual enterprise, but the accumulated emissions from all firms may surpass the prescribed limits, thus requiring a systems level solution.

Several investigations reveal the necessity of using ST to understand WM dynamics. This is the case of Salvia et al. (2021), a study that was conducted in Kisumu, Kenya, which shows that enacting ST requires attention to not only organizational processes, but also inter-stakeholder communication and procedures. In addition, scholars have underscored the importance of comprehensive and integrated approaches to WM that consider social, economic and environmental dimensions. Therefore, while WM strategies often excel in technical and environmental realms, they frequently fall short in achieving social acceptance (Falcone & de Rosa, 2020).

1.2. Waste Management

1.2.1. Waste Management Framework

The primary focus of WM literature is on balancing the protection of the environment and the conservation of natural resources (Gharfalkar et al., 2015). WM studies and policies are shifting toward new challenges, with a growing understanding of WM as more than just a technical problem, broadening to include non-engineering fields and the public. Increased attention towards resource recovery and recycling has prompted scholars, policymakers, and even industries to consider new approaches (Vergara & Tchobanoglous, 2012). Information exchange between the design process, production, and WM systems has increased, shifting the focus from 'end-of-pipe' to systems-oriented resource management, by preventing waste generation and ensuring sustainable treatment (Singh et al., 2014).

The operational, technological, and institutional progress in WM can be divided into two parts: the initial 'end-of-pipe' treatment from the 1960s to the 1980s, which sought only to

dispose of waste, and the most recent systems-oriented process (Singh et al., 2014). Since the 1990s, the focus has shifted to environmental concerns, which was when the waste hierarchy was born. According to the EU directive 2008/98/EC, the waste hierarchy follows this order: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g., energy recovery; and (e) disposal. The hierarchy has served as a fundamental principle in sustainable WM, prioritizing the preservation of resource value for as extended a period as feasible and maximizing the use of products (Abila & Kantola, 2019). Many developed countries have incorporated the waste hierarchy into their frameworks, including the European countries and Japan where the strategies serve the purpose of environmental conservation. However, in developing countries there seems to be an absence of a consensual implementation of the waste hierarchy, tending to be country-specific rather than regional (Abila & Kantola, 2019).

In the 2010s, the waste hierarchy was criticized for its lack of scientific basis, its difficulty to be implemented, and its failure to account for specific local situations (Vergara & Tchobanoglous, 2012). Another weakness noted in the waste hierarchy include the absence of guidance on trade-offs and the social, environmental, and economic consequences for a local economy (Meidl, 2021). The established waste hierarchy was criticized because it did not conceptualise circularity, novelties, or ST at all when it was created (Meidl, 2021).

New paradigms surged, including industrial ecology, design thinking, Integrated Solid Waste Management (ISWM), and circular economy (CE). Industrial ecology advocates for WM systems modelled after natural systems, presenting them as the most viable and sustainable option. Furthermore, waste scholars and policymakers have increasingly identified the importance of design, in which manufacturers have a key role in designing durable goods, that minimize or eliminate the use of hazardous substances and decrease overall energy consumption (Vergara & Tchobanoglous, 2012). Another new approach is ISWM, "considered 'integrated' because it advocates a holistic view that includes all waste flows in society and aims to control all its resulting solid, liquid, and gaseous emissions" (Vergara & Tchobanoglous, 2012, p.280). Different from the waste hierarchy, ISWM offers principles which allow locals to develop their system according to their context, this paradigm has been widely adopted, including in directives of the EU (Vergara & Tchobanoglous, 2012).

A promising innovative paradigm is Circular Economy (CE), a concept introduced by the Ellen MacArthur Foundation and promoted by the EU (Meidl, 2021). Its objective is to interrupt the current linear economy by encouraging a system renovation that eliminates waste, increases resource efficiency, and decouples growth from the consumption of resources (Meidl, 2021). The ultimate goal is to achieve a regenerative circular system where social, environmental, and

economic value is maximized over time. In summary, CE provides an economic system with a flow model that is cyclical and no longer wastes resources (Meidl, 2021).

Therefore, unlike the waste hierarchy, the goal is not to effectively manage waste but to eliminate waste altogether. However, Meidl (2021) highlights that circularity per se does not guarantee positive social, environmental, and economic performance; in other words, circularity does not automatically result in sustainability. The author argues that there is a need to assess WM through the lens of systems sustainability, where strategies are consistently measured against their linear counterparts, applying a holistic approach that avoids unintended externalities (Meidl, 2021).

1.2.2. Waste Management processes

To have a complete picture of the problem, it is necessary to comprehend the general waste management processes. This section summarises important aspects like generation, collection, treatment, policies and challenges. integrating findings from important research works in the field.

Waste Generation

Waste generation varies deeply depending on the region and it is affected by different factors, such as population, socioeconomic development index, income level and climate of the region (Singh et al., 2014). Generally, the greater the economic prosperity, the greater the amount of waste produced. The composition of solid waste also varies according to societies. Industrialized societies tend to dispose more waste, which mostly consists of recyclable material or electronics, while industrializing societies discard less and contain a higher proportion of biodegradable components in their waste (Singh et al., 2014). Barles (2014) argues that waste mirrors the society that has produced it and their relationship with the environment and the resources they mobilize.

They are various types of waste, according to Dermibas (2011), a common classification is: (1) domestic waste, (2) commercial waste, (3) ashes, (4) animal waste, (5) biomedical waste, (6) construction waste, (7) industrial solid waste, (8) sewer, (9) biodegradable waste, (10) non-biodegradable waste, and (11) hazardous waste (Demirbas, 2011). However, waste classification extends beyond a mere list and is subject to variations based on country-specific legislation. One of the most important and most studied waste streams is municipal solid waste, since it is the waste that citizens have the most contact with, and its management is considered the responsibility of politicians and local government (Amasuomo and Baird, 2016). In the EU's

Landfill Directive, municipal solid waste is defined as 'waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households' (EU, 1999).

Waste Collection and Transport

Waste collection and transportation plays a crucial role in WM (Zhong et al., 2023). Research proves that urban regions are more organized, since they have better structures and funds in contrast to rural regions, that deal with poor infrastructure and scarce funds (Zhong et al., 2023). In addition, in recent years WM technology indicate a notable improvement in collection, with a shift away from monocultural WM systems towards multi-material collection system, designed to collect multiple types of recyclable materials together, either through curb side pickup or designated containers (Cossu & Massi, 2013).

Waste treatment and disposal

Various methods are used in different regions for waste treatment and disposal, each with their own environment and health risks. Literature highlights that waste prevention and recycling should come before any waste treatment technology, including Anaerobic Digestion, Waste to Energy, Pyrolysis, Gasification, or even the energy generated all through the process (Gharfalkar et al., 2015; Meidl, 2021). When assessing the performance of treatments, waste to energy approaches are shown to have a superior performance compared to mechanical biological treatment, considering criteria of both the environment and economy, as well as generating job opportunities and reducing greenhouse gas emissions (Parveen et al., 2024). Yet, incineration, the most typical waste-to-energy technology employed, emits numerous greenhouse gases, harming both the environment and human and animal health (Abila & Kantola, 2019). Therefore, the best option for environmental sustainability is to decrease waste admission to incineration and to boost source separation and biological treatment (Istrate et al., 2021).

1.2.3. Waste Management Policy and Governance

Creating efficient, sustainable, and transparent WM policies depends on effective governance. Wilts et al. (2016) point out some important tools for boosting efficiency in WM, such as waste targets to improve resource efficiency, eco-design of products that prioritize repairability and longevity, and increasing the producer's responsibility to the post-consumer life cycle of their products. The interconnectedness of global trade and waste production requires a necessary global system approach for WM (Singh et. al., 2014). This method supports a complete insight

into the global WM systems, which calls for a united vision on a worldwide scale because of global supply chains. Additionally, WM practices should effectively integrate local contexts, reflecting particular cultural and economic parameters. This illustrates the need for local solutions instead of generic solutions for all environments (Vergara & Tchobanoglous, 2012).

A variety of regions have proven to have effective WM practices through inventive governance methods. Silva et al. (2017) demonstrates the case of Flanders in Belgium, as it is one of the most successful areas in the EU for separate collection and recycling. This result stemmed from the use of Transition Management where the government became proactive in network building, leveraging a multi-actor model, and encouraging learning and experimentation. The reinterpretation of governance shifted from the standard waste three tier model (government, households, waste company) to a multi-level and multi-actor governance structure. As a result, the transition motivated inclusive innovative thinking, supported by participatory methods that encouraged knowledge sharing and the emergence of new industrial systems, where an altered societal mentality was apparent with a spike in home composting and effective re-use of collected items (Silva et al., 2017).

1.2.4. Challenges in Waste Management

Despite the shift towards a CE and the implementation of measures under directives established by the EU, WM still needs further enhancement. According to the United Nations Environment Programme (2015), landfilling of waste is still the most practised method in handling waste globally. In 2024 the United Nations Environment Programme released again a global outlook on the state of waste management in 2024[1], stating that the situation has not improved since 2015, in fact, they stated that humanity has regressed, producing even more waste and emissions.

Therefore, WM challenges can be classified into four dimensions: governance and policy, economic, technological and social. Governance and policy challenges comprise of highly active informal sectors which reduce the chances of standard control and proper implementation of waste treatment (Singh et al., 2014). Additionally, poor information and limited data on WM causes inadequate planning (such as shortage of landfill space), while limited legislation translates to the provision of low technology (Singh et al., 2014). Alongside, there is a focus on the short-term approaches that do not consider the complexities of WM.

[1] More on the Global Waste Management Outlook 2024 report: https://www.unep.org/resources/global-waste-management-outlook-2024

Additionally, from a technological angle, WM demands constant adaptation, due to the rising complexity of waste. Even nations with developed infrastructure experience difficulties because of ineffective waste sorting and products that are not amenable to recycling, such as those that contain ink and metals (Singh et al., 2014). Therefore, conventional disposal strategies may still be required over a transition period (Ciacci et al., 2016; Zink and Geyer, 2018, as cited in Ghisellini & Ulgiati, 2020).

From an economic point of view, one of the challenges is "throw away" culture that leads to a decrease in the demand for eco designed products. There are also social biases that cause a reluctance to accept reused products from consumer perspectives (Wilts et al., 2016). Another concern is that waste treatment plants are not aligned towards a CE, since they rely on a consistent inflow of waste to maintain their operations. As a result, their focus is not on preventing waste (Greco et al., 2015). Additionally, policies such as extended producer responsibility, have high administrative costs, especially due to product identification.

On the social dimension, one challenge is consumerist behaviour, along with a low willingness to adopt more environmentally sustainable alternatives (Wilts et al., 2016). Also, policies and infrastructure for handling municipal solid waste do not tend to engage in inclusive and participatory methods, and as a consequence, decision making becomes more at risk of failure because citizens are either ill-informed or the decisions are not suited to local conditions (Medayese et al., 2021, as cited in United Nations Environment Programme, 2024).

It is undeniable that the concept of waste and its management has evolved, and waste is nowadays viewed as a valuable resource rather than something discardable (Wilts et al., 2016). This transformation results from increased social awareness, technological progress, political initiatives, and governmental policies. However, the waste crisis remains for the most part unresolved due to insufficient prioritization and a trust in short-term solutions (Ghisellini & Ulgiati, 2020). As a result, new technologies on their own are not adequate; a systemic level change is necessary, involving innovative approaches in technology, organization, society, policies, and financial methods (Wilts et al., 2016).

1.3. Collaborative approaches in Waste Management

Effective WM often requires the involvement and participation of all stakeholders, including waste generators, waste processors, formal and informal agencies, non-governmental organizations, and financial institutions. Joseph (2006) highlights that such inclusive coordination is crucial for successful WM activities. Polzer and Persson (2016) argue that

understanding the different perspectives of societal segments is essential to minimize the risk of group decision-making failures and to resolve conflicts over solid WM. Additionally, the European Framework Directive on Waste (2008/EC) introduced the need for participatory approaches and transparency in waste policy making, including a consultation in each stage of the planning process in order to take informed decisions.

Given the complexity of WM, collaborative approaches have become widely applied. A stream of literature explores the connections between collaborative governance and ecological outcomes (Baudoin and Gittins, 2021, as cited in He et al., 2022). Therefore, collaborative governance is recognized as a powerful concept that can significantly contribute to solving various societal problems, including WM (Fatmawati et al., 2022).

The collaborative stakeholder approach as proposed from collaborative governance entails managing of programs that interface stakeholders externally of the government with a mechanism that advances consensus and directional decision making in a group setting. According to Ansell & Gash (2008), as cited by Dhimas et al. (2022), the criteria for collaborative governance include:

1. Forums initiated by public institutions
2. Inclusion of private sector participants
3. Direct involvement of participants in decision-making
4. Organized structure
5. Decision-making aimed at consensus
6. Focus on public policy or public management

Different types of models for collaboration are available, such as Triple Helix, Quadruple Helix, and Penta Helix models (Dhimas et al., 2022). The Penta Helix model came after the other two combining government, business, academia, NGOs or civil society, and mass media (Hardi, 2020 as cited in Dhimas et al., 2022). The elements include communication conducted face to face, the creation of trust, commitment towards the process, shared understanding and the accomplishment of intermediate goals (Ansell & Gash, 2008 as cited in Dhimas et al., 2022).

According to Ritchie-Dunham (2020), deep collaboration is achieved through three critical elements: the visibility of the feedback loops, the co-ordination across these loops, and the ability to learn and adapt. This can be done only through circular thinking where a multiple actor view creates, recognizes and co-creates the ecosystem implying that all partners in the ecosystem have to win.

One the best examples of co-operative effort relates to brewery solid waste management in Brazil. According to Silva & Morais (2021) stakeholders' responsibilities are established by

their shared values and goals, adjusting priorities, and distributing payoffs fairly. The use of this strategy demonstrated the significance of engaging various stakeholder in shifting to CE, which the authors noted can be adopted in other industries apart from craft breweries. Collaborative governance was also used in the waste banks in Makassar City and Bantaeng Regency (Fatmawati et al., 2022) that engaged institutions from the government, traditional village organizations, businesses and the communities. Highlighting the need to enhance the participation of public and private entities in WM to enhance transparency, awareness and efficiency. However, this study focused on stakeholder communication rather than implementation, making it closer to a participatory approach than effective collaborative governance.

Practical initiatives, such as the UrbanWins project, exemplify the application of ST principles together with collaborative approaches in WM. Their process was designed following the Collaborative Planning Theory, that emphasizes stakeholder engagement and participatory decision-making (Vasconcelos et al., 2022). By involving a diversity of stakeholders, creating constructive dialog and using all relevant information, they created new contacts and partnerships, promoting integration and innovation in WM strategies. This approach is also consistent with ST principles because stakeholders are interconnected, and such collection action is required to manage the issues under consideration.

Most of the research mentions collaboration in WM, but these issues are in the context of participatory approaches, including stakeholder participation but are more oriented to feedback rather than shared responsibilities and contributions. Additionally, few studies analyse WM on a national scale, with most focusing on specific types of waste (He et al., 2022), cities or small regions (Fatmawati et al., 2022), or specific sectors or companies (Silva & Morais, 2021). Therefore, its application in solid WM applied nationwide requires more exploration.

CHAPTER 2

Methodology

As mentioned in the previous chapter, with the increasing concern towards environmental problems and sustainability, new trends began to prevail in WM. These suggest that the subject is a multilayered phenomenon characterized by the entangled dynamics of cultural, economic, political, and technologies. This complex problem requires a new way of thinking, which justifies the adoption of ST in this study. This lens is appropriate to provide a holistic understanding of the situation, to track the flow of information and resources, as well as to help create a common understanding and promote collaborative approaches. It is also relevant to the present shift to CE, for new paradigms demand new strategies that might provide new answers. In light of this, this research aims at finding out how the ST approach can help to achieve appropriate WM by revealing the various dynamics and stages that come with it.

In light of this, this research aims at finding out how the ST approach can help to achieve appropriate WM by revealing the various dynamics and stages that come with it.The questions the study seeks to answer are: How can systems thinking approach support WM? What are the main processes involved in WM as a complex issue? What is the role of collaboration in managing waste as a complex issue?

Italy's MSWM system is used as a case study. The analysis covers the period from 2008, a significant time marked by extensive international coverage highlighting the WM crisis in the Campania region, until 2022, the most recent year for which data is available. While Falcone et al. (2020) conducted a study on the WM system in Italy using a movements lens, this study, on the other hand, adopts a ST lens. According to literature review, studies that adopt a ST in WM are limited. The literature available concerning Italy is primarily dedicated to the Campanian area of Italy. As a result, this study seeks to offer a systemic and interactive view of MSWM in all of its aspects in Italy and also looks for new trends regarding cooperation.

This study is qualitative and employs a case study approach, since it aims to achieve a detailed and comprehensive analysis of a specific context, focusing on complex systems and real-world phenomena. It also assumes a relativist ontology, excluding the possibility of one true construction. As stated by Rashid et al. (2019, p.3), "how we interpret the world belongs both to what is interpreted and to a system of interpretation". Therefore, it recognizes the importance of multiple perspectives and interpretations in understanding the complexities of WM and collaboration. It also proposes an abduction approach since the work tries to explain a phenomenon based on the lens of social actors.

To address the research questions, the empirical analysis addresses the Italian WM System in the case study section, identifying the processes and characteristics of the system. Followed by a casual loop diagram that highlights the dynamics and interconnections, giving a clear picture of the feedback loops and complexities involved. Subsequently, interviews with system representatives are analysed to identify MSWM processes, collaboration initiatives, and barriers, as well as model of the system is presented.

2.1. Data collection

Primary qualitative data was collected through semi-structured interviews with stakeholders and experts of the MSWM field in Italy. The semi-structure interviews allowed more flexibility during the interviews and adaption towards the study's goals. The interview focused on identifying signs of ST, open system thinking, as well as understanding the processes and dynamics of MSWM and collaboration efforts. Secondary data was also used such as quantitative data from annual waste report provided by the Italian Institute for Environmental Protection and Research (ISPRA), official government reports, legislation and other documents.

Participants Selection

A list of important stakeholders was created based on Caniato et al.'s (2014) study, which identified five stakeholder groups: government authorities, the public sector, academia, civil society, and others. However, it became clear that these actors could not be neatly categorized, as many hybrid organizations in Italy are both public and private. An initial draft of stakeholders was made using these categories and was later reviewed by two specialists in Italian WM. These specialists helped identify specific actors and provided their contact information.

Stakeholders were contacted mainly via email, with some exceptions being contacted via LinkedIn or phone calls. In total twelve stakeholders were contacted and seven responded and were interviewed. Among these seven respondents, there were two researchers: one focused on the technical aspects of WM (interviewee 1) and the other on social movements (interviewee 2). Additionally, one respondent represented a private WM company in northern Italy (interviewee 3), another represented a private consortium managing end-of-life packages (interviewee 4), one represented a company that works with both private and public WM entities (interviewee 5), one is a director of an environmental organization in Italy (interviewee 6), and the final stakeholder was a regional environmental public entity (interviewee 7), as can be seen in table 1. Therefore, the interviewed stakeholders represent the private and public sector, as well as civil society and academia.

Interviewee	Role	Focus/Representation
Interviewee 1	Researcher	Technical aspects of WM
Interviewee 2	Researcher	Social Movements
Interviewee 3	Representative of private WM company	Waste Management company
Interviewee 4	Representative of private consortium	End-of-life package management
Interviewee 5	Representative of company working with private/public WM	Works with both private and public WM entities
Interviewee 6	Director of environmental organization	Environmental organization
Interviewee 7	Regional environmental public entity representative	Public entity

Figure 1: Interviewees

Source: Own elaboration

Interview Protocol

The interview protocol was developed based on the Literature Review and can be found in Annex A. There were eight questions in total and since it followed a semi structure, the order of the questions was adjusted according to the flow of the interview and additional queries eventually emerged. The objective of the first question was to recognize the dynamics of systems, which related to ST and system interconnections. The concept originated from literature that emphasizes systems being open and working with other systems, as analysed by Grewatsch et al. (2023), and from the idea of system interconnections discussed by Arnold & Wade (2015). The second question focused on how the external environment impacts the system, related to the Open Systems Theory (Zarghami, 2024). The third question was guided by the framework of Grewatsch et al. (2023), which distinguishes innovation promoters in two levels: upper hierarchy systems including social customs and laws and the lower hierarchy types consisting of firms and individual entities. The goal was to locate the source of innovation

within the Italian WM and identify the interactions between its lower and higher hierarchy systems.

The social element of WM took centre stage in the fourth question, aimed at understanding the importance that stakeholders attach to citizens' roles and their potential impact on WM systems. The fifth query set out to identify flows of trust and the frequency of beliefs (Grewatsch et al., 2023). The sixth question, however, concentrated on initiatives aimed at collaboration, identifying collaboration and looking for signs of a multi governance and multi-level structure for WM in Italy (Silva et al., 2017). The seventh question related to WM as a complex challenge, that is, a wicked problem with weblike connections (Salvia et al., 2021), looking to identify the challenges to implementing effective WM strategies. While the last question sought to identify if interviewees mentioned system solutions instead of focusing only on isolated problems and solutions (Grewatsch et al., 2023).

Interview Process

Interviews were conducted through videoconferencing due to geographic constraints, as well as convenience for the interviewees. Each interview lasted approximately 45 minutes and was recorded with the participants consent; interview questions can be found in Annex A. Recordings were transcribed using artificial intelligence that later was checked and polished to ensure comprehensiveness and integrity, three meetings were conducted in English and four in Italian, that were translated.

Ethical Considerations

All participants were informed of the goals and purposes of the interview and gave consent to sharing information and recording of the interviews. To protect participant identities, all data were anonymized, and pseudonyms were used in the reporting of findings.

Challenges

Challenges included reaching all participants, which proved more difficult with the public sector due to various formalities and lack of responses. In addition, there were some technical issues and some internet connection problems with one of the participants. Despite these challenges, the interviews led to valuable insights, which could benefit in the future of a broader participation of public representatives.

2.2. Data analysis

In order to decipher the collected data, a qualitative framework was used, using content analysis, which allows extracting the essential information from the data collected. Content analysis was also chosen for its effectiveness in managing a wide variety of sources and was considered more suitable than other methods given the relatively small sample size of fewer than 30 informants (Bengtsson, 2016). Additionally, latent analysis was also employed, which differs from manifest analysis, by delving beneath the surface level of the text to uncover underlying meanings, themes, or concepts (Bengtsson, 2016). This approach is in line with the study's aim of examining latent variables such as identifying signs of ST, complex systems and interconnections through interviews with stakeholders.

The transcriptions of the interviews were coded, with the goal of exploring the properties and dimensions of categories, identifying relationships between categories, and uncovering patterns (Zang & Wildemuth, 2005). The coding process followed the steps of the Manual of Coding for Qualitative Researchers written by Saldaña (2021). Consisting of a first cycle of descriptive coding where the transcripts were reviewed highlighting words or even full sentences, followed by a second cycle characterized by a reconfiguration of the codes. After these two cycles of coding, themes were spotted being an outcome of the coding and analytic reflection (Saldaña, 2021). In total there were 130 codes and four main themes, these can be found in Annex B, the codes are descriptive, therefore use the exact words said by the interviewees.

In addition, a casual loop diagram was developed, which is commonly used in ST. It consists of a network of variables and casual influences, that focuses on feedback loops and is usually built around a 'core system engine' (Barbrook-Johnson & Penn, 2022). A casual loop diagram was chosen over other types due to its qualitative nature, in addition to its focus on feedback as a key component and organising structure for complex systems, but at the same time allows the inclusion of all sorts of concepts and variables (Barbrook-Johnson & Penn, 2022).

To build the loop first the variables were extracted and possible connections between them were identified, which lead to the identification of the main variables, and these were written down. Based on this14 variables were identified that are influenced by or influence the cores, later two feedback loops were spotted. Additionally, after the interviews a new diagram was created, following the systems model of the Italian MSWM, it was based solely on the

information provided by the interviewees and sought to follow step 7 of Arnold & Wade's (2015) eights steps of developing ST.

2.3. Limitations

It is desirable to mention several restrictions, despite the fact that this study has been conducted using scientific methods, following all the methodical recommendations, there are some limitations. First, the study encountered issues in ensuring that the interviewed stakeholders were reproducing the perspectives of all the Italian MSWM system, because of difficulties in contacting public entities, as well as some private entities. Therefore, not all of the stakeholders defined at the first stage were included in the investigation.

Second, the use of semi-structured interviews and qualitative coding may create potential bias. Variations in how interviews are conducted and interpreted by different researchers may influence the results. Furthermore, different outcomes may be welcomed or responded to in a positive or negative way depending on which set of stakeholders or people were interviewed and hence may lead to different conclusions. In summary, it can be suggested that all these limitations are typical of most works in the field of qualitative research and it identifies avenues for future investigation.

CHAPTER 3

Case Study: The Italian MSWM

In the transition to a CE within the EU, Italy is a leader in recycling, with an average recycling rate of 68%, compared to the European average of 35%[2]. The achievement results from improved WM infrastructure in correspondence with European directives, emphasizing both mechanical-biological processes and resource recovery. However, regions including Campania are recognized around the world for having serious waste crises, defined by unpleasant aesthetics and, a firmly established link between waste pollution and cancer rates within the local population (Agovino et al., 2021). The peculiar combination of characteristics makes Italy an interesting case for conducting WM analysis through the framework of ST.

This chapter will give an overview of the Italian WM system, focusing on the Municipal Solid Waste Management (MSWM), including its processes and reasons underlying its dualism. Consequently, the following sections of this paper are based on the available literature and discuss the governance, economic, technological, and social aspects of Italian MSWM. It is important to note that while these classifications provide analytical ease and clarity, in practice they are linked together, highlighting the holistic nature of MSWM.

3.1. Governance and Policy in Italian MSWM

Italy's MSWM is constantly evolving due to new frameworks in the EU, marked by a journey toward sustainable practices, where the EU is leading the transition to CE (Chioatto & Sospiro, 2023). This commitment has been done through a unified legal framework, that emphasize the importance of the waste hierarchy principle, as well as prioritization of closing the loop. Key directives such as the Council Directive 1999/31/EC on the landfill of waste, Directive 2008/98/EC (known as the European Waste Framework) and the 2015 CE action plan[3] have been instrumental in shaping WM policies across member states. The CE package proposed the revision of the main EU directives on waste, namely 2008/98/EC (waste), Dir 1999/31/EC

[2] Synthesis report on circular economy in Italy 2022. The report can be found here: https://knowledge4policy.ec.europa.eu/publication/synthesis-report-circular-economy-italy-2022_en

[3] More information on the First Circular economy action plan can be found here: https://environment.ec.europa.eu/topics/circular-economy/first-circular-economy-action-plan_en

(landfill), Dir 94/62/EC (packaging), these last were definitively amended in 2018 with the new directives Dir 2018/851, Dir 2018/850, and Dir 2018/8525.

The latest reform "Circular Economy Action Plan"[4], was adopted in 2020 and introduced initiatives that target the lifecycle of products, focused on preserving EU resources for as long as possible. Building on the 2015 package, the 2020 action plan has as objective to develop CE from an emerging stage to a major economic activity, while also separating economic growth from resource consumption (Popa & Popa, 2021).

In Italy the decree most relevant to WM was the Legislative Decree 22/1997 known as Decree Ronchi, which introduced the recycling of waste and identified role and responsibilities of major stakeholders. The decree was repealed by Decree 152/2006, that shifted out of landfilling for waste treatment and embraced the waste hierarchy. Furthermore, the legislation properly defined different sources of wastes and created specific collection systems for individual waste flows, as well as set recycling rates goals (ISPRA, 2023). The latter was later modified by Decree 205/2010 in order to implement at the national level the requirements of the European Waste Framework Directive of 2008, which in turn characterized the national roles in the context of the Italian WM system. One of the most recent updates is Law 68/2015, which regards to certain aspects of WM for increasing performance, effectiveness and legal conformity to the EU directives.

The Italian MSWM process involves a collaborative effort between regional, provincial, and municipal authorities. Strategies are developed by regional authorities, while procedures of waste collection are within the purview of the provincial authorities. Local government officials act as central organizing and managerial centres, implementing these approaches on the ground. These operations are governed by general legislation and national laws as well as the European directives (Cialani et al., 2020).

The current program for MSWM in Italy is the PNGR (National Program for Management of Waste)[5], part of the green revolution and eco transition in the CE component (ISPRA, 2023). Adopted in 2022, this strategy showcased a new notion for Italian MSWM as it represents the first plan implemented at a national scale. Regarded as a belated action, the plan addresses inequalities in the selective collection and uneven disposal of waste. The intent is to improve

[4] For information can be found here: The EU's new circular action plan paves the way for a cleaner and more competitive Europe, from https://ec.europa.eu/environment/strategy/circular-economy-action-plan_en

[5] More information can be found here: https://www.fao.org/faolex/results/details/en/c/LEX-FAOC213142/#:~:text=The%20National%20Program%20for%20Waste,for%20the%20period%202022%2D2028.

the capabilities of the national system to fulfil self-reliance and improve efficiency. The application of this strategy among the regions and autonomous provinces serves to adjust their plans, unless they are already in compliance or can effectively meet the goals set by European regulations. Consequently, each region has integrated the program into their regional management in its own way—in Piemonte, the main goals, as of 2023, are to achieve separate collection of 82% by 2035 and reduce complex productions, while in Lazio the objectives emphasize increasing material recovery from waste and lessening landfill disposal (ISPRA, 2023). Consequently, PNGR aims to encourage the uniform and coherent development of the MSWM system, while addressing weaknesses and Italian 'hot spots' of MSWM.

In recent years, MSWM has emerged as a top priority in Italy, witnessing a notable upsurge in the rate of selective collection across all regions and for various waste categories. The country managed to achieve one of the EU's targets, that is the selective collection of municipal waste and a 50% recycling rate by 2020. However, there is a discrepancy between Italian regions. For example, according to ISPRA (2020), in 2020, while there were some northern regions, such as Veneto, that had a 76% rate of selective collection, other regions such as Sicily had only 42%, which is below the target established by the EU. The variation observed among regions can be attributed to several factors, including disparities in sorting and waste collection expenses, as well as the diverse policies advocated by local municipalities (Cialani et al., 2020).

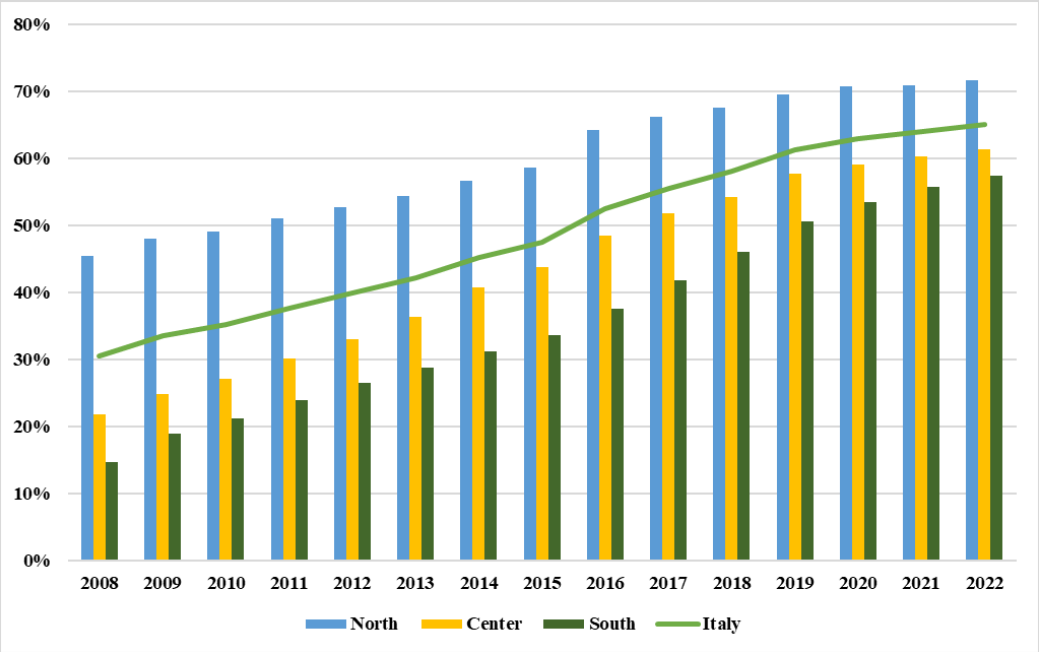


Figure 2: Evolution of separate waste collection in Italy from 2008 to 2022

Source: Own elaboration based on ISPRA, 2023

As can be seen in figure 1, in 2008 the national average of separate waste collection was 31%, and by 2022 this figure more than doubled to 65%. The increase can be attributed to

prioritization, new legislation and European directives. Regional differences can easily be noted, where the Northern region has the highest rates, followed by the central region and the southern regions are at the lower bottom. This pattern shows the stark differences in the social and economic status of the different regions in the country.

Studies by D'Alisa (2010) and Mazzanti & Montini (2014) suggest that one of the reasons for this discrepancy is the decentralized nature of policy making, characterized by a bottom-up approach, which can lead to irregularities and lack of stability. In addition, studies prove that lack of citizen participation and criminal activity in the south have hampered with the effective implementation of Legislative Decree 152/2006 in promoting selective collection (Agovino et al., 2017). Finally, Romano et al. (2021) underscored the relationship between the level of corruption and the degree of effective waste management in urban centres, pointing out that even MSWM cannot escape the effects of sociopolitical vices.

Therefore, the existing literature regarding the Italian MSWM is centred on sociopolitical and policy factors and their impact on the MSWM in Italy. While at the national level most policies have been aligned with the EU policies, there is much that remains to be done in terms of regional equity and institutional development for sustainable MSWM.

3.2. Economic Dimensions of Italian MSWM

In the processes of MSWM policymaking, there is strong focus on the economic perspective, since it enables project viability and acceptance among the population (Wilts et al., 2016). Hence, to gain a better understanding of the economic view of an aspect of MSWM such as costs, financial mechanism, and feasibility of various strategies, it is necessary to conduct a detailed analysis of this dimension. The costs include range of services including cleaning services like sweeping and washing of streets, waste collection and transportation, tariff and user relations, waste treatment and recovery, and disposal of urban waste (ISPRA, 2023). As depicted in the Figure 2, the expenses made in the management of MSWM in Italy have been divided as follows.

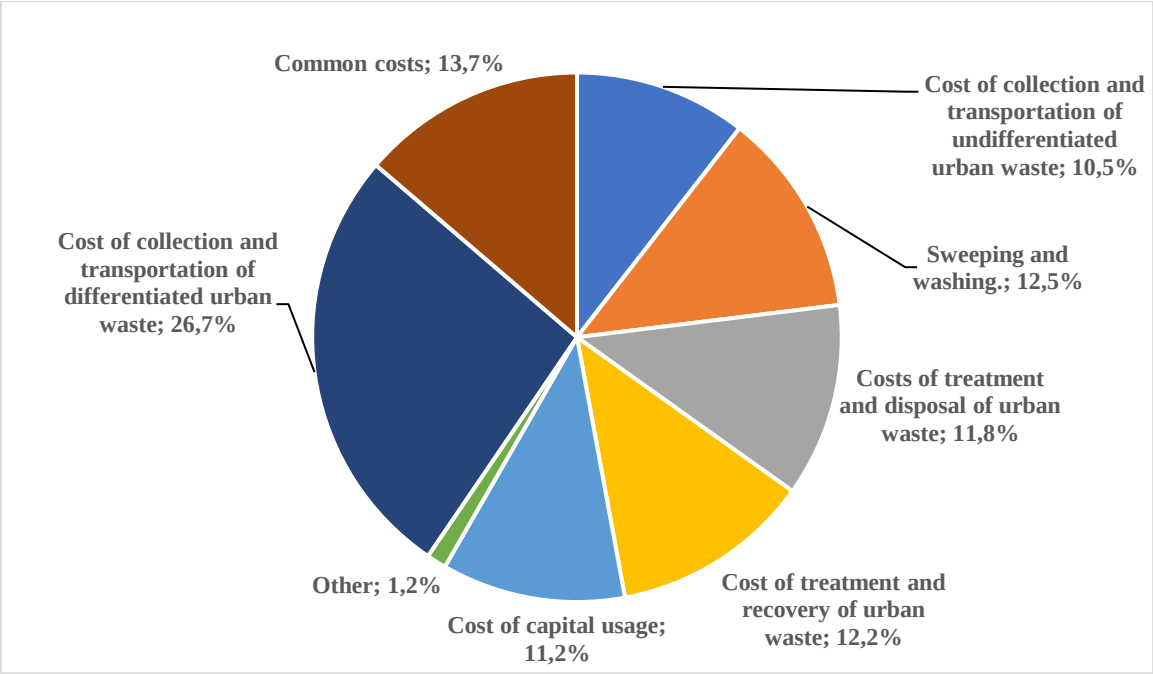


Figure 3. Division of costs of MSWM in Italy 2022

Source: Own elaboration based on ISPRA, 2023

As shown on figure 2, the highest cost in MSWM is related to collection, this varies depending on the municipality's size, population density, characteristics of the area, type/quantity of waste and the technical machineries used in collection and transportation of waste (Greco et al., 2015). A closer look at cost structures and efficiency drivers in MSWM exhibit interesting findings. Cialani et al. (2020) suggest that waste recycling has increasing returns to scale in the municipalities of Italy, which means that there is a highest cost advantage when recycling increases. Conversely, Greco et al. (2015) reveal that undifferentiated waste has the higher cost advantage when the quantity collected increases. Therefore, growing waste production can result in an economic incentive for collection of undifferentiated waste and regions present diseconomies of scales. To overcome these challenges, the authors highlight the need for regulatory stability and infrastructure enhancements to optimize recycling programs.

Moreover, financial instruments have a significant influence on the improvement of MSWM practices (European Environment Agency, 2020). Italy has a wide range of taxes and tariffs, using a nationwide tax on landfilling of residual waste to control the activities in this field. Legislative frameworks empower regional authorities to determine tax rates and develop compensation systems, underscoring the decentralized nature of MSWM governance. At the moment, the regulation of urban waste in Italy is done through TARI, which is calculated

according to the type of property, the area of the property and the number of inhabitants, although each municipality has its own structure and method of calculating this tax. Some of the municipalities apply the Pay-as-you-throw tax, which is about 16,4% of the cities in Italy, out of these 84% are in the north (ISPRA, 2023). If Italy has to meet the European CE goals it has to enhance the number of municipalities that employ Pay-as-you-throw taxes meaning enhancement of technology and infrastructure in the centre and south of Italy.

Another frequent measure to encourage higher rates of separate collection and recycling is taxation on landfilling (European Environment Agency, 2020). Italy established a tax for the landfilling of residual waste, in which individual regions are allowed to set the rate of the tax (European Environment Agency, 2022). Due to Italy's decentralized nature, the more economically developed regions have higher landfill taxes, for example in Veneto and Sardinia the landfill fee is €25.8 per ton, while in Campania it is €10.3 (CEWEP, 2021). The taxation of landfill is managed in these regions with the goal of increasing recycling rates.

Additionally, it is important to note that Italy is now transitioning towards CE. As a country that has scarcity of natural resources and dependence on imports, transition to CE would render the economy more sustainable, competitive and reduce its exposure to the negative effects of its high resource dependency (Ghisellini & Ulgiati, 2020). As mentioned above, Italy leads in recycling rates, with a positive trend in resource productivity over the last decade, being higher than the European average. However, the target of securing the country with intelligent employment of resources available in the national territory remains a distant objective[6].

In view of the foregoing, the economic perspective provides insight into the relationship between the financial factors, legal systems, and performance of MSWM. Recent literature on the economic perspective of MSWM in Italy focuses on the transition to a CE, highlighting that promising perspectives are emerging.

3.3. Technological Innovations in Italian MSWM

The technological view in MSWM is an important factor related to issues affecting the environment and the development of new solutions. This perspective encompasses treatment approaches, innovative technology, and regional disparities, which contribute to the development of a holistic understanding of MSWM in Italy.

[6] Synthesis report on circular economy in Italy 2022. The report can be found here: https://knowledge4policy.ec.europa.eu/publication/synthesis-report-circular-economy-italy-2022_en

Statistics from ISPRA (2023) show that mechanical-biological systems play the leading role in the Italian methods for MSWM, particularly by focusing on biological waste stabilization and their dimensional reduction. These are commonly located close to dump sites or grounds and represent what is referred to as 'treatment platforms'. With reference to the enhancements made to the national system, there is a growing trend toward the greater development of biological treatment technologies that combine floating aerobic treatment and anaerobic digestion, able to provide energy and material recovery, reduce emissions, and exploit purified biogas for energy and biomethane generation (ISPRA, 2023). Incineration is an alternative approach in which the heat generated from the legal burning of waste drives steam that then helps to power turbines. Nevertheless, landfilling is, remarkably, the cheapest method for municipal solid waste management, though it is economical, it is greatly detrimental to the environment, introducing air, soil, and greenhouse gas pollution as well as resource depletion (Demirbas, 2011).

In Italy, there exists a pronounced inequality in the distribution of MSWM infrastructure. Illustrated in figure 3, there's a notable clustering of waste treatment facilities in the northern regions, reflecting the higher level of economic development. Therefore, the north mainly relies on incineration and composting as way of disposal. In the south however the application of these strategies has been impeded due to outdated and potentially hazardous technologies, being of risk to public health. Thus, the southern regions opt for investment in mechanical biological treatment and fuel derived from waste (ISPRA, 2023).

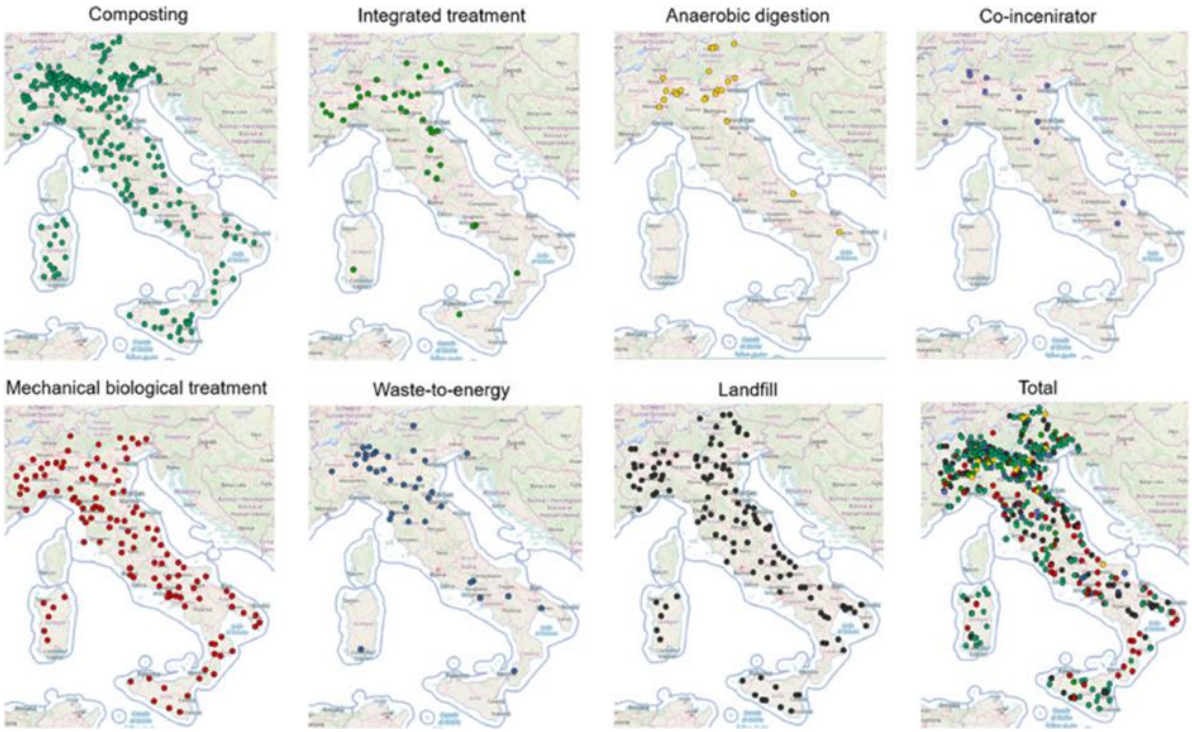


Figure 4: Distribution of waste treatment plants throughout Italy

Source: Di Foggia & Beccarello, 2021

As can be seen in Figure 3, there are still regions that do not have enough facilities, consequently these regions send their waste to be treated elsewhere. This practice is allowed by Legislative Decree 152/2006 which says regions do not have to handle their waste themselves if they do not have the means to do so (ISPRA, 2023). In 2022 there was a slight reduction of waste being sent out, in which the region that most sends out waste is Campania and the largest share of waste for treatment is sent to Veneto (51%), followed by Lombardy (20%) and Emilia-Romagna (9%) (ISPRA, 2023).

The new National MSWM Programme (PNGR) has the goal of building of new treatment/recycling plants for organic waste and the construction of innovative plants for flows and improvement of the network of separate collection. The objective is to increase self-sufficiency by promoting the building of anaerobic digestion plants in underserved areas to produce biogas (ISPRA, 2023).

Therefore, to achieve effective MSWM in Italy, it is imperative to tackle additional political and economic barriers hindering the advancement of technological infrastructure in the southern regions. As has been noted by the national plan, simply transporting waste from one area to another is not a sustainable solution; rather, comprehensive investments are required to address this issue holistically.

3.4. Social Aspects of the Italian MSWM

MSWM practices not only affect the environment, but also communities and individuals, especially in underserved areas (Walters & Loreiro, 2020). The growing awareness of the risks associated with toxic waste disposal and waste pollution has raised concerns about environmental justice, which entails the human right to a safe and healthy environment (Walters & Loreiro, 2020). Scholars adopting an environmental justice framework have extensively covered waste conflicts and toxic disposal in poor and racialized spaces worldwide (Pellow, 2004,2007, as cited in Falcone et al., 2020). Studies have included Italy as part of the Environmental Justice struggles, such as Navas et al. (2018) that analysed the region of Campania, a region characterized, since 2008, as an icon of waste mismanagement in Europe and a case of environmental injustice (Armiero & D'Alisa, 2012, as cited in Falcone et al., 2020).

In 2008, a significant social conflict arose in Campania over MSWM. On one side, the government intervened and began to clean the streets and prioritized MSWM, eventually declaring the end to the MSWM crisis. On the other side, activists went on demonstrating and drawing attention to the fact that years of mismanagement had led to severe health problems among people. This led to a series of confrontations between activists and the state, during which activist movements were criminalized. Falcone et al. (2020) highlight that, since 2008, the activist movements slowly went from being dispersed to transforming into a tightly interconnected network. Consequently, this movement has reached several achievements, such as speeding up the approval of the Law 68/2015 that enriched the Italian penal code with four environmental crimes.

Research also further examined the role of social transmission effects in the understanding of the development of MSWM in society. For example, Crociata et al., (2016) revealed that a positive environment for recycling can lead to positive behaviour change in areas that are less likely to be concerned with the environment. In addition, according to Agovino et al. (2017), lack of citizen participation had an impact of slowing down the effectiveness of the waste regulation. Musella et al. in (2019) showed that in the South of Italy, waste collection is still considered inconvenient and unattractive by the citizens, hence the MSWM authorities have not been able to encourage the required changes of behavior. In the same way, Gastaldi et al. (2020) while in the north of Italy found out that the socio economic demographic such as population density, education, age, employment and income level have a positive relationship with the consumer's willingness in waste reduction and recycling enhancement. Consequently,

the sociopolitical factors that define the level of engagement and participation of the citizens impact MSWM in a very considerable manner, particularly across Italy.

3.5. Casual Loop Diagram of the Italian MSWM System

From a ST perspective and based on the available literature on Italian MSWM, a causal loop diagram was created. This tool helps visualize the interconnections between various elements of the Italian MSWM system. Three main variables were identified that drive the system: MSWM infrastructure, MSWM sorting efficiency, and environmental impact. As shown in Figure 4, additional variables were identified related to governance, economic, technological, and social perspectives. As can be seen in figure 5, two feedback loops were detected: a reinforcing loop (positive) and a balancing loop (negative). The reinforcing loop shows that more community initiatives lead to increased public awareness, which leads to greater citizen participation, thereby resulting in more community initiatives. The next loop is the balancing loop which depicts that government polices foster proper sorting of waste done by the citizens, thereby reducing the need of the role offered by government policies.

All these feedback loops are important in understanding of MSWM as a complex system. They show that choices of the best policies for increasing efficiency of the waste sorting may not start with the waste sorting process. Instead, they can start with the promotion of information for citizen awareness and inclusion, highlighting the interlink between various system variables.

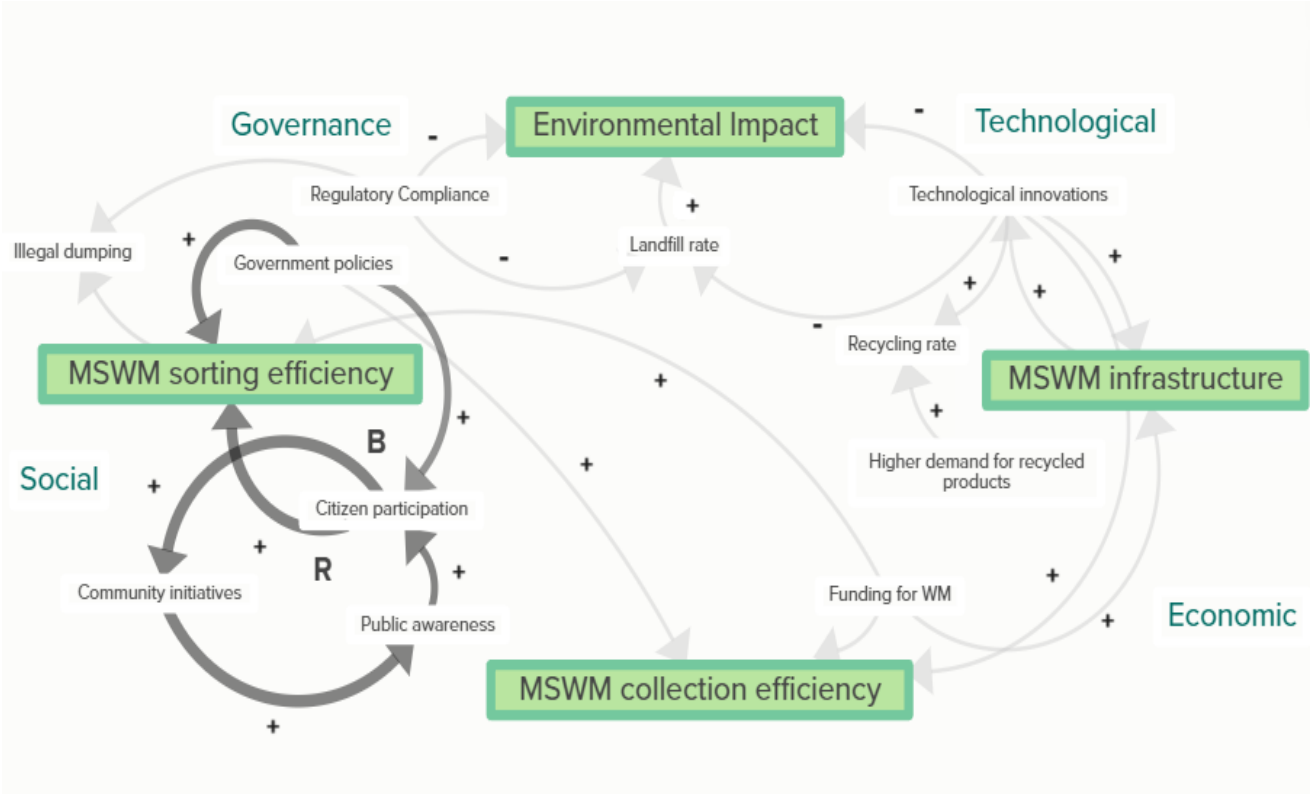


Figure 5: Casual Loop Diagram of the Italian MSWM System

Source: Own elaboration

3.6. Collaborative approaches in Italian MSWM

There are a variety of signs of partnership between the public and private sectors in MSWM in Italy. Many collaborations typically stress the importance of increasing citizen participation via information sharing. In order to meet the EU's recycling objectives, the public sector, which includes ministries, public administration and the waste authority, enacts laws and enforces obedience. During the same period, the private sector, commonly led by CONAI, mobilizes funds and specifies methods for take-back, recycling and recovery (ISPRA, 2023). The management of public information initiatives by CONAI is important for both the preparation and the enablement of citizens to actively participate in waste valorisation[7]. This collaboration has helped to achieve recovery and recycling targets on time and at a cost much lower than the rest of Europe.

Generally, partnerships are oriented toward regional or municipal levels due to the decentralization of MSWM in Italy. As an example, during the Campania crisis of 2008, the stakeholders identified the need for a collaboration supply chain involving local actors. De

Chiara (2015) analysed the development of a network of businesses in Agro Caleno in response to the crisis. The network aimed to promote the growth of the area, together with social progress and preservation of cultural heritage. However, even though there was a good level of cooperation, the network did not meet expected results, because when dealing with complex problems, cross-sector collaboration is not sufficient. For effective MSWM it is not about just cooperation between private and public institutions, "it is necessary to initiate a systematic approach focused on the relationships between different stakeholders and the progression towards shared goals" (De Chiara, 2015, p.88).

Specifically, there is evidence of systemic cooperation in projects such as UrbanWins and Life HIA21 implemented in the cities of Cremona and Arezzo, in Tuscany. These projects encouraged collaborative and participatory approaches through ST, aggregating various parties and stakeholders for the purpose of knowledge sharing and encouraging active participation and support (Vasconcelos et al., 2021; Linzalone et al., 2017). The second illustration is the Valle D'Aosta project which brought together 35 stakeholders and set up partnership for the formulation of a common plan of actions to tackle the issue of wastes and promote proper collection and treatment (Marciano, 2023).

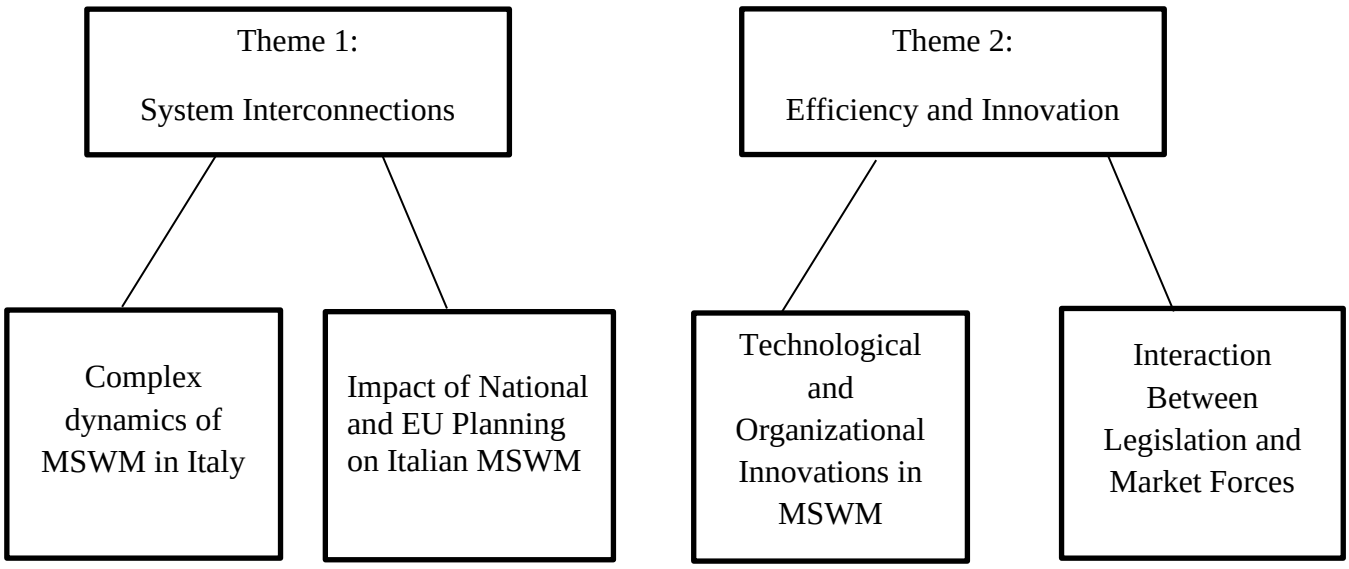
Despite these systemic collaborative approaches helping in the separation of problems, creating ideas for innovation, and needs, these stated ideas have not seen nationwide execution. Investigations and projects concentrated on particular cities and have been successful, suggesting that new approaches are required to tackle Italy's wider MSWM issue.

CHAPTER 4

Analysis of results

The analysis of the transcripts of interviews with representatives of the Italian MSWM revealed several key patterns and themes, as well as diverse perspectives. Common arguments were detected, including public versus private management, hybrid models and collaborations, roles of municipalities, regions and private companies. Signs of ST were identified in all interviews, where interviewees mentioned social, political, economic and technological factors, highlighting the interconnections between these. However, while some interviewees claim to identify flows of trust and true collaboration in the Italian MSWM system, others present scepticism and called for stricter regulations and systemic changes.

Four main themes were detected related to the objective of this study (Figure 5), which constitute the basis of the findings. First, System Interconnections involves the detection of different models of MSWM, dynamics and actors involved, which also includes external factors, highlighting the many systems and complexities. Second, Efficiency and Innovation, the way various innovations affect the efficiency of the MSWM system. Third, Community and Participation, the importance of society's role, as well as citizens trust, was highlighted by all interviewees, some with more optimism, others with more pessimism. Finally, Collaboration Barriers which enumerates typical obstacles that hamper collaboration and the features that are needed for successful cooperation in the MSWM system.



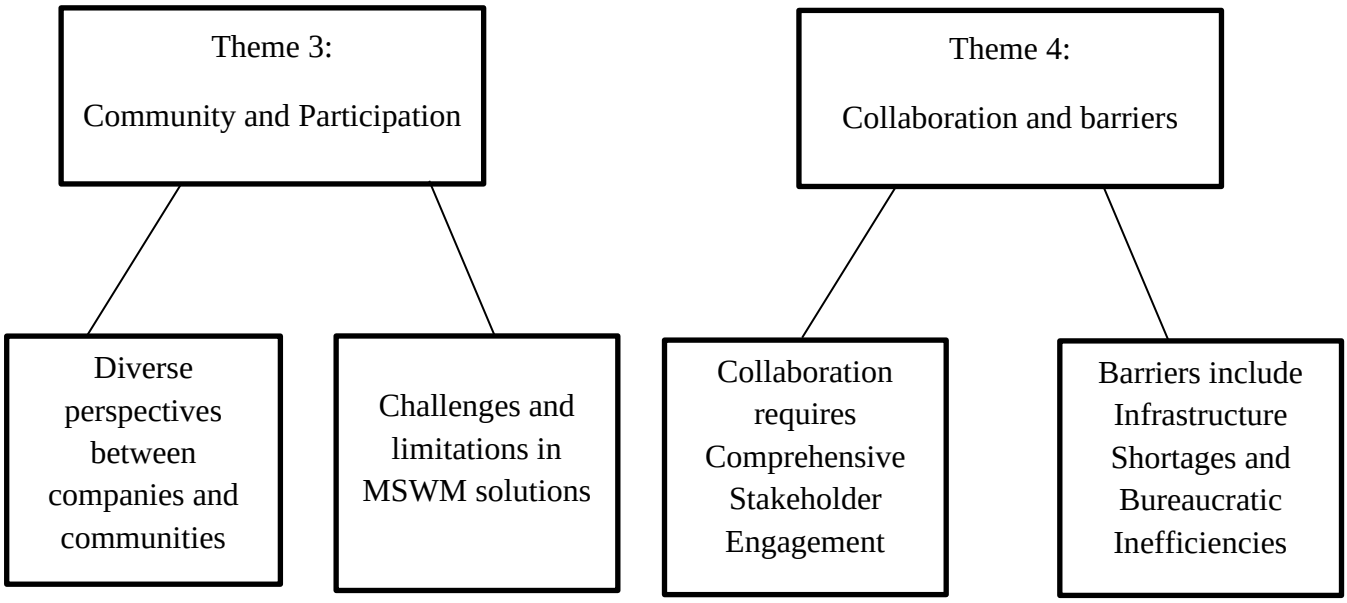


Figure 6: Themes Identified through Coding

Source: Own elaboration

4.1. System interconnections of MSWM in Italy

Representatives of the system highlighted key actors and their interactions, revealing complex dynamics. The following actors are listed in order of frequency mentioned, from most to least. In the Italian MSWM system main actors include firstly municipalities, these are considered responsible for maintaining cities clean, collecting and separating wate. These services are guaranteed by companies, normally owned by the municipalities. MSWM companies follow the rules set by municipalities, so the frequency of waste collection and the costs paid by citizens are determined by agreements between the two parties. There are companies who are completely owned by municipalities, which is considered an in-house service, and there are private companies' activities, that have stipulated by contracts with municipalities. Different from the public ones, private companies have the freedom to operate anywhere in Italy by participating in public bids and can also operate internationally, for example, there are cases of French companies who work in Italy.

The dynamic between municipalities and companies is directly affected by the dynamic between municipalities and citizens, since MSWM service depends on the amount the municipalities intend to charge the citizens. In addition, unsatisfaction of citizens towards MSWM, due to unclean streets or waste that has not been collected, is normally reported to municipalities which then leads to conflict with the companies that are providing the service.

However, there are cases of innovation from private consortiums that through eco-compacters communicate directly with citizens without the mediation of the municipality. This direct contact enables them to tell the story of their packaging, the characteristics of their packaging and correct management, bringing knowledge to citizens that municipalities do not have.

Regions are another main actor in the Italian MSWM system, since planning happens at a regional level. They are tasked with planning and programming, especially regarding the construction of plants necessary for the management of urban waste. This encompasses all types of waste, from wet organic waste to plastic, and involves equipping territories with the necessary infrastructure, being the first link to CE. To develop MSWM plans, regions rely on regional agencies for environmental protection as their main support. Additionally, they collaborate with other agencies to establish technical tables comprising institutional representatives, the scientific and research community, and economic sectors to address specific MSWM issues. Regional planning also considers various inputs from national agencies and ISPRA, which is part of the National System for Environmental Protection (SNPA).

Since 2022, with the PNGR, there is also national planning. This innovation was highlighted by almost all the interviewees. The document guides the work of regions in regional planning, to ensure coordination and addresses the different levels of development of MSWM in Italy. Some actors considered the plan an innovative approach, since it proposes two methodologies for the regions: analysis of flows and life cycle assessment.

> "This was an innovative approach, because it is pragmatic, science-based, based on data and number, which leaves less room for ideological aspects, leaves less freedom for the influences of politics", emphasized interviewee 5.

However, other stakeholders believe the PNGR is insufficient. While they agree that the direction is correct, they argue that the efforts are still inadequate to meet the objectives.

"Investments need to be strengthened from this perspective; in our view, the National Recovery and Resilience Plan should have allocated more resources for CE facilities. So, we definitely need to do more. The direction to take is clear, but the efforts are not yet adequate to meet the objectives. There is also a need, for example, for end-of-waste regulations, especially for certain types of waste. I mentioned earlier the regulations for the construction of facilities. There is also a need to simplify and accelerate these processes, because otherwise we are moving in the right direction, but too slowly", stated interviewee 6.

Another set of actors mentioned that are essential to the MSWM system in Italy are the 'world of recycling', as referred to by interviewee 3. These actors are primarily composed of

private companies. In Italy these big utilities are in stock exchange, in which some have a small percentage of ownership by municipalities. These companies have the infrastructure to treat the waste, such as incinerators, as well as plants for the treatment of organic waste, that leads to biomethane or compost for agricultural use, or for the reuse or treatment of plastic. The activities of these companies are significantly influenced by policies such as extended producer responsibility. Under this policy, companies that produce waste pay those who treat it, in contrast to other types of waste, like organic waste, which are not covered by the policy and therefore represent a cost to the treatment companies. Additionally, extended producer responsibility policy results in the inclusion of the 'whole world of producers of goods', as called by interviewee 5, by giving them obligations.

These private companies are also influenced by external factors, such as the fluctuations of international economy, such as energy crisis and price increase of virgin raw materials compared to recycled materials. For example, if China's economy performs badly or well, it has a big effect on the prices of materials in Europe and, consequently, affects the market for recycled material. Many of the interviewees advocated for policies that shelter MSWM and use of recycled material from the dynamics and trends of world economics, arguing that, without such protection, it is challenging to maintain a sustainable system over time.

Among the external factors, though not entirely external, the EU is considered by all interviewees to be the key influencer in sustainable MSWM practices in Italy. Through its goals and funding the EU has established a pathway to MSWM in Italy. The pressure of improving the performance has led to a constant improvement of performance with new technologies. These are promoted through subsidies and targets. The EU also gives the guidelines for the management of packaging in Italy. Additionally, some stakeholders view the EU as the entity responsible of providing protection against international fluctuations, and for addressing the scarcity of raw materials through the implementation of CE practices. Consequently, the EU is regarded as a crucial player and a reliable support for the Italian MSWM system.

"It is the European Union, that with its directives, raises the bar, indicates the goals and establishes objectives to be achieved. So, the role of the European Union is decisive", stated interviewee 6.

Another important dynamic, highlighted by one of the interviewees, is the process of creating waste legislation and regulations. This process involves institutional discussions with representatives from various sectors within MSWM. For example, packaging producers participate to present the perspective of those responsible for generating waste and covering the associated management costs. Additionally, representatives from the MSWM industry and

institutions, that represent both the industry and producers, also take part. Public consultations further enrich this process by involving a wide range of stakeholders, including trade associations, the national association representing municipalities, and technical standardization bodies. These consultations help in shaping legislation, developing secondary regulations, and defining and implementing rules concerning producer responsibility.

In summary, clear dynamics between the actors of the MSWM system can be detected. The interactions between municipalities, MSWM companies, and citizens show clear dynamics. Municipalities set rules that companies follow, and these rules are influenced by citizen satisfaction, creating a feedback loop. This traditional waste three tier model (government, householders, waste company) was the most identified by interviewees. While some briefly mentioned dynamics that show signs of the multilevel and multi-actor governance structure, the predominant model was the traditional. One interviewee claimed that the interactions are quite limited across different systems - social, economic and political.

4.2. Efficiency and Innovation

When interviewed about innovation, the first topic that often came up was technological innovations and how these have improved efficiency in the Italian MSWM. These are seen as a result of European Legislation and as essential tools to meet the mandated targets.

“I would say there is a lot of pressure in improving performance of waste in general. So, I’ve seen a lot of improvement, for example, in the technology and the technologies of sorting waste”, stated interviewee 1.

One of the most frequently mentioned technologies is plastic sorting. In Italy, advanced systems now have the capability to differentiate between various polymers and separate unwanted components. This process is achieved by bio-robotics and sensors. These technologies allow a higher percentage of recycled materials to be used into new products. In addition to the clear benefit of increasing the recycling rate, they also address two issues: they help rectify the problem of mixed waste sorting by citizens, and they enable companies to avoid penalties associated with the mixture of components.

Interviewees also emphasized innovation in the treatment of organic waste, such as anaerobic digestion that produces biogas and biomethane. This innovation is promoted by subsidies leading to a continuous improvement of the performance of plants, not only in terms of environmental impact, but also in energy recovery. Interviewee 5 specifically highlighted

the 2018 decree on biomethane, responsible for promoting the building of new plants and the production of biomethane.

“This decree has ensured that in five years Italy has gone from 0 to producing 200 million standard cubic meters of biomethane, just from the treatment of plants and new plants being built. And I believe that in another three years we will be able to double this production”, stated interviewee 5.

Although these new technologies have enhanced MSWM efficiency, some barriers remain in recycling certain materials. While the recycling of glass and paper is easier to achieve or already have been achieved in Italy, other materials, such as plastics and, to some extent, aluminium present more challenges. Moreover, these new technologies are not uniformly spread in the Italian territory; rather, they are implemented by large companies that have the financial capacity to do so, and these companies are mainly found in the northern regions of Italy.

In addition to innovation in waste treatment, the interviewee representing a consortium highlighted advances in product design, emphasizing the importance of intentional design for collection and recycling. This underscores the importance of design-thinking and the key role of manufactures in minimizing environmental impact.

“So, innovation will be simplification. Simplification to give an example, the bottle, only one material will be used, no longer coupled poles, because only one material is more recyclable. Or in form, shapes will be used that will allow the best management of the product, during the start-up, recycling and collection phases. So, the evolution will be more of a simplification of packaging, in my opinion”, stated interviewee 4.

Furthermore, there is also innovation in collection systems, such as door-to-door collection with bar codes and digital detection systems for the waste delivered. These practices optimize the management of urban residues, as well as identifies critical issues and calibrates the territorial distribution of collection systems.

Another practice that was marked as innovative by interviewees is the rewarding of good practices, typically carried out by environmental organizations or regional environmental agencies. For example, Interviewee 6 mentioned a new initiative called ‘Common recyclers’ which rewards the best performance of municipalities in reducing dry fraction that is not recycled. Interviewee 7 mentioned that in their region a reward system is applied for the most virtuous private and public entities in MSWM.

As discussed in the literature review, Grewatsch et al. (2023) highlights that ST distinguishes innovation and change at two levels: higher hierarchy systems like social conventions and laws, and lower hierarchy systems such as firms and individuals. The authors argue that higher hierarchy systems are more stable and change slowly, while lower hierarchy systems are more flexible and can adapt quickly. Interviewees emphasized that technological innovation results from legislation, promoted by public subsidies, as well as by the pressure of meeting the targets. Therefore, according to interviewees, technological innovation comes from higher hierarchy systems, particularly European legislation.

"They are (the EU) really boosting innovation because we are facing some targets until 2023 that are very, very ambitious", stated interviewee 1.

However, while subsidies from European legislation encourage innovation, they are primarily granted to companies and consortia that place their packaging on the market. Therefore, lower hierarchy systems also play a role, by creating and promoting these new technologies, which are affected by market competition. Thus, economics also drives innovation, especially the profit that results from the sale of recycled materials. In sorting plants, the most desired products are those of good quality and recyclable, while unwanted residues, which incur costs rather than generate profit, are least desired. In addition, there is consumer demand, where interviewee 4 emphasized that consumers are more informed and no longer fooled by green claims, therefore companies are concerned about communicating the sustainability of their packaging to consumers.

Another type of innovation, already mentioned in the previous theme, is an innovation that directly affects the dynamics of MSWM. This is the case of private consortiums that through eco-compacters communicate directly with citizens without the mediation of the municipality. To the consortium this innovation is essential, since it enables to tell the story of their packaging, such as specifying polymers and how each polymer has to be treated.

"The citizen doesn't know this thing here, because the municipality has always told him plastic, plastic, plastic. Because it is more complex, it (the municipality) is less experienced, it has no knowledge. So, I see this as the future modality that will have to be more and more of the consortium and the citizen", stated interviewee 4.

In summary, interviewees emphasized the role of innovations and how these have made the Italian MSWM more efficient, especially regarding the collection models and the use of bio-robotics and sensors. Besides technological innovations, interviewees also emphasized innovations at organizational level, such as direct contact between citizens and manufacturers.

The new technologies are normally promoted by the European legislation, as well as market forces. Therefore, innovation in the Italian MSWM exhibits interactions between higher (legislation) and lower (market forces) hierarchy systems, in which some interviewees have emphasized the need for regulations that control the volatility of lower forcers, creating greater stability and a smoother transition towards CE. Lastly, it is important to note that most of these technological innovations mentioned depend on the approval of territories, which is directly connected to the role of the community, discussed in the following section.

4.3. Community and Participation

From the very beginning of the interview process, it was clear that the stakeholders' perspectives on the role of the community were the most varied and divergent. In fact, they can be separated into two different groups: those that represent companies and those that represent communities. The representatives of companies consider that citizens have a negative role in MSWM since they hamper the implementation of new technologies and new treatment plants due to the 'Not in my backyard' logic, while the representatives of communities consider that companies put profit before well-being and lack the inclusion of citizens in the decision-making process.

Stakeholders representing company's interest consider that the primary reason for citizens rejecting waste treatment plants in their territory is fear, often stemming from lack of information. This lack of social acceptability affects the political dimension, which in turn influences industrial choices and the implementation of waste treatment plants.

"But when it comes to plants, the technology, they (communities) are really not helping to address the problem. We need to very honest from this point. I've seen so many situations where people are against and then the politicians, they follow the people, of course, if they wanted to get their votes you must agree with them", stated interviewee 1.

The most mentioned example was the case of Rome, where citizens and environmentalists rejected the construction of an incineration plant, leading to waste being shipped to the Netherlands instead. Interviewee 3 and 5 highlighted that this goes against the principle of proximity established by the EU, which mandates that waste should be treated locally.

"Because if I collect waste separately but then I'm forced to treat it 600 km away my organization will not be as efficient as if I have plants in my territory", explained interviewee 5.

The lack of waste infrastructure accentuates the regional differences of MSWM in Italy, where interviewee 5 highlighted that the north of Italy has high rates of separate collection, energy recovery and very low landfill rate, thanks to its well-developed infrastructure. In contrast, the center has a mixed situation, while the south is the opposite, with a high landfill tax due to the absence of recovery plants.

"In the waste infrastructure the perception is that people don't want anything in their backyard. "So, nothing in my backyard. We are for the environment, we help you collect properly the waste outside my house, but please don't put an incinerator nearby my house or also don't put a plant for treatment of waste in the fields in front of my house.", stated interviewee 3.

Interviewees from the company sector also highlighted the importance of individual behaviour and the role of citizens in waste separation. They emphasized that, in Italy, there are many communities very much committed to this effort, which has been essential to achieve the EU recycling goals. Interviewee 3 also noted that differing individual behaviours can be a cultural barrier, as in some parts of the country, the use of different bins for waste separation is still not widely accepted. However, they highlight that this can be overcome with national government intervention and education starting from elementary school.

"The cultural barrier could make the difference and you can see it in different regions, the different perceptions of the waste management from citizens.", stated interviewee 3.

On the other hand, there is the perspective of stakeholders that represent citizens and communities. These stakeholders emphasize the importance of involving citizens in decision making process, asserting that an active role for people is fundamental. According to them, waste and its management is a shared responsibility, and everyone should contribute based on the principle of responsibility. This perspective was also shared by some of other stakeholders of the system, such as interviewee 4 who highlighted that everyone should contribute their 'know-how'—their knowledge and their viewpoints.

"The local community can play a positive role if involved in decisions and allowed to contribute. Unfortunately, can play a negative role if decisions come from above without local involvement (…) This can be addressed through participatory approaches and informative activities before making decisions. It is important to show the environmental, economic and social benefits of separate urban waste collection systems and plant creation", explained interviewee 6.

Therefore, all stakeholders across the system share a common view when emphasizing the importance of individual actions and community initiative to separate waste, as well as the need

to inform citizens. However, opinions divert when talking about which treatment plans, as shown by interviewee 6 statement:

"Unfortunately, in places like Sicily and Rome, shortcuts like building incineration plants are being considered instead of focusing on separate collection and recycling, which is counterproductive to circular economy."

According to environmentalists, incinerators are the antithesis of sustainability, due to their toxic fumes and effects on local communities, as well as the fact that they directly compete with all the recovery and recycling systems.

"So, to synthesize the problem again was the increasing of volume of waste generation. This volume created conflicts over finding landfills. The technical solution was to implement incineration, even though we know it also posed health risks in many cases. However, it was a significant solution in terms of dramatically reducing the space needed for waste disposal, as incineration reduces the waste volume by 80-90% into ashes", explained interviewee 2.

These stakeholders believe that instead of focusing on the prevention and reduction of waste, the emphasis of MSWM has been on incinerators and improving technology to lower emissions, even though this goal is not always achieved. As a result, the complexity of MSWM is not being addressed, and this wicked problem is being patched rather than solved at its root. Interviewee number 2 also highlighted that incinerators generate large profits because they are heavily subsidized.

"There has always been a significant push from stakeholders in the economic sector to secure subsidies for incineration. It's well known that waste incineration is one of the most heavily subsidized industrial activities, along with all energy sectors in our growth-oriented economic system", stated interviewee 2.

Even though advances in technology have presented solutions to MSWM problems, there is a factor that remains the same: these infrastructures require a constant flow of waste to continue functioning. According to interviewee 2, this represents a system lock in that must be addressed through the engagement of local communities, and solutions that account for all the complexities of the system.

As mentioned in the literature review, while MSWM strategies often excel in technical and environmental realms, they frequently fall short in achieving social acceptance (Falcone & de Rosa, 2020). As shown in this section, this is also the Italian case, where participatory approaches are lacking and a conflict between territories and companies exist. This further highlights the complexities involved in MSWM that should be considered when developing solutions.

4.4. Collaboration and barriers

Collaboration in MSWM is complex due to the diverse interests involved. As highlighted by Dhimas et al. (2022), achieving effective collaboration requires a common goal and the ability of navigating through different perspectives to reach a consensus. This was also highlighted by many interviewees, that emphasized the idea that stakeholders have diverse priorities. For example, Interviewee 5 emphasized the distinct 'worlds' of public administrators, consumers, and environmental associations, each bringing unique interests to the table.

"Well, everybody is concerned about the environment, let's put it this way, but then everybody has to take into consideration also the economic factors that could affect their decisions", stated interviewee 3.

The interviewees pointed out that citizen awareness of environmental problems has improved, increasing the efforts towards the common objective of addressing these concerns. However, they also illustrate divergent stakes, for example, economic ones where people do not want greater tariffs, while businesses prioritize profits. Despite this diversity of viewpoints there are areas where stakeholders find common ground, this is where negotiation becomes crucial, as compromises must be made to reach a mutually agreeable solution.

"If there had not been collaboration between all the actors of the supply chain and the representatives of the world of waste management, Italy would not have achieved the objectives it is achieving", stated interviewee 5.

Interviewee 1 described successful examples of MSWM collaboration, concentrated in Lombardy (north of Italy), where all the key stakeholders were involved. When asked about the factors contributing to this success, this interviewee stated that the presence of a clear common goal was the main reason. Additionally, the availability of knowledge, followed by a robust and efficient waste treatment infrastructure. The strong relationship between the public (citizens) and plant owners also played a role. This example is especially valuable because it covers many complex dynamics, such as the dynamic between communities and waste treatment plants. Also highlighting the importance of information to overcome barriers such as fears and misconceptions. This approach aligns with ST principles by acknowledging the interconnectedness of all stakeholders and the need for collective action to address complex challenges.

A case of unsuccessful collaboration was also highlighted by interviewees, in Calabria located in the south of Italy. It happened during an MSWM emergency that required the appointment of a special commissioner. The commissioner, as the representative of the public

sector, was appointed alongside representatives of a foreign private company as the waste treatment provider. Issues started with the company not being paid in due time, which led to a break of trust between the two actors, exacerbating the already poor state of the MSWM system. This is a case of a collaboration with low involvement of other actors of the system, since it just involved the public actor and a private company, therefore, lacking participatory approaches, trust-building process and shared understanding.

According to other interviewees, successful collaboration requires the involvement of all actors, such as municipalities, local communities, citizens, associations, schools, and large-scale distributors in Italy. Interviewee 4 mentions that there are virtuous projects where all the actors share a common goal and work together to achieve it. However, there are also disastrous examples when one actor decides to act alone without considering the others. Additionally, interviewees mention that while most collaborations come from formal agreements or are based on frameworks, this does not guarantee their success.

"But putting it into practice (the project), putting it into good practice, it always depends on the will of the individual subjects", stated interviewee 4.

In addition, stakeholder 7 mentions cases of how MSWM collaboration works in their region, located in the north of Italy. Characterized by a partnership between the Region and the basin councils on creating the regional plan. Basin councils are important institutions of governance that bring together various stakeholders, such as government agencies, citizen committees, non-governmental organizations, local communities and enterprises in the management of waste and water. In addition, the interviewee noted that when creating regional policies, they establish a technical table on End of Waste, aimed at achieving the strategic objectives of related to the CE. This process involves not only various Directorates of the Region but also the Union of Provinces, and a Network of Universities for Sustainable Development, and some trade associations depending on the type treated. This example embraces all the components of systemic collaboration as proposed by Dhimas et al., (2022), since it directly involves stakeholders out of the government, while focusing on agreement and tackling group decisions.

Collaborative efforts in Italy further highlight regional disparities, as all the successful examples of collaboration mentioned were from the north of the country. However, interviewees were also of the opinion that separate collection and community initiatives have been rising in southern regions and that Italy is on the right track to sustainability. These successful examples reveal a common pattern of recognizing the complexity of Italian MSWM

and involving multiple stakeholders, while cases that oversimplify the process, or exclude communities, have failed.

“Collaboration of everyone, the citizens, the companies that do the collection, the plants that treat waste, those who use raw and secondary materials, municipalities, provinces, regions, ministries, without the ability of this world to collaborate we would not have arrived where we (Italy) are now. You can improve, you have to improve absolutely, but we are not starting from scratch.”, stated interviewee 5.

While there are many examples of virtuous collaborative initiatives in the different contexts, stakeholders have also highlighted many barriers to effective MSWM and collaboration. The most mentioned challenge was the lack of infrastructure for waste treatment in certain regions. Measures recommended included accurate national planning that addresses the issues of regional differences, the sharing of information and inclusion of communities in the decision-making process. In general, stakeholders emphasized the need for more national indicators, as well as communication and collaboration between regions and guidance by the ministry. Another mentioned barrier was the impact of political volatility on MSWM, which leads to easy solutions that don’t address the complexity of the system and creates one-size-fits all solutions.

“Barriers are certainly of ideology that does not lead you to analyse the problems and confront the complexity. Ours is a complex world that requires complex solutions. This requires you to make an effort. And unfortunately, easy recipes don’t bring results.”, stated interviewee 5.

Additionally, both interviewees representing communities mentioned a barrier that undermines community trust in waste management: corruption. They highlighted that this is a significant issue in Italy, particularly with the involvement of criminal groups such as the Camorra and Cosa Nostra.

“Previously, it was only related to the management of waste landfills, but now these infiltrations by the mafia and environmental crime risk affecting the circular economy supply chains as well”, stated interviewee 6.

This corruption has infiltrated public administration, and interviewee 2 mentioned that it is also present in the companies that manage waste and those that receive subsidies for the construction of incinerators. Interviewees noted that the addition of environmental crimes to the penal code was a step forward and has helped combat illegal activities, but stricter regulations and more consistent enforcement are still needed.

Lastly, many stakeholders mentioned bureaucracy as a significant barrier in Italy, which hampers MSWM results by slowing down the process. Therefore, interviewees emphasize that the focus should be on the qualitative enhancement of the administrative capacity so that it does not hamper efficiency and encourages the development of innovations.

4.5. Discussion of Result

As discussed in the literature review, ST seeks to understand how parts become a whole, framing the world as a set of feedback loops. ST characterizes a system by higher hierarchy and lower hierarchies and complex dynamics. Ultimately, deconstructing complexity and addressing 'wicked problems' (Salvia et al., 2021).

The Italian MSWM exemplifies this complexity through its multi-layered specialization, that requires the participation of municipalities, citizens, regions, private/public MSWM companies, national agencies and the EU. The relationship between these is influenced by a number of factors internally, as well as externally. Including polices, such as policies that dictate how waste is managed and provide standards, economic factors that can lead to budget constraint and are affected by market fluctuations, as well as international dynamics that affect the economy and also sets trends. Building on ST, it is possible to pay more attention to the difference between stocks, flows, and variables involved in these systems, contributing to a better understanding of the behaviours and results of those systems.
Stocks:

- Physical Stocks: This means infrastructure of incinerators, of treatment plants, of collection facilities.
- Emotional/Perceptual Stocks: Citizen's trust to the municipalities due to efficiency of waste management services, trust amongst collaborators for realization of the goals.

Flows:

- The process of waste collection, treatment, and recycling, which changes based on the agreements between municipalities and companies.
- Flows of waste going to landfill or waste treatment.
- Flows of funding and technological advancement from the EU to regional and municipal levels.
- Flows of materials that are recycled and put into the market.

Variables:

- Policy changes (e.g., extended producer responsibility).
- Economic factors like the price of recycled materials.
- International economic conditions affecting material prices.
- Technological advancements.
- Behavioural factors.

Therefore, based on the themes developed from the interviews, a diagram (Figure 6) was developed deconstructing the various complexities and creating a clearer picture of the Italian MSWM. This diagram follows step 7 of the Arnold & Wade (2015) eight steps for applying ST and creates a reductive and homogenized model of the Italian MSWM system.

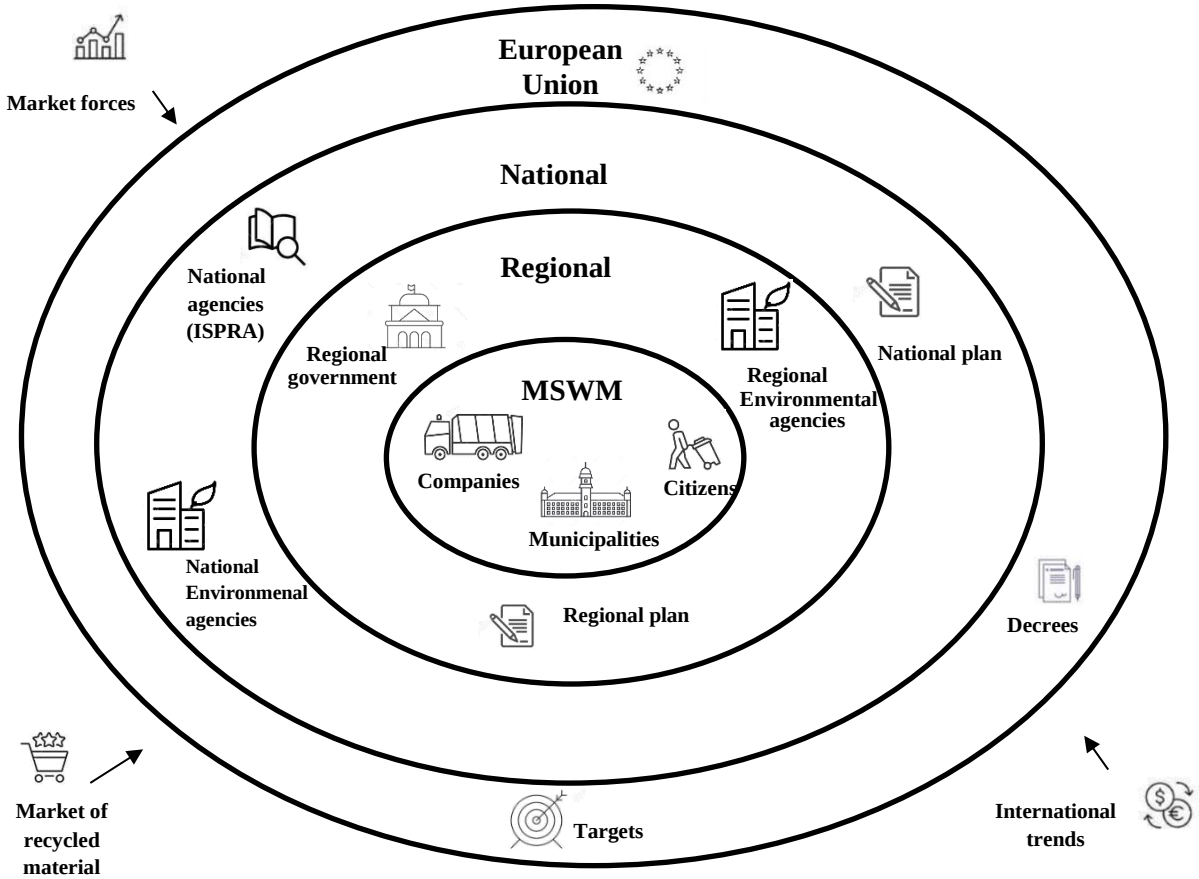


Figure 7: Italian MSWM system

Source: Own elaboration, images[8]

As mentioned in the literature review, systems thinking seeks to identify the points where a system is capable of achieving positive change and the points where its vulnerable (Grewatsch et al.,2023). The responses from the interviewees indicate that in the Italian MSWM system there is a focus on the first scale: the interaction between the municipalities, MSWM companies and citizens. Although this feedback loop is important for adaptive waste management practices, it may not capture the dynamics of the interactions between different actors and the change of their relationships over time in diverse contexts. This can result in limited interaction between social, economic, political and technical realms, developing large gaps and insufficient integration of system solutions. However, the brief mentions of multilevel and multi-actor governance by interviewees suggest an emerging trend towards more complex and inclusive waste management frameworks. Additionally, interviewees highlighted the PNGR plan as a step forward, where more coordination is hapenning at the national level. Lastly, there is a significant influence from the EU, that sets targets and goals incentivizing innovation. At the same time, stakeholders have high expecations from the EU, seen as an entity that should also protect the MSWM system from external market variations, highlighting its important role.

Strong aspects in the Italian MSWM system include increasing environmentally conscious citizens, who engage in effective separate collection, helping achieve targets and goals set by the European Union. As well as the role of social movements that demand environmental justice and sustainable development, that have also played a part in the improvement of national legislation on WM. There are also successful cases of collaborative efforts that have been put into action with multilevel governance approaches. These create a path for other regions to follow, where science driven, transparent and participatory initiatives are welcomed, while short term solutions that are mainly profit-driven and exclude community have proved inefficient. These examples showed the value of systemic collaboration to achieve MSWM efficiency, as highlighted by Dhimas et al. (2022).

However, there are vulnerabilities in the system. Such as the 'system lock in' phenomenon, where even innovative and clean technologies rely on a constant flow of waste. Additionally, corruption infiltrated within the administration affects the flows of trust between stakeholders, and hinders the relation between citizens and public institutions or political figures. Further barriers include bureaucratic inefficiencies and inadequate funding to address regional

[8] Images from https://www.dreamstime.com/

disparities. These further highlight the importance of considering all aspects of the system, where technological innovation and economical investment in waste treatments should be accompanied by participatory approaches, as well as educational campaigns. The system's non-linearity further complicates MSWM, since it deals with various uncertainties, such as fluctuating waste volumes, market force, international trends, as well as political volatility. These variations can lead to draft changes and disrupt progress towards CE and must be considered for sustainable and effective MSWM.

In conclusion, Italy has been laying the proper groundwork for the subsequent development of an efficient MSWM system. But to invigorate and build on that progress there has to be consistency in the goals, permanency in funding, and a systemic approach that is integrated in a multilayered model. Only this way Italy can persist in the process of building a long-term sustainable model of MSWM and provide valuable lessons and motivation for other countries that are on the similar path.

CHAPTER 5

Conclusion

MSWM is a dynamic and complex issue that benefits from a system thinking approach by revealing and breaking down these complexities (Arnold & Wade, 2015, Grewatsch et al., 2023 and Silva et al., 2017). This study addressed the critical necessity for a different approach to effectively manage the 'wicked problems' of today's world, as pointed out by Grewatsch et al., (2023) and Salvia et al., (2021). Which, importantly, encapsulates the complicated processes involved and the interdependencies among different elements, which require engagement of all stakeholders, necessitating not just collaboration, but systemic collaboration (Vasconcelos et al., 2021).

A systemic approach was taken in the analysis of the Italian case across multiple dimensions—social, technological, economic, and political—which emphasized the interrelationship among all components. The findings of this study suggest that managing MSWM involves a variety of stakeholders, such as waste producers, waste collection services, treatment and recycling facilities, all of which have intricate interconnections and relationships. The relationship among regions, national planning (PNGR), and the EU reveals that governance functions at multiple levels. Furthermore, complex dynamics were analysed, such as the EU's constant pressure leading to improved MSWM practices and technological innovations, and the evolving relationships between municipalities and MSWM companies, driven by citizen satisfaction and policy changes. These dynamics are also shaped by external factors such as international trends, market forces, and cultural habits.

The analysis demonstrated that MSWM demand's a holistic perspective, addressing all phases of waste management. That being not only the post-consumption waste processes, but also the pre-consumption phase, highlighting the importance of including manufactures as important stakeholders, and the need to consider their role in political discussions. Additionally, the dynamics between manufacturers and other stakeholders, such as consumers, must be considered, since open communication between manufacturers and consumers leads to flows of trust, enhancing system effectiveness. Lastly, disruptions in one part of the system, can lead to repercussions towards all the other actors, this is the case of public decisions being made on MSWM without citizen-involvement, such as the case of Rome and other cities in the South of Italy regarding the building of waste treatment plants.

Therefore, in effective MSWM, collaboration is vital, with the involvement of all stakeholders, local and national authorities, business community, NGOs, and citizens, being not

only intra-organisational, but also inter-stakeholder (Salvia et al., 2021), evidenced by the fact that it cannot be achieved by the actions of single entities. Successful examples of collaboration in Italy reveal the necessity of addressing the connectedness of all parties with ST, as well as engaging communities, addressing a common goal and using approaches, such as, trust-building and open communication. These examples follow the criteria's established by Dhimas et al. (2022), such as inclusion of private sector, direct involvement of participants in decision-making, strategic planning aimed at consensus, emphasizing commitment towards the process and shared understanding.

Another important dimension is to build up multilevel governance, which implies that national and regional governments improve their coordination mechanisms. This guarantees the alignment of goals and tackles the spaces between different governance levels, as well as regional disparities. It is particularly important to have clear policies that can go beyond the concept of the three-tier system, which includes only government, households and waste companies. These frameworks should involve all the interested parties including the manufacturers, non-governmental organizations and, most importantly, the citizens. This broader approach can help to build new sustainable manufacturing system that considers all the complexities of the system (Silva et al., 2017), while aligning as well to the needs and insights of the communities they serve.

Overall, ST offers a holistic grasp of a complicated issue, recognizing its flows, stocks and variables, as well as the complex dynamics that take into account all the processes involved. The mapping of these elements resulted in a more transparent understanding of the 'wicked problem,' thus revealing potential resolutions. The Italian case suggests that finding solutions may involve systemic collaboration alongside multiple levels of governance. Importantly, these observations are relevant beyond the Italian setting, offering valuable guidance for any nation striving towards sustainable development and a circular economy.

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Annexes

Annex A – Interview Protocol

1.From your experience, what are the main actors of the municipal solid waste management system? How are they interconnected?

2. In your perception, what are the external factors that affect the management of municipal solid waste, such as economical, technological, legislative, cultural factors?

3.Are there any other types of innovative solid waste management approaches in Italy, and what actors promote this type of innovation?

4.What is the role of the local community in the development of waste infrastructure?

5.Regarding your experience, do you believe stakeholders across all the different levels share common goals in waste management, or do they pursue different objectives?

6.Are there any collaborative approaches used in Italian waste management? Can you give examples of successful or unsuccessful collaborations?

7.In your opinion, what are the main barriers to effective waste management in Italy?

8.In your perception, what type of actions can be done to overcome these barriers?

Annex B- Codes

System Interconnections	Efficiency and Innovation	Community and Participation	Collaboration and barriers
Responsability of Municipality • Collecting Waste • Keeping City clean • Separating Waste	Innovation promoted by EU legislation • Targets • Subsidies	Negative role of local communities • Do not want waste treatment on their site • Fear • Politicians follow the people • Waste is shipped • Rome as a case: public doesn't want a plant and waste is shipped to the Netherlands	Municipalities and Regions share the same goals • Improve the separation of waste • Reducing the production of waste
Planning at regional level	Innovation promoted by Economics • Search for good quality recyclable material • Avoiding tariffs and paying for disposal	Positive individual behavior • Waste separation • Many communities committed to waste separation • Leads to high national performance	Operators of waste plants have a goal to optimize performance • Don't have the goal of waste prevention, because they need the waste to operate • Can lead to issues and conflicts with other actors
Companies • Operators of waste • Owner of facilities • Public or public/private	Technological improvements for separation of plastic • Avoids penalties because of reduction of non-desired components	Negative role of community • People don't want anything in their backyards • Against the principle of proximity of treating waste locally • Rome wants to build an incinerator, but citizens and environmental associations are against • This is not only Italy, but also all over the world	Examples of Collaboration in Lombardy- North of Italy • Common goal • Good presence of knowledge • Efficient infrastructure • Good relation between the public and private actors
Public has most of the control	Funding from European Union • Allows innovation in Italy by financing high technology	Cultural barrier that people don't want different bins for collecting different waste • Depends on the region, this isn't the case of Lombardy that there is a lot of separate collection	Example of lack of collaboration in Calabria – South of Italy • Lack of trust between public actor (commissioner) and private actor (private international company) • Financial issues
Owners of plants that are fully private	Innovation private consortiums that through eco-compacters communicate directly with citizens • Without the mediation of the municipality • Able to tell the story of their packaging, the characteristics of their packaging and correct management • Brings knowledge to citizens that municipalities don't have	Positive role of community if they are allowed to contribute • Participatory approaches • Informative activities before making decisions	Good example of overcoming a crisis: Campagna- South of Italy • Good commitment of citizens in doing source separation • Building an energy plant

Pressure by EU legislation • Improved technology	High technical plant capacity in Veneto		Emergency has now moved to Rome and Lazio region
Management companies that follow rules set by the municipalities • In charge of collecting waste • Cost and times of collection must be an agreement between the two • Service depends on how much the municipalities want to charge citizens	Innovation comes from consortia • Guarantees that the sustainability of packages is part of the product value chain • Companies are worried about communicating the sustainability of their packaging to consumers- result of a broader societal shift towards sustainability	Negative role of communities when they are not involved in decision making • Such as the not in my backyard movements	Barriers is the "Italian Approach" • Lack of trust in public institutions • Lack of trust in local authorities • People are skeptical, they don't trust and are fearful for bad waste management
Role of collecting centers • Citizens go there to leave waste such as: tires, televisions, sofas, etc. • Controlled by cards that the citizens own • Is included in the waste collection tax	Innovation from consumer demand • Consumers are more informed and no longer fooled by green claims	New technologies that are innovative but not accepted by community • Territories do not always accept even when the energy recovered is 100% renewable	Solutions to the barriers: • Science-based information • Transparency
Companies completely owned by the municipalities • In-house providing service	Innovation will be simplification • In the production of bottles only one material will be used • Best management of product for collection and recycling	Social acceptability affects the political dimension that unfortunately influences industrial choices	Everybody is worried about the environment but there are economic factors • Sensibility of people regarding the environment has increased • But people don't want their tariffs increased • Companies must run a business (profit)
Completely private companies • Contracts with municipalities- penalties if you don't follow it • Private have more opportunities everywhere in the country and abroad, can participate in public bids.	Innovations • Biodegradable plastic • Door-to-door separate waste collection • Digital detecting system for waste delivered	Problem of the south of Italy not having recovery plants and high landfill tax • Depend on social acceptability	There is a common understanding of the problem
Then there is the world of recycling • Mostly private companies • Some have a little ownership by municipalities • They have incinerators, plants for treating organic waste, plastic and to reuse it	Innovation in regional level with organizational systems: collection models	All subjects can participate in public consultation for new regulations • All local stakeholders can make their observations to a regional plan that includes for example an incinerator instead of landfill	Strict collaboration between municipalities and the waste management companies • Sometimes there is economic conflicts but it's a normal kind of business relationship • Sometimes conflict between these actors because citizens are not satisfied with the WM • Bad WM services in regions such as Naples and Palermo (south of Italy)
Companies Owned by Municipalities: • Collect waste then go into the market for bidding of the waste • Some waste they get paid for (extended producer responsibility) • Some waste they pay to dispose of (mostly organic waste)	Innovation in governance with new organizational models	Waste is a common good and should be treated as such and not privatized	Barriers are lack of waste treatment infrastructure in some regions of Italy

.Influence of economic factors • Cost of disposal and taxing on landfill affects the decisions made • Some regions like the South must choose between paying landfill tax or shipping tax due to lack of infrastructure to treat waste locally	Importance of duration of awards • Since many plants are capital intensive and need time horizon of 10-15 years	Interaction in privatized system with consumers and users is very low • Unless there is specific problem related to health people are not engaged	While in European level there is a focus on reuse in Italy the focus is still in recycling
Influence of international economy • Energy crisis and increase of prices • Chinese economy that may refuse import of waste	Innovation with the national waste management program • Overcomes regional differences and differences of speed • Innovative because it is pragmatic and science-based • Leaves less freedom for the influence of politics	Workers of WM such as waste pickers should be the main actors to improve the WM process	Need of government at national level to intervene to promote stabilization of WM
Municipalities • Organize the collection of waste	World of industry innovates everyday towards sustainability	Engage local communities	Need of education at school level • Students are going to be future citizens
Consortia • Task of recycling and pay municipalities		Need for a huge discussion at a social level on how to diminish generation of waste as an economic system	Need for laws and incentives actions for citizens from the government
Large scale distributors • Where eco-compacters are housed, case of bottles, used oils • Where citizens bring back their waste		Economic incentives alone are no sufficient need for social innovation • It shouldn't be just about finding effective solutions but should be just solutions for everyone	There is collaboration between: municipalities, consortias, local community, citizens, associations, schools, large-scale distribution • Need for a common goal
European Legislation • Guidelines for management of packaging		Naples is a example of how social conflict and movements lead to results in WM • The movements were able to transform burning waste into a penal felony	Lack of collaboration due to isolation • When one starts to say they want to work alone the projects do not go forward
International factors • Europe must protect itself from the volatility of the international market • Volatility of international economies lead to more or less demand of recycled material • Examples: Chinese economy and Ukraine war			Successful collaboration depends on the good will of individual subjects • Frameworks and agreements are less important than good will
Citizens, research, technology companies, consortias must all be involved • Everyone should bring their "know-how-to"		Plants were initially opposed as always happens in Veneto • Overcome by representing a source of work and creating awareness	Barriers: Not allowing the private sector to play a significant role in the WM sector • There is a resistance to change in Italy

		of the need for recovery	• Limiting private sector innovations • With this the system would become more efficient and sustainable
Main actor municipalities • Local administrators • Municipal companies • Consortia of municipalities			Challenge of Corruption • Waste Management companies that bribe politicians and local administrators • Organized crime • Threat to circular economy
.Role of companies • Works in synergies with municipalities • Consortias and big companies such as CONAI			.Need for a strict regulatory system of criminal law • Combat illegal trafficking of waste
.Role of regions • Planning and programming • Especially regarding construction of new plants			Economic factors • Urban waste management is burdened by taxes that citizens pay • Need for green public procurement policies that reward products coming from circular economy • Public spending should prioritize products that come from recycled supply chain
Need for qualified entrepreneurial system • Guarantee advanced technology • Guarantee quality of products that come out of treatment plants			Benefits of participatory approaches • Exponential growth of municipalities implementing effective waste collection
Role of Citizens • Principle of responsibility that concerns the individual • Active role of people is fundamental			Incentive methods • Environmental organizations rewards municipalities with best performance in reducing dry fraction that is not recycled
Role of Environmental organizations • Environmental Organizations strongly urge local administrators and regions to ensure the achievement of objectives			Need of a national strategy to overcome discrepancies of regions
Role of European Union • Raises the bar • Indicates the goals and establishes the objectives to be achieved • Solution to the problem of raw materials running out			Avoid shortcuts such as building an incinerator in Rome • There should be a focus on separate collection and recycling • Incinerators is counterproductive to circular economy
Legislative and authoritative part • Authorities and public administrators			The national plan of the moment is not enough • Planned investments must be strengthened • More resources to circular economy plants

• Parliament and ministries			
Legislative and authoritative part • Authorities and public administrators • Parliament and ministries			Voluntary agreements • Agreements of world of producers, representatives of waste managers and is already enshrined in legislation
Regions for planning • Regional Waste Management plans			Legislation must favor and not hinder industrial development in the WM sector
.Regulatory authority • Novetly introduced in 2018 • Regulates quality of services			Importance of regulations that increase the demand for secondary raw materials • With separate collection you don't close the circle • Importance of favoring the market to close the cycle
Governance part • Municipalities and government bodies • Authorization and control aspect			In WM everyone brings different interests • World of public administrators • World of consumers • World of environmental associations
World of producers of goods • Context of extended producer responsibility • Point of view of those that produce waste			.Certainly aspects in which all this diversity manages to find convergences • Importance of negotiation • In the end a point of fall must be found • Compromises are always found
Representatives of the WM industry • Provide support for planning for legislation			If there wasn't collaboration Italy wouldn't have achieved the objectives it has achieved • Collaboration of all citizens, companies that do collection, plants that treat waste, those who use raw secondary materials, municipalities, provinces, regions, ministries
Public consultations • National association that represents municipalities			Good practices and advancements from Italy • 2018 decree on biomethane • Application of extended producer responsibility • Wouldn't be possible without the collaboration of subjects
All the representatives and consultations help the legislator to legislate well			Barrier: ideology and volatility of politics
Hybrid bodies in Waste Management • Both a public part and a part representative of the business world • Very common in Italy			Need to avoid easy recipes and recognize the complexity

Local authorities collaborate with private companies			Barrier is bureaucracy • Needs to improve administrative capacity
Excellent waste management in Veneto • Effective partnership between municipalities and consortias • Constant information and training from operators and citizens • Large plant sector for recovering waste • Separation of waste by citizens and operators • Technical table of research and science			Need for capacity of dialogue on concrete issues • Need for confrontation between different points of views
Always update of regional waste plan according to EU legislations			Interactions are quite limited across the system: social, economic, political
Participation of numerous actors on creating the regional plan			Economic system is a problem • Increasing generation of waste • Leads to new technologies to deal with this that have bad health repercussions for the population, example: incinerators • Which leads to a push to secure subsidies for incinerators- heavily subsidized
			Waste trafficking is one of the most important environmental crimes worldwide
			Subsidies are taken from citizens and lead to corruption and non-efficient system
			System lock in: plants need more waste to be efficient
			In the logic of economic growth and capitalism circular economy is a not a real solution
			Problem with dataset in Europe because of leakage • 30% of waste is completely lost systematically in our economy
			Change in the Italian code was crucial and it came from struggle and not from best practices from the North of Italy
			Need to deal with the informal system where waste isn't account for and workers work informally • Change needs to come from them
			Avoid one-size-fits-all solutions such as incineration
			Need to involve all main stakeholders

			• Need for direct confrontation
			Collaboration between Region and Basin councils • Incentives that reward municipalities with best results • Fairness of prices of tariffs
			Initiatives to meet circular goals: technical table on End of Waste • Collaboration of different departments, Union of Veneto Provinces, Network of Universities for Sustainable development
			Lack of indications at national level
			Lack of network and cooperation between regions