



The Case Study of Transitioning Centralized Solid Waste Management in Lebanon: The Devolution and its Limitations

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The presented research has been written to finalize my Master Study in Environmental and Infrastructure Planning, at the Faculty of Spatial Sciences, University of Groningen. This masters is a continuation of my academic career, to my degree in civil engineering (NDU university-Lebanon), and the spatial planning pre-master's program at the University of Groningen. As for my professional career, Civil Engineering opened the opportunity to this academic adventure. In August 2020, when I started this program, Rami, Ralph and I co-founded Plastic Lab, a recycling company based in Lebanon. The startup mission and vision fit well the EIP program in general, and my thesis specifically. Believing in the benefits of the program for our start-up, I am immensely grateful for their support, conversations, technical and data resources that Rami, Ralph and the team have offered during my studies.

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Abstract

Lebanon has a poor and deteriorating solid waste management (SWM), caused by recurring crises in the sector. After the end of the civil war in 1990, the sector followed a centralized system that limited its improvement. The aim of this research is to determine the advantages and disadvantages of devolving the solid waste sector to a certain degree of decentralization. The direction of the transition that the research aims for will be centered on sustainable solid waste management (SSWM) in a decentralized system, while considering the possible roles of the central government in such a system. The National government's role will be focused on supporting the willingness and abilities of local governments to perform SWM. The focus will be on correcting the disadvantages of decentralization, related to limited economies of scale, the existence of external effects, and the weak profile of SWM in local governance, and finally drawing an institutional frame for local governments, as a reference for its governance work and targets. The research has found that the SWM system should have two types of hybridities: one on the governance level, where the central government and local authorities divide responsibilities of the sector's decision making, creating a synergetic balance of both powers toward SSWM responding to potential disadvantages of decentralization. The second, focused on the physical level, where tasks of SWM should be hybrid; the household collection task to be collected at a clustered of municipalities level, recycling and composting to be integrated with the current Lebanese industrial scene with room for improvement and finally landfilling practices to be more centralized, including tasks for monitoring and management measures. The private sector, formal and informal, are to be well integrated in the system, where most solutions do require the participation of the community and private sector's efforts.

Key words: Sustainable Solid Waste Management - Hybrid governances - Decentralization constraints- Sustainability- Degree of Decentralization

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Cover Figure

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List of Acronyms

CBO: Community based Organizations
CC: Climate Change
CDR: Council for Development and Reconstruction
CE: Circular Economy
DRI: Democratic Reporting International
EMF: Ellen MacArthur Foundation
EU: European Union
FR: Financial Resources
GDP: Gross Domestic Product
GHG: Greenhouse Gas
HR: Human Resources
HSW: Household Solid Waste
IFM: Independent Municipal Fund
IHCW: Infectious health care waste
IPCC: The Intergovernmental Panel on Climate Change
ISWM: Integrated Solid Waste Management
KR: Knowledge Resources
MoE: Ministry of Environment
MSWM: Municipal Solid Waste Management
NGO: Nongovernmental Organization
NIMBY: Not in my Backyard
OSMAR: The Office of the Minister of State for Administrative Reform
PLO: Palestinian Liberation Organization
PPP: Public and Private Partnerships
RoI: Return on Investment
SDG: Sustainable Development Goals
SME: Small and Medium enterprises
SSWM: Sustainable Solid Waste Management
SW: Solid Waste
SWM: Solid Waste Management
TR: Technical Resources
UN: United Nations
UNDP: United Nations Development Programme
WTP: Willingness to Pay

Chapter 1: Introduction

Climate change (CC) is widely accepted as being among the largest human made threats to our societies (IPCC, 2022). It is manifested by unpredictable and acute natural hazards (IPCC, 2022; Steffen, 2015). The rise of environmentalism in the 1970's started the 'shy' transition in awareness of the impact of our behavior on the environment (Pak, 2011). In response, spatial and environmental policies and infrastructure projects are more and more taking into consideration the environmental and social aspects in parallel with the economic impacts (Broto, 2016; Lemos, 2006).

Solid waste management (SWM), is one of those infrastructure systems that has many variables, taken from its complicated nature. Waste is a by-product from human activities, coming from residential, industrial, commercial, and agricultural practices. Waste is a consequence of our economic and social lifestyle (Kaza, 2018). Its journey starts from the mentioned above sources, gets collected from the public or/and private sector, transferred to stations, directly dumped in landfills, or put in incineration plants. In transfer stations, if the waste initially is not segregated, sorting could take place extracting recyclable materials to be used for recycling, composting and waste to energy (Bui, 2022; Shekdar, 2009).

In the transition toward sustainable SWM (SSWM), many factors should be taken into account. Among them, is a reliance on more centralized or decentralized forms of waste collection, sorting and disposal, which both have their assumed advantages and disadvantages. After analyzing the advantages and disadvantages of centralized and decentralized systems in general, this research will focus on four main points that are shaping SWM; which are interconnected. Firstly, the physical system for SWM, a centralized, hybrid or even decentralized system, are important factors influencing transport flows and pursuing a more integrated approach, on the meso (provinces) and micro (municipal) level (Bui, 2022; Kojina, 2019). Secondly, a multiplicity of (new) stakeholders is involved, ranging from the public, private and community sectors, in collecting, sorting, and recycling who are either competing or working together in a holistic approach (Bui, 2022; Mmereki, 2016). Thirdly, integrating the SW sector with other sectors, such as energy, which is generated through incineration and biomass (De Boer, 2015; Kusnetsova, 2019), or the transport sector, by reducing waste mobilization cost and transport distances, or the industrial sector with the recycling scene, and even the agricultural sector transforming the organic waste into compost. Finally, the increased call for a more circular approach does align with the latter three mentioned points in this transition toward SSWM, with the thought of better understanding human behaviors, when it comes to waste and responsible consumption (Bui, 2022; Sariatli, 2017; Steffen, 2015).

The Sustainable Development Goals (SDGs) set by the UN during the Paris Agreement could be used as a guideline to push for a transition to SSWM, in response to the 17 SDGs (Figure 2). Challenges in SWM are diverse and it include soil, water and air quality around landfills, which affects the health of the community (Rushton, 2003; Tian, 2013). Methane released from landfills

increases greenhouse gasses (GHG) which is one of the contributors to CC (Alam, 2013). Plastic run-off is another major issue caused by unsustainable practices of SWM (Lebreton, 2019). Finally, the linearity of our economy, where the resources are being extracted, transformed and disposed of, with a very short life cycle, is draining our planet's resources at a high pace, with an environmental and polluting side-effect, deteriorating the status of our ecosystems (Sariatli, 2017). A new model called the circular economy (CE) approach is still under development, made to counteract the effects of the linear thinking of society's lifestyles, where consumerism is high. The "R's" concepts stand for refusing, rethinking, reducing consumption or responsible consuming behavior, reusing, refurbishing, remanufacturing, recycling and recovering products (Geissdoefer, 2017; Leider & Rashid, 2016; Mandpe, 2022).

The concept of CE is still not well defined, with academics and practitioners interpreting CE differently, as is visible in considering the multitude of 'R's as part of CE. This shows that CE remains in its infancy with much development to come. Nowadays, CE is also linked to a wider transition towards SSWM (Mandpe, 2022; Sariatli, 2017; Steffen, 2015).

Figure 1: United Nations' 2015 SDGs



Source: FUND, 2015

Transitioning towards SSWM follows various goals of the SDGs. Most importantly, SDG 9, 12, and 17. Nevertheless most SDGs are included and/or influence that transition. Table 1 showcases the main points present in SSWM based on the relevant SDG.

Table 1: SSWM X SDGs

SDG #	Transition from SWM to SSWM Relation to the SDGs
SDG 1	Sustainable practices will preserve resources, working against poverty such as recyclables and organic waste generating income.
SDG 3	SSWM reduces pollution from landfills that could affect health and wellbeing of communities
SDG 4	Sustainable education is part of SSWM, raising awareness and education on consumption behavior.
SDG 6	Groundwater protection from leachate and landfill pollution
SDG 7	Waste to energy lowers waste sent to landfills while creating energy
SDG 8	SSWM opens new sectors, especially in developing countries in the industrial (recyclables) and agricultural (organic waste) and energy sectors, generating new job opportunities.
SDG 9	SSWM is directly evolving the infrastructure of SWM toward a resilient and sustainable sector. Enhancement of best practices in the waste sector leads to a more sustainable sector. Development of the sector in developing countries is one of the main aspects of that goal.
SDG 11	SSWM is part of national and regional development planning, for resource recovery and efficiency and policies related to inclusion.
SDG 12	Most important goal in SSWM where many key points are highlighted such as consumer behavior, waste management, CE, sustainable practices etc.
SDG 13	Climate change requires reduction of emission, which SSWM aims to do in its practices.
SDG 14	Protecting the marine environment from waste pollution, specifically from plastic and hazardous materials and chemicals.
SDG 15	Open dumps solutions from SSWM, protecting land environment from waste pollution.
SDG 17	Partnership goals are important and relevant to all other SDGs such as creating partnership between the public and private sector for a SSWM. Integrating different sectors with SWM is a must for the transition toward sustainability.

Source: FUND, 2015; Hák, 2016; Rodić, 2017.

Transitioning to SSWM is taking many shapes within different contexts, and many gaps in this transition exist depending on: the internal political stability of countries and regions, the SW infrastructure sector and its history, the institutional barriers or voids found in a decentralized system (Beunen, 2019), and the economic and social conditions present in the case (Kinnaman,

2009; Mmereki, 2016; Shekdar, 2009). The research focus will be on the Lebanese SWM sector. Highlighting the shortcomings of the present sector, and the possible transitions needed to move towards a more sustainable and efficient sector.

Lebanon is a Middle Eastern country with an area of 10452 km² and a population of 6,750,000 inhabitants (Worldometer, 2022). The Lebanese SWM sector is in poor and deteriorating condition (Abdi-Ahad, 2020; Massoud, 2019). During the Lebanese civil war (1975-1990), many services were disrupted, one of them was the SWM sector. Consequently, SWM solutions were ad hoc in e.g., informal dumping and the sector faced its first post-war crisis (Sadek, 2000). After the civil war, municipalities did not have the financial, technical, and infrastructural capacities to implement a SWM strategy, while being formally (by law) responsible. In response, the central government stepped in by privatizing the sector until a structured master plan was drawn (Jadam, 2010; DRI, 2019). Strategies were built around the same measures as applied during the civil war, unorganized collection and dumping. This led to the waste collection and informal dumping crisis to reoccur in different intervals (DRI, 2019). Waste was not picked from the streets or local bins and partial solutions were implemented, by treating the symptoms with very little innovative and sustainable plans (Basim, 2016; Massoud, 2019).

The solutions on the physical level were focused on opening new landfills, to cover the waste demand disposal. This choice is not without controversy or problems. For one, the crisis was reoccurring when landfills reached their full capacity, or when political and social pressures were present for closing the dumping site for environmental and health reasons (Khawaja, 2017; Massoud, 2019). In the face of the recurring crises, the national government repeatedly took a dominant role by allocating SWM responsibility to a limited number of private companies (Verdeil, 2017; DRI, 2019). The companies were hired by the central government even though the Lebanese legal system dictates that SWM falls under the responsibility of the municipalities (Khawaja, 2017). Secondly, the lack of political stability and of transparency led the sector to adopt the same emergency plans that resulted in this recurring crisis. Thirdly, transportation distances and the lack of tailor-made approaches to local circumstances in a centralized SWM sector also contributed to environmental and economic losses (Massoud, 2019; DRI, 2019). The aim of this research is to find a transition in this sector on the governance and physical level toward a more SSWM in Lebanon. Notably, this research will assess the advantages and disadvantages of more centralized and decentralized forms of SWM and how these may be combined within a Lebanese context.

While this study focuses on Lebanon, the case shows similarities with other regions across the globe. Studies also reveal some of the common problems encountered in Lebanon and also provide suggestions for improvement (Kojina, 2019), by giving examples on the problems of local SWM that are being generated in other countries. The case of plastic debris in the Oceans and how economies of scale in small municipalities are being solved by including the private sector are key examples of such examples. According to Kuznetsova (2019) combining both physical systems (centralized/decentralized) could help the success of this transition toward SSWM. Population, type of waste, financial resources, awareness, sustainable lives, access to infrastructure and technology are key components for SWM (Bui, 2022; Mmereki, 2016). Decentralization in the SWM sector has several advantages allowing for such a more tailor-made

approach, proactively drawing strategies and involving local stakeholders in the process. As for the disadvantages, the willingness and ability of the local level to organize and afford SWM may be limited due to a lack of economies of scale, the relatively weak profile of SWM as compared to other local (political) priorities and external effects due to assuming 'others' will solve the problem. All these limits will be discussed in more detail in section 2.1 and 2.2. **The research elaborates** specifically on how decentralization may be pursued in the SWM in a Lebanese context given the risks of (a) encountering disadvantages of decentralization and (b) the ability and willingness of key actors on the local and national level.

In my research, I will argue how municipalities may respond to the disadvantages of decentralization, and in doing so, establish agreements, collaborations and partnerships with sorting, recycling and awareness companies and with organizations in the private and public sector. **This study explores** to what degree and how the devolution of centralized SWM in Lebanon may be a strategy to support a transition to a more sustainable and efficient SWM. This research will be done in collaboration with several SW facilities (municipal and private), NGOs and municipalities, informal pickers and data collection from the central government.

Aim of the Study

The Lebanese waste crisis requires a transformation and transition in the SWM sector, moving away from a sole reliance on a poorly functioning central waste management sector, in terms of both efficiency and effectiveness (DRI, 2019). The result of the study could be valuable for exploring how far to move from centralization in the SW sector (Llanquileo-Meglarejo, 2021). Additionally, it will examine the willingness and ability of the actors at each level and sector (local and national, private, and public) for this transition. This will help us understand the relationships that can be established across levels, related to this transition overcoming obstacles such as economies of scale, external effects, and weak profiles related to the system. Finally, this research will add to the many case studies on the jump from a centralized to a decentralized or hybrid SWM, from different contexts and explore the limitations of that transition, proposing possible solutions for a transition toward SSWM.

The central aim of this research is to identify how the SWM sector in Lebanon can be transformed to be more sustainable and efficient, while considering the advantages and disadvantages of decentralization of the sector, and how far can we move from centralization. Answering the following questions will help reach the target of this research:

Primary Research Question

- To what degree and how may the devolution of centralized SWM in Lebanon be a strategy to support a transition to a more sustainable and efficient SWM, while considering the advantages and disadvantages of more centralized and decentralized forms of SWM and how these may be combined?

Secondary Research Questions

1. What are the potential benefits of decentralizing SWM regarding efficiency and sustainability? And what are the potential risks and limitations regarding that efficiency and sustainability, also considering benefits of more centralized systems?
2. What are the key constraints on local (decentralization) willingness and ability to cope with SWM tasks?
3. Who are the key actors on the local level, how can they be involved and how do they perceive these benefits and risks?
4. How can hybrid combinations of central/decentralize SWM allow to ameliorate risks and harvest benefits and what may be the role for the central government?
5. How can we merge the SWM process for several municipalities, considering the high number of municipalities (1108 municipalities over 10452 km²), and how may this help SWM?

Research Approach and Outline

This study followed a qualitative research method combining literature review, policy review and semi structured interviews. The study first in chapter 1 introduced the research, and gave an overall background on SWM, (de)centralization and the Lebanese context. The research objective and questions were discussed showcasing the importance of transitioning toward SSWM. Chapter 2 will help the reader understand SWM in different systems discussing the theoretical background and relevance across different contexts and levels. The sector will be discussed on the governance and physical aspect of SWM. Categories will be unpacked showcasing the advantages and disadvantages of centralization and decentralization in the categories. Relevant solutions to the Lebanese context will be presented thoroughly which will help this paper determine a favorable configuration of systems toward a sustainable SWM. Chapter 3 will be focused on the methodology of this research for the chosen method to collect data for this research around the SWM in a Lebanese context, to answer the research question. Chapter 4 will focus on the data collection through academic literature or interviews conducted during the study or from other secondary sources. The presentation of findings will help the reader understand the Lebanese SWM context, the (dis)advantages of the current system and the constraints that the sector has from being sustainable. Chapter 5 will discuss the findings and the transition toward SSWM in the Lebanese context. Recommendations will be shared. Chapter 6, conclusions and limitations will be showcased, opening rooms for further studies toward this transition.

Chapter 2: Theoretical Background

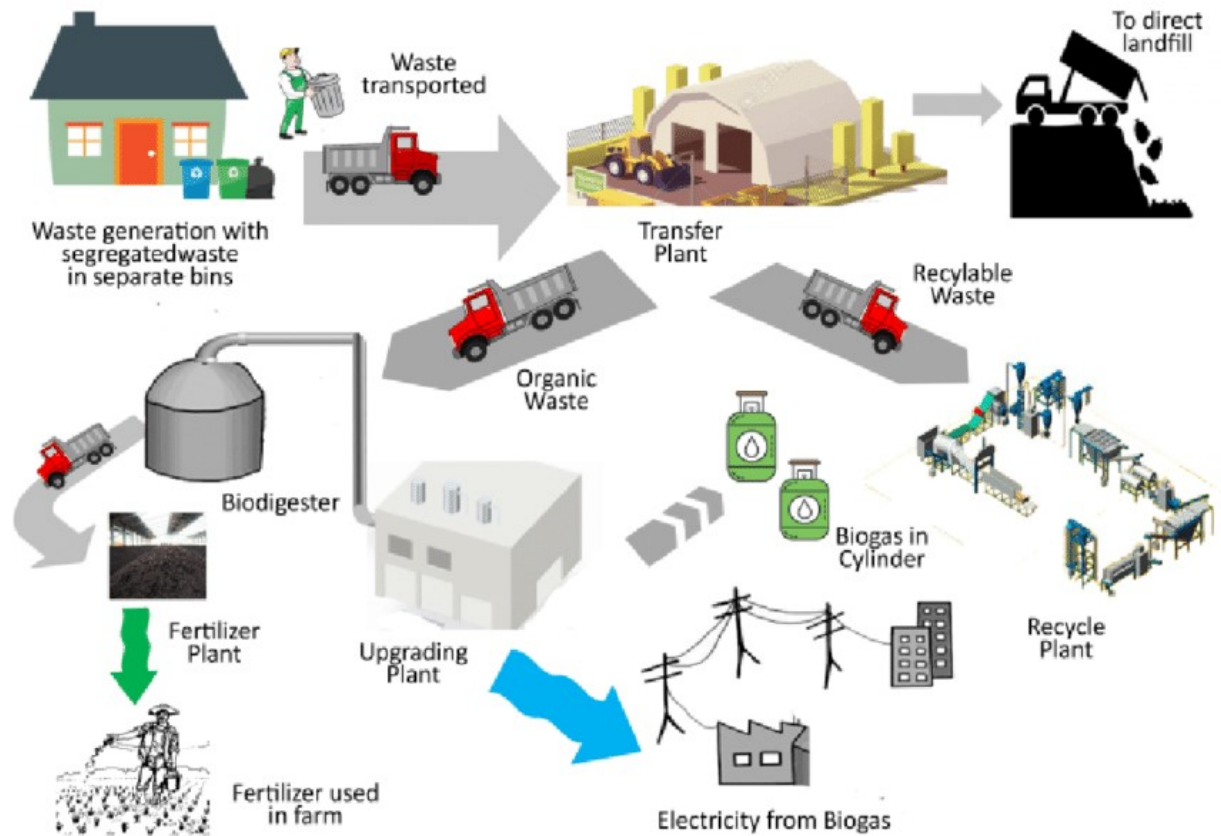
SWM and its relevant infrastructure have many physical compositions (collection, transferring and landfilling) on all levels of governance. There are many variables that can affect the sector such as the waste composition and its relation to the GDP, the financial situation of the city/country (Bui, 2022; Mmereki, 2016), the behavior and awareness of communities toward consumption behavior, the type of collection and the favorite system to be adopted in the particular contexts. Anwar (2018) mentioned 3 systems: centralized, decentralized, and clustered. Depending on the context, one of these three systems can be chosen, while considering a combination of the 4 categories of waste treatments: sorting, composting/recycling, waste-to-energy and landfill (Anwar, 2018). This illustrates that organizing an SWM system, thus, will need to consider a variety of criteria.

Recent lessons indicate that growing urbanization followed by the growing consumer behavior, is putting a lot of pressure on central systems for SWM, sometimes pushing for a tailor-made approach that is more suitable for the transition towards SSWM (Bui, 2022; Kuznetsova, 2019; Mmereki, 2016). Decentralization in a physical sense has many assumed advantages, such as increasing efficiency and effectiveness of the recycling and composting activities, reducing transportation cost etc. (Araya, 2018; Bui, 2022; Mmereki, 2016). The first section of this chapter will discuss the SW sector itself, its stages and processes. The second section will categorize the stakeholders in SWM scene, public, private, community and informal actors. The third section will explain the key organizational challenges regarding SWM: governance and physical systems of SWM. The fourth section will unpack the advantages and disadvantages of a centralized and decentralized system, and how to overcome the disadvantages and limitations of decentralizing the SWM based on academic literature. In doing so, this section draws from literature on decentralization in governance (e.g., Zuidema, 2016), concluding with the research analytical framework.

2.1 SW Stages and Process

Waste is a generation of unwanted things from society (Min'an, 2011). Society that involves mainly the residents generating residual waste. Not all residual waste is collected using the same process. Figure 2 gives key aspects of the waste process, from generation to dumping. Separating hazardous and non-hazardous waste is essential to reduce and eliminate contamination of other waste and landfills. Hazardous waste is more present in hospital, industrial and agricultural waste than residual and won't be the main focus in the research but should be treated separately. The main focus will be more on residual waste.

Figure 2: The Household Waste Process



Source: Mahrajan, 2019

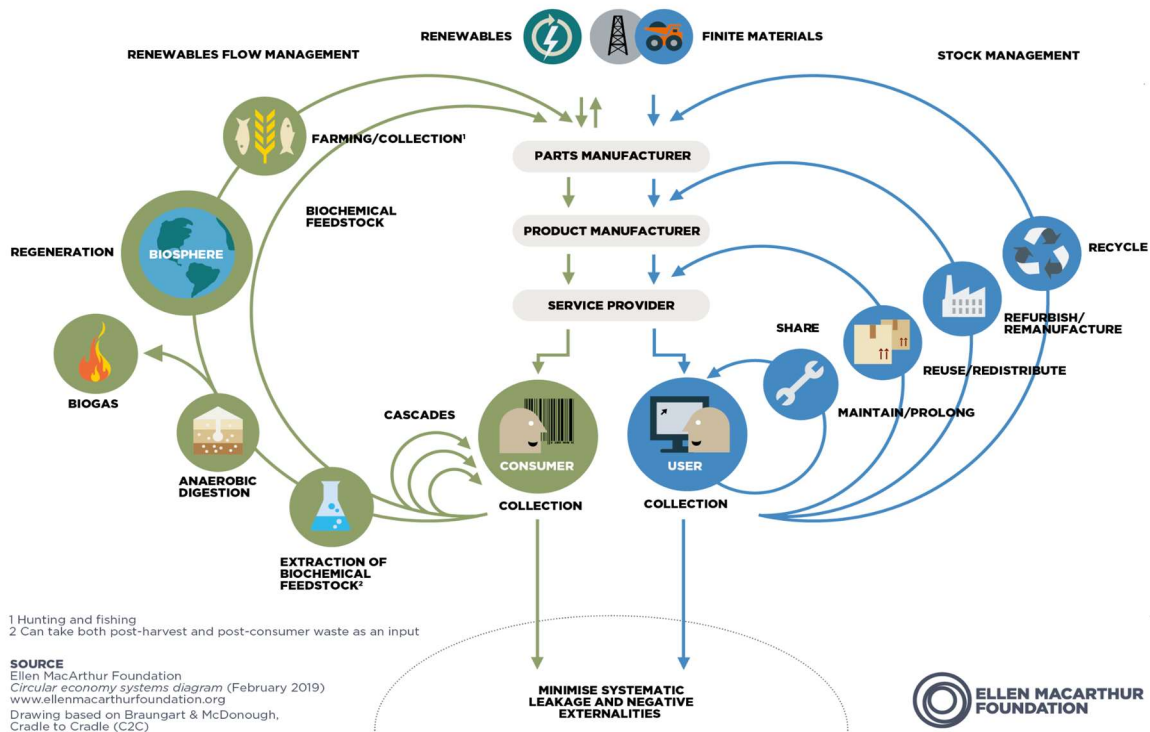
The collection from households could have several shapes. Waste has different characterization in waste composition between countries, containing organic waste, plastics, metals, paper and cardboards, electronic waste, glass, etc. Many types of disposals could take place that could but not always, include waste separation before or after disposal. Sorting at source and collecting separately the recyclables and organic waste is one of the methods (Rousta, 2020). Other methods of collecting household waste, sorted or not, could be from curbside bags, or from bins located in neighborhoods (Kinnaman, 2009). In densely populated areas, recyclables could be traded for cash from residents to local sorting entities, where local residents visit the facilities to trade the waste. Kolte (2021), gave the example of cash for trash in India, especially in the e-waste scene, creating new business opportunities. Finally in contexts with the high presence of the informal sector, bins are scavenged and drained from recyclables (Imam, 2008). This phenomenon is popular in developing countries with picking waste from bins (Wilson, 2006).

Transportation of waste is done differently, according to the context, stakeholders involved and methods. In developed countries, many cities segregate their waste from the source and collect the waste separately on a weekly basis. For household waste, separation could be organic and

non-organic, and even many cities segregate the recyclables, which will increase the trips of collection (each type of recyclable) (Dubey, 2020). Transportation of waste has many means such as compactor trucks, cranes to empty underground containers, regular trucks, pick-ups, reduced to tuktuk depending on the actors collecting and geographic, social and economic context and waste characterization (Kinnaman, 2009; Miranda, 2015). If waste is separated at the source, it will be transported to a transfer station or directly to recycling factories.

Organic waste can be processed in different ways, through a biodigester turning the organic waste into biogas, biomass, and even fertilizer and composting. Lastly incinerators and waste to energy could be another solution. Organic waste that is transformed to compost, fertilizers, biogas, and electricity, is integrated in the agriculture, industrial and energy sector (Pant, 2012; Westerman, 2005, De-Boer, 2015). As for recyclables such as paper, steel, aluminum, paper, glass etc. after treatment, the recyclables are sent to recycling centers and industries using recyclables, after enhancing and recovering its recommended manufacturing characteristics (Delveve, 2019; Pensupa, 2018; Tam, 2006). Recycling and composting are being widely expanded and innovated within one of the stages of the CE approach as observed in circular approach Figure 3.

Figure 3: CE Approach for Recyclables and Organic Waste - Butterfly Diagram



Source: EMF, 2019.

Finally, the unprocessed, not recycled or processed non recyclables waste are usually sent to sanitary landfills or incinerated. Landfilling generates GHG (Onyanta, 2016), aggravating the effect of CC (Sadavisam, 2014), creating a vicious cycle between hot waves of CC effect on landfills that generates GHG (Bouzonville, 2013; Fei, 2021). Sanitary landfills are theoretically the

last resort for any country, but the percentage of waste landfilled in countries differ greatly (Eurostat, 2023; Kaza, 2018). The less percentage of landfilled waste is being generated, the better the waste sector is considered to perform (Kaza, 2018). Most developed countries have a low percentage of transferred landfills such as Sweden (9%) (Infographic, 2018). Other countries have a higher level of percentage such as New Zealand that is 77% of total waste not treated divided between landfills and open dumps (Kaza, 2018). SWM might lack sorting, composting, recycling, and incineration facilities that will increase the percentage of waste sent to landfills. Open dumping and illegal incineration are present in almost all countries, leading to unsustainable practices of SWM. Most illegal forms of dumping are to be found in developing and poor countries (Kaza, 2018).

2.2 Stakeholders Relevant in the SWM: Informal Pickers, Private, and Public Sector

Stakeholders in SWM are numerous and their roles and presence can vary from one system to another. The main stakeholders can be differentiated based on the governance triangle (Lemos, 2006): public sector such as the national government and municipalities, private sector such as private sorting facilities, waste collection organization, recycling and incineration facilities etc.(Anwar, 2018; Bui, 2022; Shekdar, 2009). Additionally, we have societal involvement such as international and local NGOs working on social awareness around SWM, neighborhood committees. Meanwhile, informal pickers are not categorized and could be placed in a category between the private and community. Informal pickers play an important role in shaping the SW sector in developing countries. In some contexts, informal pickers are the only sorters and recyclers in the system (Anwar, 2018; Bui, 2022; Mmereki, 2016).

2.2.1 Public Sector

The public sector differs in responsibilities and functions depending on the system and its level of centralization or decentralization. In a centralized oriented SWM, depending on the scale and context, the central government mainly manages the waste sector and is responsible for the decision making of the allocation of resources while creating partnerships with the private sector if needed. On the local level such as municipalities or regional authorities have little influence and can only help and facilitate the master plan drawn by the central government, followed by a top-down approach (Oliveira, 2019). Abedin (2015), as an example, Bangladesh, where the national government has a fixed system across the country to deal with the waste management, policies are uniform across the country, where the municipal authorities are only responsible for collecting the waste with very little guidance in terms of sustainability from the central government, and no room for maneuvering in their governance. The system has a lack of regulation related to waste management, affecting landfilling activities. Communities have little awareness and there is a lack of adequate technical and financial resources for the proposed enhancement of SWM (Abedin, 2015). As for the decentralized SWM, the local authorities such as municipalities have a bigger role in the decision-making and operational implementation in the SWM (Abdein, 2015; Gadenne, 2014). The Netherlands has a decentralized system in the SW sector, where the 344

municipalities in the 12 provinces (*CentraalBureauvoorStatistiek, 2021*) are directly responsible for SWM. One of their tasks is waste collection, where each municipality has the freedom to decide on the operational system depending on the context and the relative residents (Rijksoverheid, 2010; Rijksoverheid, 2012). MSWM requires more integrated management including more stakeholders with a hybrid top down and bottom-up approaches (Shekdar, 2009; Mmerekhi 2016). In other words, a more centralized sector has a top down approach where the only decision maker is the central government. On the other hand, with decentralized SWM the municipality has a stronger position, integrating all stakeholders on a local scale, favorably building tailor-made approaches.

2.2.2 Private Sector

SWM is a complex sector that involves several stages in the process, from the waste source, to collection, sorting, treatment, and ultimately, reselling or landfilling (Abedin, 2015; Bui, 2012). In many contexts, the public sector hires, privatize or partners up with the private sector to do one or more of the tasks of SWM (Bui, 2022; Mmerekhi, 2016; Shekdar, 2009). The private sector could be involved at each stage of the process, either as a generator of waste or on the operational side. Table 2 shows different types of private sector involvement in the process.

Table 2: Private Sector Roles or Activities in SWM

General Involvement in SWM	<ul style="list-style-type: none"> ● Environmental and waste experts ● Consultants for SWM plans ● Waste monitoring companies
SW Generated	<ul style="list-style-type: none"> ● Residential waste (dwellings) ● Commercial waste (Hotels, Stores, restaurants, markets, buildings, office) ● Institutional waste (schools, governmental bodies, prisons) ● Industrial waste ● Municipal services (landscaping, streets, parks, beaches, recreational areas caused by littering)
Collection System	<ul style="list-style-type: none"> ● Bins manufacturer (household, neighborhood level different types) ● Collection companies' door to door, neighborhood, focal point (depending on the company and context), cash for trash etc
Transportation	<ul style="list-style-type: none"> ● Compactor trucks ● Tuc-tuc ● Trucks
Sorting and Processing	<ul style="list-style-type: none"> ● Transfer station (sorting facilities) ● Treating and cleaning facilities ● Recycling & refurbishing facilities ● Waste to energy facilities (incinerators) ● Composting facilities ● Biomass and biogas facilities
Landfilling	<ul style="list-style-type: none"> ● Landowners ● Landfill operation companies for sanitary landfills

Source: Bui, 2022; Mmerekhi, 2016; Ndongye, 2022; Kinnaman, 2009; Mahrajan, 2019; Shekdar, 2009.

The private sectors mentioned are not always present depending on the governing system. Stakeholders could be positioned in competing positions depending on the type of collection, the sorting and processing method and the landfill availability. Private actors will have advantages/disadvantages depending on the context, taking into account geography, density (Khan, 2014), and the waste composition affecting the type of collection, as well as the processing and sorting (Anwar, 2018; Bui, 2022; Kuzentzova, 2019; Oguweleka, 2009). Incinerators and compactor trucks for example, are less suitable in developing countries. High organic waste composition with high moisture will reduce the heat exchange (Bui, 2022, Mmereki, 2016) and compactor trucks are not efficient in collecting organic waste (Ogwueleka, 2009). In conclusion, stakeholders in the private sector are dependent on many variables between the physical aspect to the governance and policy aspect set by the public sector (rules of the game). Stakeholders involved cannot be confined to one specific activity, as they may be involved in executing multiple tasks.

2.2.3 Community Involvement, NGOs, and CBOs

The community involvement will be focused on community awareness and the role of (inter)national community-based organizations (CBOs) and nongovernmental organizations (NGOs). Residents have a major impact on the SWM (Rijksoverheid 2012), the community can affect the private sector's solutions for municipal SWM (Johnson, 2012). (Inter)national NGOs play an important role in many contexts in shaping and raising local awareness with those residents, promoting SSWM solutions across sectors based on the SDGs (Habila, 2022; Henry, 2006; Johnson, 2012; Kamaruddin, 2013). The CE concept was discussed firstly in 1982 by Stahel (1981), which inspired many researchers and organizations to promote CE in the SWM such as the Ellen-Mcarthur-foundation. Many NGOs employ the CE strategy to aid in the achievement of the aforementioned SDGs while raising social awareness (Sharma, 2021). Sharma (2021) contends that decentralization is necessary for this transition to SWM, with finance for the private sector coming from NGOs operating locally (Gadenne, 2014; Sbeih, 2021). Additionally, in case there is a gap in SSWM, specifically in developing countries, the NGOs could play the role of waste collectors, policy implementers and promoters of social awareness related to waste (Abedin, 2015). Harikrishnan (2014) adds that NGOs could play a crucial role in participating and aiding the public sector in achieving desirable goals of SWM. A lack of knowledge resources might affect NGO participation toward the desired goals (Harikrishnan, 2014). NGOs have many important roles alongside the private and public sector in transforming the SWM toward sustainability, such as financial and grant manager, promoting social/environmental awareness, and policy advocacy (Abedin, 2015; Gadenne, 2014), taking the responsibility for filling the gap of the public sector in developing countries (Harikrishnan, 2014).

2.2.4 Informal Sector

Informal pickers are present in several contexts, searching for recyclables in dumping areas and landfills, neighborhood bins, picking littered waste from the streets and industrial areas (Aljaradin, 2015; Sembiring, 2010). Informal pickers in developing and poor countries are more present than in developed countries, and have more influence and power (Anwar, 2018; Mmereki, 2016). Scavengers collect recyclables and sell them to recycling industries (formal and informal) (Matete, 2008). The process of scavenging happens in many contexts and in different dynamics. Anwar (2018) explains that the informal pickers in the Egyptian context are called 'Al Zabaleen' which means garbage collectors in Arabic, and they are the major recyclers in Cairo, collecting the organic waste and transforming it into compost. Same goes for Nigeria, where the informal pickers, usually members of vulnerable families, recycle around 8% of the 60% organic waste (they use pushcarts to collect recyclables from transfer stations). The informal sector in communities where the public sector is not collecting the waste properly, could fill that gap by getting fees from households to collect their waste informally, and selling it (Ogwueleka, 2009). Informal pickers have negative environmental and health impacts, such as polluting the groundwater and threatening their own health (Ogwueleka, 2009). Another negative impact is the draining of the municipal waste from recyclables, which will discourage municipalities to sort their waste, because of the high operating cost and the low return on investment(ROI) (Shekdar, 2009). The informal sector in some contexts are powerful actors in the SWM and fighting them could create opposition to the mentioned plans (Alemu, 2017). Informal sector could be a key factor in improving the SWM if handled properly. Decision-makers should work closely with this sector, giving them training and workshops for better recycling and integration in the system (Alemu, 2017). NGOs and the public sector through partnerships should transform this sector in the SWM transition through an integrated approach lowering the chances of opposition (Alemu, 2017; Bui, 2022; Ogwueleka, 2009; Shekdar, 2009). As a context of this research, the informal sector is strongly organized internally, considered as the main recyclers in the country. Directly confronting the sector would be prone to failure. Structured governance, inclusion and formalizing the informal sector in Lebanon will be discussed further in chapter 4.

2.3 Differentiating the Governance and Physical Systems of SWM

In this section, centralized and decentralized systems will be presented in SWM. Before discussing these systems and their relevant (dis)advantages, we should highlight that the SWM systems are divided in this research into two aspects. Firstly, the physical (geographic and process) aspect of SWM that was presented already in the collecting, processing, recycling/composting, and dumping activities, and secondly related to the governance of the system that includes policy making, institutions and decision-making that determine and draw guidelines for the best practices of SWM, facilitating the implementation of the physical aspect. The Actors presence is dependent on the responsibility of the relevant task, and the decision-

making process is heavily dependent on the configuration of the system chosen in SWM, from both governance and physical perspectives.

This research categorizes the physical aspect into two parts: geographical boundaries of SW collection and the process practices that sometimes could be outside the geographical boundaries of the collection creating a hybrid system. Firstly, the geographical boundary will be described followed by the physical process practices related to the geographic boundaries. Finally, the governance systems will be discussed.

For the geographical physical aspect: Anwar (2018) in his comparative study, defined 3 types of SWM: Centralized, clustered, and decentralized. A centralized system has one major and central operation across a relatively big area such as on a national scale in small countries, or a state/region scale in larger countries. A clustered SWM system is a group or coalition of municipalities, to have one collection and one sorting operational sector. Finally, the decentralized system, which operates on the micro level and takes into account the local aspect of SWM, has a localized municipal collection center with a localized sorting facility (Anwar, 2018). For example, in India, 2 separate provinces showcased by Harikrishnan (2014) have different physical approaches. The province of Kerala has a geographic and physical centralized SWM, whereas the province of Tamil Nadu has a decentralized physical system. In large countries, centralization could be applied on the level of provinces or states such as the United States, India, and China etc., where states could be larger than other countries.

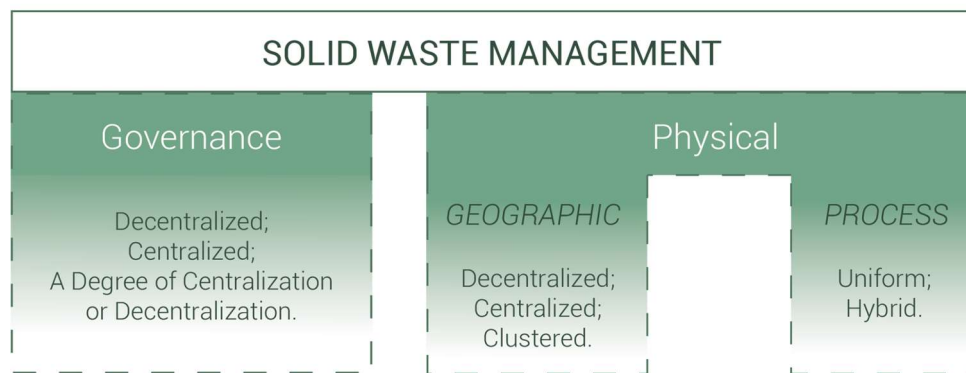
As for the physical process, SWM as discussed has several stages of physical activities (collection, transport, transfer, recycling etc.), that could be found in contexts hybrid in practices. For example, a system could have a decentralized collection, sorting, recycling system but have a centralized dumping site, which makes it in this research a hybrid physical system. In the study of Anwar (2018), he considered that all the physical activities of SWM are the responsibility of one governance level and practiced physically (sorting, collecting, etc.) either in a central, decentralized or clustered in the boundary of its geographic jurisdictions taking a uniform shape. In practice, this may be much more nuanced. On the other hand, Kuzentsova (2019) mentioned the physical hybridity of practices is found in the case of Singapore, where transition toward integrated SWM is being shaped, covering many sectors at once, i.e. waste to energy.

Finally, the governance system, which includes decision-making, policy drawing, institutions and laws that kind of determine the physical and geographic boundaries of SWM zones, while organizing, conducting and monitoring the process, will be discussed. In a centralized system, governance originates usually from the national level, using a top-down approach, drawing policies for a (de)centralized physical system. On the other hand, in a decentralized governance, decision makers will be closer to local stakeholders in the SWM related to the physical and geographical aspect. If the scope of the work is too big in a decentralized system, task delegation is observed in some contexts, to higher levels, due the lack of resources (human/financial). As an example, small municipalities around Groningen such as Haren, delegate its permits and governance of SWM to the municipality of Groningen, having a larger capacity (Od-Groningen, 2023). This will be examined and reflected more in the following sections while tackling centralization and decentralization.

The degree of centralization/decentralization is based on the literature of De Roo (2004, 2017), where he links the degree of decentralization with the complexity theory. From this spectrum, ideally, function and structure are contingent: the more complex the system is, the more decentralized the system should be, including a multitude of stakeholders with an integrated approach.

This results that the SWM sector has a large set of systems that could be combined and chosen from, depending on the context's scale, criteria of waste and transportation, community, geography, density and governance. Stakeholders could really influence the SW scene caused by the multitude and complexity of SWM, not to mention the roles and responsibility between the private and public sector that could be different from one context to another. In the figure below, types of systems that the SWM could have, from the physical geography, physical process aspect and type of governance are presented.

Figure 4: Systems of SWM



Source: Sbeih & Marques, 2023.

In this research the study is around the SWM sector in Lebanon, that is a small country, primarily with an unstructured governing body of the sector (DRI, 2019), thus the focus will be more on the governance part, that eventually, its decision-making will affect the physical system of SWM in Lebanon. The following section will describe the advantages and disadvantages of a centralized and decentralized system both on the governance and physical aspects. Zuidema (2016) built on this, worked closely on the shortcomings of decentralization, and how centralization could still play a role in the transition toward decentralization. Three key constraints to potential local willingness and ability to perform decentralized tasks were determined: economies of scale, weak profile, and external effects, which help this research to compare both systems in SWM on every aspect. The following section will be built on those phenomena, and discuss it in the context of SWM, taking into consideration the many governance, physical and geographical systems.

2.4 Centralization versus Decentralization: Advantages and Disadvantages in SWM

Deciding on the best system in SWM with the complexity of governance and physical aspect of the sector is dependent on many criteria related to the context, policies, society, institutions, laws, level of stakeholders' engagement, access to resources such as financial (FR), knowledge (KR), human (HR) and technical (TR). In this section advantages/disadvantages of a centralized/decentralized system in SWM will be discussed respectively. After comparing both systems, and focusing on the limitations and constraints, the section will be suggesting how to choose the SWM system and how to make it work, overcoming shortcomings.

2.4.1 Centralization in SWM

Centralization in general has many advantages as a system (Anwar, 2018). First, economies of scale refer to the benefits that larger units have over smaller units. Economically, this refers to the relative lower cost per unit of output once the overall output is increased, which applies to e.g., recycling installations or incineration plants. In organizations, economies of scale refer to the greater capacity of larger units to attract qualified personnel, ensure functional specialization of personnel in relevant expertise, and reduce repetitive tasks and to allocate resources, (Zuidema, 2016). In SWM, such economies of scale are also crucial to e.g., being able to have a large enough service area to hire garbage trucks, create sorting or recycling centers and hire sufficient qualified personnel. On the physical level, centralized systems in SWM have one facility for e.g., sorting, recycling or incineration that could create a more favorable cost-benefit situation than other systems, since operation and sorting cost are reduced, with larger amounts of recyclables, organic waste sorted in Anwar (2018). Nonetheless transportation costs could as well increase depending on the proximity of the centralized facilities, negatively affecting this cost-benefit (Anwar, 2018; Ogwueleka, 2009). Secondly, in a centralized system, governmental control is assumed to be stronger than local units (Zuidema, 2016), safeguarding the level of service of SWM. Strong policies, drawn by an ambitious central government, will help reach the target toward a sustainable SW sector, covering the physical aspect. The availability of different resources a strong profile could be drawn from a centralized system, shaping a centralized structured system, while strong policies could be implemented (Zuidema, 2016), that could reflect on investments on infrastructure projects related to SWM. Thirdly, centralized systems have the strength to coordinate actions of lower units (Zuidema, 2016), having the same quality of service, same prices for the service and same type of collection. For example, environmental protection could be secured in different areas equally, whether rural or urban, having the same policies. In the SWM it can be showcased that waste between areas is transferred only if the plan (physical aspect) and policies (governance) dictated that, controlling informal dumping and sanitary landfills spread. In that case there are no external effects within a country in the SWM scene related to unregulated spillovers of waste such as random landfill practices across borders (Antonioli, 2018; Bartone, 1991), where the central government has the power to protect the sector from unsustainable practices having a homogeneous level of service (Zuidema, 2016).

Nonetheless, a Centralized system might have disadvantages, depending on the context and the central government behind it. First Harikrishnan (2014) compared two provinces in India. Kerala province has a centralized system, where Tamil-Nadu has a decentralized one. The research explains that the decentralized system was able to handle and sort plastic and electronic waste unlike Kerala, where the centralized could not. It was explained that decision-making was closer to decision makers, which included them more in the solution. Recycling innovations were found lacking in a centralized system, as one of the disadvantages. Another disadvantage, in a centralized system, decision-makers and practitioners are far from the local unique context, where actual waste management takes place, which could prioritize the economic impact over the social and environmental. For example, Anwar (2018) compared the 3 physical systems (centralized, clustered and decentralized) in the province of Desoq, it was found that the centralized physical system was the best economic option, thus the best selection. This central selection of governance and physical system, however, might have negative social and environmental impacts, such as low recycling rates, health degradation from unsustainable practices and low stakeholder inclusion (Bui, 2022; Jesudass, 2018; Shekdar, 2009). Even in some other centralized contexts the economic impact might not be the best fit, as the proximity will be reduced, increasing the transportation cost, such as the case of Lebanon (Massoud, 2019) and Nigeria, that has a high maintenance cost in developing countries with degrading road infrastructure (Ogwueleka, 2009). Another criteria related to transportation in a centralized system, that in developing countries waste collection is not well organized, and truck collectors are mainly compactor trucks that are expensive in terms of cost, operation and maintenance, like Nigeria (Ogwueleka, 2009), Lebanon (Abbas, 2017; DRI, 2019), and other emerging countries, increasing the operation cost (Shekdar, 2009). Finally, generalizing waste stream composition in a centralized system, considering that waste composition is the same in rural and urban areas, could play a negative role in optimizing the level of service and operational efficiency and cost of the system (Boateng, 2016).

2.4.2 Decentralization in SWM

Decentralization is the devolution of power, moving away from central government control on the national level toward a more local level (Zuidema, 2016). De Roo (2004) argues that the more complex situations are, the more decision making and planning should have a participative interaction with multiple composite dependent goals. Decentralization and the devolution of power has several added advantages when compared to the central system. Governance and decision-making are closer to the local context, stakeholders can be better included in the decision-making, implying a better way to respond to NIMBY effects (Lemos, 2006) and pursue integrated solutions with SWM from other sectors (Shekdar, 2009). Lemos, (2006) discussed environmental governance, and in doing so also explained that decentralization could offer many other benefits such as unlocking the capacity of the community, and improved efficiency with closer participation in the decision-making. Decentralization will facilitate a tailor-made approach, governing in a more plural world (Lemos, 2006, Zuidema, 2016).

In developing countries, a lack of trust in the state for failed governance, could lead to a loss of trust in the states to manage the economy (Corbridge, 1992; Wunsch, 1996), which is pushing more for decentralizing the governance with integrated and innovative solutions (Silver, 2003).

Despite the different benefits discussed, decentralization also faces risks and has potential disadvantages. As Zuidema (2016) explains, there are at least three key constraints to the ability and willingness of local units, such as municipalities to successfully perform tasks and responsibilities delegated to them through decentralizations. These constraints are: economies of scale, weak profiles and external effects, that were discussed previously, and will be unpacked in relation to SWM, with the shortcomings and limitations in the SW system related to social, economic (Llanquielo-Melgarejo, 2021), knowledge and technical resources. Without sufficient time, resources and expertise, municipalities may be unable to develop a well-functioning SWM, which ranges from hiring personnel, to affording trucks and sorting facilities and the control and maintenance of companies that may be hired to perform such activities for them (Bah, 2021; Bel, 2008). Hence, economies of scale matter: there have to be large enough units to have sufficient resources and personnel, which in the case of Lebanon, and its small municipalities, can be very hard to achieve, without some degree of collaboration between municipalities and thus, up-scaling to generate economies of scale. Lack of economies of scale on the governance level could lead to poor decision-making, mainly caused by the lack of environmental and SW experts in decentralized systems. For example, decentralization to the municipal level could lead to a lack of HR experts in the SW and environmental scene, having low financial and human resources. On the physical aspect, the small number of residents will generate a limited return in terms of waste resources (organic and recyclables). Having several decentralized transfer stations will increase the operation cost and decrease the RoI that comes from recyclables (Anwar, 2018). In addition, it is not beneficial for each municipality to find solutions independently, if they can learn from others (best practices) or work together. Hence, rather than reinventing the wheel, it may help to have more collaboration and sharing of good practices or even quality standards and personnel.

Another argument is that the SWM may not have the same local priority as e.g. economic development, building roads or attracting jobs. Zuidema (2016) calls this a 'weak profile', which he mostly connects to environmental objectives, but may also relate to SWM as a sector. Weak profiles in the environment and SWM might be at risk, since decision-making will be relevant to the municipalities. The willingness and ability to pursue environmental policies is under the responsibility of the local authority (Zuidema, 2016). The directed focus on the economic aspect of SWM, might result in less ambitious goals in the SWM resulting in poor environmental governance on the local level. On the physical level, in a decentralized system the availability of facilities responsible for sorting, recycling/composting might be missing which will increase the demand for landfilling waste. The weak profile of either public or private local actors, could freeze the ability of sustainable practices in SWM. On the micro level, the economic aspect is usually prioritized over the environmental and social aspect (Kamphorst, 2006; Oates, 2001) and that even local authorities might downgrade the environmental situation favoring economic growth. The willingness and ability to pursue environmental policies at a local level is generating this status of weak profile (Zuidema, 2016).

Thirdly, external effects, mostly in environmental governance, are effects that are affecting the local context influenced by the practices beyond the geographic and physical responsibilities of the decentralized boundaries. In a decentralized system, the local unit has limited or even zero power outside of its jurisdictional area. Some outside practices in the SWM scene in this case could have major impacts on the decentralized system at hand of reaching its desired targets. Good examples are CC, air pollution and urban sprawl, etc. (Zuidema, 2016), in environmental governance. External effects are described as spillovers by neighboring territory or even remote sources depending on the type of the infrastructure discussed. Collective goods produced on the local level, either from a governance or physical level are at risk from external effects. Local progress could be erased by external effects occurring on the local level (Prud'Homme, 1995). In SWM, external effects could be related to the different level of services and quality that municipalities could offer. Some municipalities could be able and willing to have SSWM (Bui, 2022), whereas some others who are not willing or able to follow through, by sending their waste to landfills that might not even be sanitary. Those practices could lead to environmental and health degradation that could not only affect the local community, but the entire society, creating this external effect to neighboring communities. In other words, the proactive push to have a more sustainable and efficient SWM may be beneficial to not just the municipalities that engage in such a push, but also to surrounding municipalities. Obviously, the costs for such a push are for the proactive municipality. Without coordination and collaboration between municipalities, the risk of having municipalities as free-riders on the work of others or not a single municipality being willing to be a 'first mover' is real (e.g. Zuidema, 2016).

Decentralized governance in SWM will involve 3 main changes. First, a change in the relation between the local and national public sector due to a shift of decision making toward the local level. Secondly, SWM will be closer to the local context and circumstances allowing for a better inclusion of local decision makers. Thirdly, proximity of SWM in both decision making and a physical sense to local stakeholders will allow for improved stakeholder participation.

Decentralization in SWM could have many implications. Bui (2022) argues for SSWM, in a more governance and physical decentralized system, municipalities could work closely with the informal sector, adopt CE approach with the residents related to consumerism, reusing and recycling, while gathering more data. Physical aspects could differ from one context to another, such as the type of treatment chosen (Anwar, 2018) i.e. as waste to energy (Kuznetsova, 2019), proximity of sorting centers, type of waste, type of collection (Anwar, 2018; Bui, 2022). Proximity plays another important physical role, reducing transport distance and costs, while indirectly preserving the collection trucks from continuous malfunctioning, reducing maintenance costs (Ogwueleka, 2009). Another argument that supports a more decentralized organization of SWM is related to waste characterization related to type of transport. In developing countries organic waste is around 50 percent (Anwar, 2018; Mmereki, 2016; Ogwueleka, 2009). Organic waste has a high level of density and moisture (Anwar, 2018; Ogwueleka, 2009). This will lead to compactor trucks, used in developed countries with less organic waste and a higher share of recyclable waste (Ogwueleka, 2009), are not as efficient for waste collection in developing countries for two reasons. First waste with a high percentage of organic waste does not need to be compacted. Secondly, compactor trucks tend to break down and face technical problems more often when the collected waste has a high organic composition (Massoud, 2019; Ogwueleka, 2009). Sorting at source could be a solution for waste diversity and characterization, which could be best

practiced at a local level between authorities, private sector and residents, separating at least organic from non-organic waste. Decentralizing governance will help create a tailor-made approach for SWM could help optimize the process and solve many problems in an integrated approach (Bui, 2022; Mmereki, 2016). Integration that could include sorting facilities, recycling, and agricultural industries, depending on the waste and community's nature. The more organic waste you have, the more initiatives related to composting, biogas and biomass have opportunities. Same goes for recyclables. Thus, this proximity will generate more interaction between stakeholders, as expected from the shift from government to governance to deal with their resources (Lemos, 2006; Ostrom, 1990).

2.4.3 Comparing Systems

Table 3 compares the assumed (dis)advantages of the (dis)centralized systems in SWM from a governance and physical perspective. Some added points that are not mentioned in the text above are included based on literature from (Araya, 2018; Bui, 2022; Shekdar, 2009; Wilderer, 2000).

Table 3: Advantages/Disadvantages in Centralizing/Decentralizing SWM

	Centralized	Decentralized
Governance Aspect	Advantages: <ul style="list-style-type: none"> • Strong governmental presence • Economies of scale • Strong profile to support action • Holistic governance capacity to coordinate and reduce external effect 	Advantages: <ul style="list-style-type: none"> • Decision makers close to context • Integrated approach • Tailor made solutions • Improved stakeholder inclusion
	Disadvantages: <ul style="list-style-type: none"> • Generalized solutions, lack of innovative local solutions for the local context • Decision makers far from context • Fewer stakeholders included 	Disadvantages: <ul style="list-style-type: none"> • Economies of Scale lacking • Risk of under prioritizing due to weak profiles • External effects • Free riders and lack of local initiatives
Geographic and Process Aspects	Advantages: <ul style="list-style-type: none"> • Large facilities • Economies of scale: High organic and recyclable generations • Same level of service across the country • Central facility, low operation cost • Access to technology 	Advantages: <ul style="list-style-type: none"> • Low transportation cost • High quality compost • Simple technology needed • Innovation in the recycling and composting • Sorting at source
	Disadvantages: <ul style="list-style-type: none"> • High transportation cost • Needs advanced technology • Low quality compost • Lack of local stakeholders' involvement • Lack of innovation 	Disadvantages: <ul style="list-style-type: none"> • Small facilities • Economies of scale: Low organic and recyclable generations • Potentially lack of stakeholders for SSWM practices • Economies of scale: more sorting and transfer stations, higher operation cost

2.4.4 Overcoming Constraints

Centralization and decentralization in SWM have many advantages and disadvantages as described above. Nonetheless systems centralization and decentralization are not two extremes as described by De Roo (2004), indicating that a system can also have a degree of

(de)centralization. The result is a hybrid mixture of a centralized and decentralized system, which can be translated here on the governance and physical. The hybridity would help overcome these constraints of both centralized and decentralized systems (Zuidema, 2016). A degree of central stimuli checks-and-balances may help respond to the constraints and thus trigger willingness and ability locally. Where some physical elements in SWM can be more central, while others more decentralize. Institutional arrangements (Beunen, 2019) are needed by the central government to secure a shift from a centralized toward a more decentralized system with the aim SSWM (Shekdar, 2009; Lemos, 2006; Nabegu, 2015). Institutional barriers that empower solely a centralized system, should be as well removed in the shift, in case the system is being transformed from a centralized system to a hybrid one, leaving room to decentralization.

On the governance level, hybridity can create a supportive role coming from the central government in managing the constraints that accompany decentralization (Zuidema, 2016). For the economies of scale, the central government will be able to assign routine jobs in SWM across the country for decision making related to the environment, health and planning experts working closely with the local sector. For example, landfill safety regulations, quality criteria, material guidelines, regulations, classification and solutions for hazardous waste. As for the weak profile and external effects, monitoring, putting targets and references (Creedy, 2007) for the local decentralized SWM would help direct it, such as maximum waste percentage landfilled, or level of circularity, supported by the central government. The central government has the role to create a frame of reference, and the guarantor of the breached policies, balancing efforts for the economic, environmental and social aspect of the local context (Mastop, 1997; Zuidema, 2016). Subsidies and grants from the international and national governments could play a role in implementing desired policies that are shadowed by the economic aspect (Zuidema, 2016). Finally, the central government could reverse weak profiles by symbolic, persuasive and argumentative policies, next to financial incentives (taxes, subsidies), inspiring ambitions of the local public and private sector. In doing so, communities will increase their willingness and ability to balance their growth more sustainable, not only focusing on the economic impact (Matland, 1995; Jordan, 2005). Lindqvist (2013) targets the hybridity in governance of SWM, taking a Swedish context. She mentions that the macro level, on the national and European level sets the frame and boundaries of the sector, major guidelines, and rules to be followed. Lindqvist (2013) argues governance should be hybrid across levels in SWM, discussing the importance of partnership between the public and private sector on the local level. Hybridity in governance is there across scales, and scopes between different sectors and stakeholders for a successful municipal SWM of the city of Helsingborg, Sweden. This hybrid approach could be explained in fighting the shortcomings of decentralization.

On the physical level of SWM, willingness and ability of local authorities could be impacted by knowledge, technical, time, money, and staff shortages. Central governments should play the role of the supporter in these shortcomings of the physical economies of scale, external effects, and weak profiles. For example clustered systems, mentioned by Anwar (2018), that are designated by the central system could solve the issue of economies of scale by increasing the geographic boundary of waste collection, thus resulting in increasing recyclables and organic residue in transfer stations, while lowering operation and transportation cost. This will affect the weak profiles of municipalities as well. The clustered system will have a stronger profile with the

inclusion of the private sector if needed, to reverse the lack of willingness and ability of the sector to be sustainable. In a clustered geographic system, where many municipalities are working together, decision-makers on the physical level are close to the context, which will push for a more integrated approach with other sectors, companies and localities. For example, Kuzentsova (2019) took the case of the transition of SWM from a centralized to centralized-decentralized infrastructure system (physical hybridity) in Singapore mentioning key enhancements in SWM and the energy sector, while integrating both. As for the external effects, having a hybrid physical SWM with the support and guidance of the national government, will help stakeholders across boundaries to cooperate to reach the required sustainability. For example, if a clustered system does not have access to biodigester in its geographical boundaries, partnering with the nearest/most suitable actor outside of its boundary. This will reverse the negative impact of landfilling mentioned above from this hybrid physical relationship (Kuznetsova, 2019). Finally, centralizing landfilling practices will lead to a limited number of landfills, which will make it easier for controlling, managing and monitoring them without any spillovers that might be generated from a decentralized system having numerous landfills. With a shift toward SSWM, the volume of waste transferred to landfills will decrease and transportation costs will be much less compared to a total centralized physical infrastructure.

2.4.5 Analytical Framework

Constraints in a decentralized system, in the governance and physical level in this research will be assessed based on four major resources that were implicitly discussed in the previous subparagraphs and are inspired by the work of van Geet (2021) and Zuidema (2016): Human resources, financial resources, knowledge resources and technical resources. On the governance level those resources will be linked to decision-making and policy making. Some adaptations were made for the context related to the governance in SWM. As for the physical level, the resources are directly related to the physical infrastructure of SWM. Such as SWM practitioners (HR). Finance for SWM infrastructure sorting facilities, recycling facilities (FR), waste characterization and resident behavior toward waste, sorting at source (KR) and finally technology in collection, treating and landfilling (TR).

From table 3, the constraints could be determined in relation to the 4 resources that are translated into the following table 4. This table has guided and influenced the research in formulating the questions to answer how a transformation the governance and physical system toward a degree of decentralization, safeguarding the advantages found in a decentralized and centralized system while reducing and eliminating the constraints of the transitions based on the 3 phenomena: economies of scale, external effects, and weak profiles.

A decentralized system faces many challenges to consider, and to overcome such challenges, the central government can be relevant in a supportive role in implementing this transformation. Such a role applies to both physical and governance aspects of SWM (sorting facilities, machineries), human resources (environmental and waste experts), institutional role in removing/adding relevant policies and finally guiding the private sector on all levels to be integrated in that shift. Thus, it is argued that a transformation in the system towards a degree of decentralization would also imply a degree of hybrid governance to seek a balance between

centralized and decentralized. Followed by a hybrid physical system, where some tasks could be central, and others have more decentralized nature.

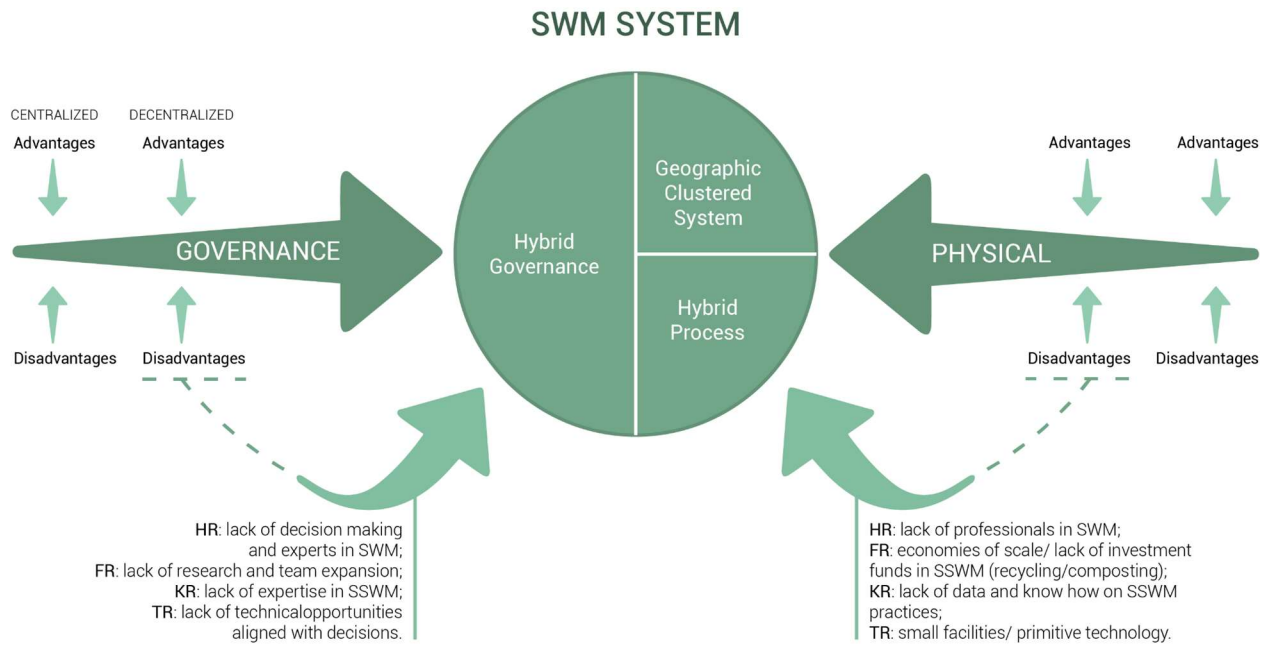
The physical and geographical clustered nature related to the boundary of collection and sorting, having more than 1 municipality, will result in better economies of scale and a stronger profile. The system chosen should be dependent on the context related to the resources mentioned above and the economic, environmental, and social situation of the context. Which means that zones might have very different physical systems in the same country depending on their local contexts.

The analytical framework is presented in figure 5, where table 3 & 4 both contribute. Table 3 comes forward with disadvantages and advantages of both governance and physical aspects, whereas table 4 comes forward with the resources that are needed with the constraints of decentralization.

Table 4: The Constraints of Decentralization in SWM

Constraints	Economies of Scale	External Effects	Weak Profiles
Resources			
Human Resources	Central governments attract more professionals for specific jobs that could be done across scales; example environmental officer, waste expert.	Private sector from neighboring territory taking all expertise. Case of job attraction in big cities, small municipalities will face shortage in human resources across all sectors.	Lack of involvement and willingness from the public and private sector, toward the transition of the SWM. Local level doesn't want to take responsibility for the sector.
Financial Resources	Lack of recyclables on a small scale. Cost-benefit, recyclables do not cover the cost of SWM due to scalability.	Public or private sector on a national scale affecting the recycling and sorting scene.	Lack of investment from the private and public sector at the local level for transforming their SWM.
Knowledge Resources	Few private companies are researching and developing in the sorting and recycling scene. Waste characterization on the local level (not generalized).	Monopoly of the sorting and recycling scene on the macro scale. Knowledge not shared on a decentralized level.	No interest or initiative on a local scale to pursue knowledge on the value of their waste. Lack of awareness in the community. NIMBY effect present.
Technical Resources	On the physical level will lead to costly machines designed for larger scales. Overhead of machines is relatively high.	Monopoly of some types of recyclables on a macro scale with lack of protective policies on the micro scale. Recycling factory outside the designated territory of decentralization. Lack of influence on building and operating facilities.	Lack of landfill availability, no willingness for sorting centers. Private sector is weak and missing in some areas on the local level.

Figure 5: SWM System



Source: Sbeih and Marques, 2023.

Chapter 3: Methodology

3.1 Unit of Analysis

The unit of analysis, or the case study, is determined by defining its spatial boundary, theoretical scope, and timeframe (Yin, 2017; Yin, 2003). The spatial boundary of this case study is the country of Lebanon. The theoretical scope is defined based on literature studies. Sustainable development, decentralization and SSWM are the key concepts theoretically embedding this study. Governance processes of the SW sector will be one of the focus areas in this case study, but it is relevant to define a timeframe. The relationships between actors and the attitudes of actors can change over time. The interviews and data collected are focused on SWM practices in Lebanon, since the post-war era (1990) until present day, mainly focusing on the past 7 years after the last waste crisis in Lebanon and the relevant developments of the sector. The research ran from 04-2022 until 02-2023.

3.2 Research Approach

This thesis uses case study research to understand the (dis)advantages of a decentralized system related to SWM in a specific developing country, Lebanon. The sector is unstructured and has a lot of potential transition scenarios that can take place. The data collection relies on a mix of various qualitative data collections techniques (Yin, 2017). Using multiple sources, the research will help identify the degree of decentralization that may be sensible for the SWM system, considering advantages, the limitations, constraints, and disadvantages of decentralization, mainly focusing on willingness and ability of the local level. Literature research, semi-structured interviews and an assessment of relevant legislation, policies and waste management facilities were used for the data collection techniques. Maps and charts related to waste distribution, governance and demographics were used as well. Defining the type of case study, the logic of research design, data collection techniques, approaches to data analysis, interpretation and reporting were priorities during the process, to have a credible and efficient data sourcing approach (Yin, 2017). A step-by-step methodology based on a combination of research methods was inspired by the work of Lalasti (2022) on the step-by-step method analyzing sustainable sanitation for Small Island, and the work of Wu (2018) with the analytical framework determining the disadvantages of a decentralized system in the energy system of China.

- Step1: The analysis uses a literature review that will present the Lebanese context, which will then further explore the existing SWM, based on academic research, journal articles and visual data such as documentary and interviews.
- Step2: will highlight major solutions for the systems either on the governance or physical level by several researchers and experts in the local context, coupled with literature into centralization and decentralization and environmental governance.

- Step3: data collection will be based on a series of interviews with the private, public and research actors, discussing the advantages/disadvantages happening on the national and local level in the SWM.
- Step4: Analysis and comparison between the sections helps answer the research questions, related to the degree of devolution of the sector, drawing conclusions on the potentially most favorable system, on how to overcome the disadvantages/constraints and protect and reinforce the advantages of the system.

3.3 Data Collection

This research comprises 3 types of data collection. The first part will focus on secondary data and information on the current SWM situation in Lebanon. This part will shed a view on the context: the governance system in the country, followed by data collection focused on SWM including the governance and physical aspects. The second part will focus on the key proposition for enhancing the sector extracted from journals, articles, and public interviews from experts in the field. The focus will be on policy recommendations, enhancement of physical and governance aspects of the sector and SW systems (centralized vs decentralized). The third part will be focused on primary data collection, involving interviews with experts, practitioners, and policy consultants from the public and private sector. The applied step-by-step approach with multiple data sources in this qualitative research will assist in building a comprehensive understanding of the sector and possible links and strategies for filling the gaps in the Lebanese SWM (Patton, 1999).

3.3.1 Document Review

Secondary data collected focused mainly on SWM in Lebanon, publications, reports, interviews, SW policies etc. Data was to determine the current SWM governance, law and regulations determining the key stakeholders and actors working in the sector. Waste operations and compositions are extracted from publications and reports alongside the policies behind them. Much data was extracted from democratic reporting international (DRI) on the governance and SWM in Lebanon and other reports from different organizations, Appendix1.

3.3.2 Proposed Solutions for the Sector

In this part, key findings will be presented and discussed from different perspectives and sources. Focusing on policy recommendation, potential solutions for the sector on the physical, and governance level. Most references are taken from the secondary data collected from the document review, Appendix2.

3.3.3 Semi-structured Interviews

The interviewed population is divided into 3 groups: public and private sector, and a research center. The approach chosen for the semi-structured interviews was a combination of structured, open-ended, and spontaneous questions (Flyan, 2015).

Five municipalities were selected from different regions and socio-cultural backgrounds in Lebanon. Either the mayor of the municipality or a SW expert in the municipality was interviewed. They were selected based on their willingness to apply and work in past and current workshops/activities related to SWM. Municipalities have different geographical, demographic, and spatial scales (population number and waste generation) characteristics (Appendix 4). As for the private sector, 3 interviews were conducted: one with a start-up that does business with SWM in urban areas. The founder was interviewed, who is an environmental engineer, and who has been active in the waste scene of Lebanon since 2019. The second interview was with a recycling company that deals with recyclable waste and who partners with sorting facilities across the country. The last interviewee is an initiative advocating the concept of sharing municipalities. Their job is consulting and implementing the system of clustered MSWM, where municipalities collaborate. Finally, 2 interviewees from the same research center participated in the data collection. Their background is on decentralization, environmental policies, and governance research in Lebanon. SW is one of their 4 main focuses in Lebanon, alongside air pollution, water/wastewater pollution and Land-Use and Land-Use change and forestry.

The recruitment of participants was selected according to participants' professional background and practices that are related to environmental governance, environmental and SWM policy-making and finally practitioners of SWM on the local level. Their knowledge will help in the research to determine the current SWM system (centralized/unregulated system), its downfalls, the relationship between the local and national level of the public sector and finally if there are any initiatives or partnerships with the public/private sector.

Interviews were conducted physically with few others through Zoom and WhatsApp due to spatial constraints. Interviews were transcribed and key findings were selected for analysis. Participants were informed about the research and explicitly asked for consent to participate, respecting their privacy and ethics. The author explained the research goal.

Several sets of questions were prepared depending on the participants background (Appendix 5). The questions were focused on the current SWM challenges, advantages and disadvantages of centralization and decentralization, based on the analytical framework.

Table 5: List of Interviewees

No.	Agency/Organization	Code
1	Municipality 1	M1
2	Municipality 2	M2
3	Municipality 3	M3
4	Municipality 4	M4
5	Municipality 5	M5
6	Sorting Facility 1 - Startup	P6
7	Recycling Center 1 - Startup	P7
8	SWM Service - Startup	P8
9	Research Center 1 - University	R9

Table 6: Private Sector Questionnaire

<p>A. Related to the physical and operational aspect of the sector (waste collection, sorting, participation):</p>
<ol style="list-style-type: none">1. Can you tell me more about your initiative (sorting facility)?2. Can you reflect on the resident participation?3. Are you able to get recyclables from other than residential buildings? (Commercial, business, industries etc).4. Is there any similar new initiative kick starting? Do they have the same type of collection? And if they work differently, what do you think about diversity in the collection practices?5. Do you have data for waste composition/generation/household?
<p>B. Related to the Governance and policies (institutional work) of the sector:</p>
<ol style="list-style-type: none">6. Are you able to partner up with municipalities? If not, why? If yes, what were the challenges?7. Where do you think the local government can offer you support in the SWM constraints?8. Where do you think you can support the local government in the SWM?9. What/where can the national government support your initiative?10. Where does the informal sector position themselves in the sector? and how do you possibly work with them?

Table 7: Public Sector Questionnaire

<p>A. Related to the physical, geographic, and operational aspect of the sector (waste collection, sorting, participation):</p>
<p>11. Can you share more on the physical aspect of SWM, such as collection type, processing, recycling, and disposing in your town/village/city?</p> <p>12. Who is responsible for collecting the SW? Is there any sorting at source? If yes, can you elaborate more? Are the residents willing to participate?</p> <p>13. What are the challenges concerning the collection logistics with the private sector (if he is in charge of collecting the waste)?</p> <p>14. What are the challenges related to recycling and composting? Is there any initiative coming from the municipality?</p> <p>15. Is the private sector involved in the process?</p> <p>16. Are informal pickers present? If yes, does the municipality have the intentions to reduce scavenging? Is there any informal dumping?</p> <p>17. How did the municipality handle the 2015 waste crisis? And did the refugee crisis affect the SW sector?</p>
<p>B. Related to the Governance and policies (institutional work) of the sector:</p>
<p>18. How can the municipality establish relationships with the private sector? What are the challenges?</p> <p>19. Were there any initiatives to work with neighboring municipalities? If yes, can you elaborate more? Can decentralizing the sector optimize its efficiency?</p> <p>20. Can you reflect on the SWM on a national scale? What are the advantages and the disadvantages/constraints of the current system?</p> <p>21. If decentralization can help the sector, then how can the national government support the governing system of the sector? And to what extent can this sector be decentralized?</p>

Table 8: Questionnaire Physical and Governance

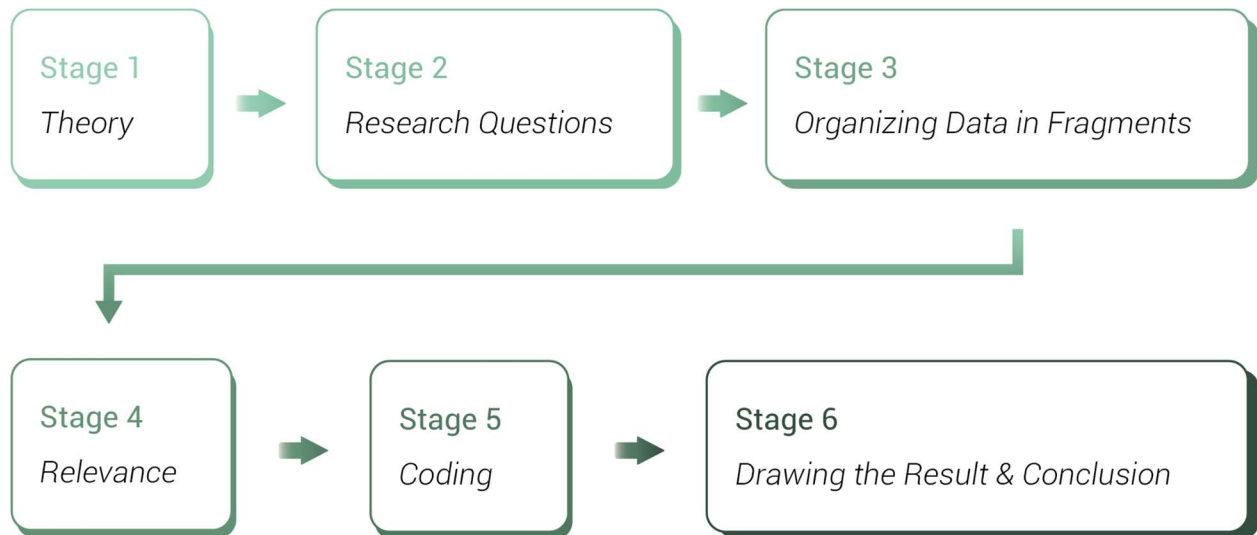
<p>A. Related to the Governance and policies (institutional work) of the sector:</p>
<p>22. Can you describe the type of work/research the center is doing related to the SWM in Lebanon? 23. Who are the stakeholders that are included in your research? How did you conduct your research across the country? 24. Can you reflect on the concept of decentralization of SWM? What are the advantages and disadvantages/constraints for the sector? 25. What is the current crucial challenge in the sector? Is it on the technical/ physical aspect or the governance aspect?</p>
<p>B. Related to the physical, geographic, and operational aspect of the sector (waste collection, sorting, participation):</p>
<p>26. What is the current crucial challenge in the sector? Is it on the technical/ physical aspect or the governance aspect? 27. What are the key policies missing in the sector? Are there any institutional barriers in the existing policies? 28. Can you reflect on the position of the private sector? In a centralized system and decentralized system? 28'. Can you assess the current level of service in the SWM scene? What is the effect of the informal sector, are there any policy recommendations for this sector? 29. Is sorting and recycling one of the solutions? Is there implementation for the waste policies? What are the obstacles?</p>

The questionnaire above will help determine the constraints and (dis)advantages of decentralization, based on the three main points discussed in chapter 2: economies of scale, weak profile, and external effects. In the following section the questions will be linked (Table 9) to develop an analytical framework of this research, which will help answer the research questions. Interviews were conducted between July 2022 - January 2023, the questionnaires are an overview for gathering information for this research and the spontaneous interaction helped provide additional data. Questions were selected based on the literature review for SWM, and on the participants' education level, experience, and organizational background.

3.4 Data Analysis

The developed analytical framework functions as a reference and inspiration for the data gathering process from both primary (interviewees and questions) and secondary data sources. The organized analytical work will provide answers to the designated primary and secondary research questions in this thesis. Analysis is conducted in line with the steps suggested by Lalaasti (2021), (see Baarda, 2014) visualized in Figure 5. The research and secondary questions will direct the research to find the relevant data and organize them in fragments. Data gathered will be coded as answers according to the analytical framework, see table 9. Data analysis will determine potential recommendations for the research questions.

Figure 6: Qualitative Research Analysis Steps



Source: LaLasti, 2022 (Updated by Sbeih, Marques, 2022).

Questions were focused on the 3 mentioned constraints of decentralization as discussed in chapter 2. But some questions shed light on Table 3, answering the advantages/disadvantages of decentralization/centralization in the Lebanese SWM situation. Questions: 6-9, 19-21, and 27.

Table 9: Analytical Framework, Translated into Questions

Constraints	Economies Of Scale	External Effects	Weak Profiles
Resources			
Human Resources	Questions: 7, 8, 10, 11, 13, 24, and 26.	Questions: 1, 9, 10, 16, 17, 18, 19, 20, 21, 24, 27.	Questions: 1, 2, 6, 8, 10, 13, 15, 18, 22, 24, and 26.
Financial Resources	Questions: 3, 4, 5, 7, 11, 13, 14, 20, 24, 25, and 28.	Questions: 9, 14, 15, 16, 19, 20, 21, and 27.	Questions: 1, 8, 13, 14, 18, 22, 24, 25, and 28.
Knowledge Resources	Questions: 1, 5, 8, 11, and 14.	Questions: 1, 9, 14, 16, 19, 20, 21, 26, and 27.	Questions: 2, 6, 8, 14, 18, 21, 22, and 24.
Technical Resources	Questions: 1, 3, 4, 7, 8, 11, 12, 13, 15, 20, 21, 24, 27, and 28.	Questions: 1, 3, 9, 12, 13, 16, 17, 19, 20, 21, 24, 27, and 28.	Questions: 1, 6, 8, 12, 13, 14, 15, 18, 21, 22, 24, and 28.

Questions as seen in table 9 could fill in many cases, caused by this complex interaction and dependence of SW across resources, as explained in chapter 2. Questions were divided into 2 categories based on the governance and physical performance of SWM. As seen from table 9, questions in the interviews might have answers to several potential constraints. The answers will be analyzed and reflected on, to find solutions for the potential constraints, answering the research questions.

3.5. Ethical Considerations

This research was conducted with the participation of a wide range of stakeholders, from different social, political, religious, sector backgrounds. Interviews were conducted with the following ethical principles: researcher did share information about the research, while keeping privacy and confidentiality of research subjects and the research will result in the disclosure of personal information. Respondents had the right to withdraw their participation at any time during the interview and agreed their information to be shared in this research. Many informal interviews with other municipalities, SWM practitioners and mostly people from the informal sector, their identity was kept private, and information shared used only as guidelines for the researcher. This research is conducted with transparency, professionalism, humanity, commitment, good intentions following moral and legal norms and consideration factors of accuracy, psychological, social, ethnic and religious sentiment of respondents.

Chapter 4: SWM in Lebanon

4.1 Lebanon, the Civil-War, Governance System & Current SWM

4.1.1 A brief description of Lebanon

Appendix 6 & 7 intensively describe the current situation of Lebanon outside of SWM and its indirect effect on the sector. The high density, with a heterogeneous geographical and population (refugees), has many effects on infrastructural projects. The sectarian influence on the political regime is one of the major sources of that instability, affecting the governance of this neoliberal, sectarian regime. Lebanon's political and economic instability is pushing its infrastructure to deteriorate more and more. As for the Lebanese political regime, Lebanon is a parliamentary democratic country, with consociational democracy (Calfat, 2018), specifically, confessionalism takes place, where sects and social groups agree on their presentation in the Lebanese regime. The current unstructured neoliberal, central governance system is being heavily criticized and contested recently, creating a fragile infrastructure, lacking environmental, social and economic advantages (See appendix 6&7)

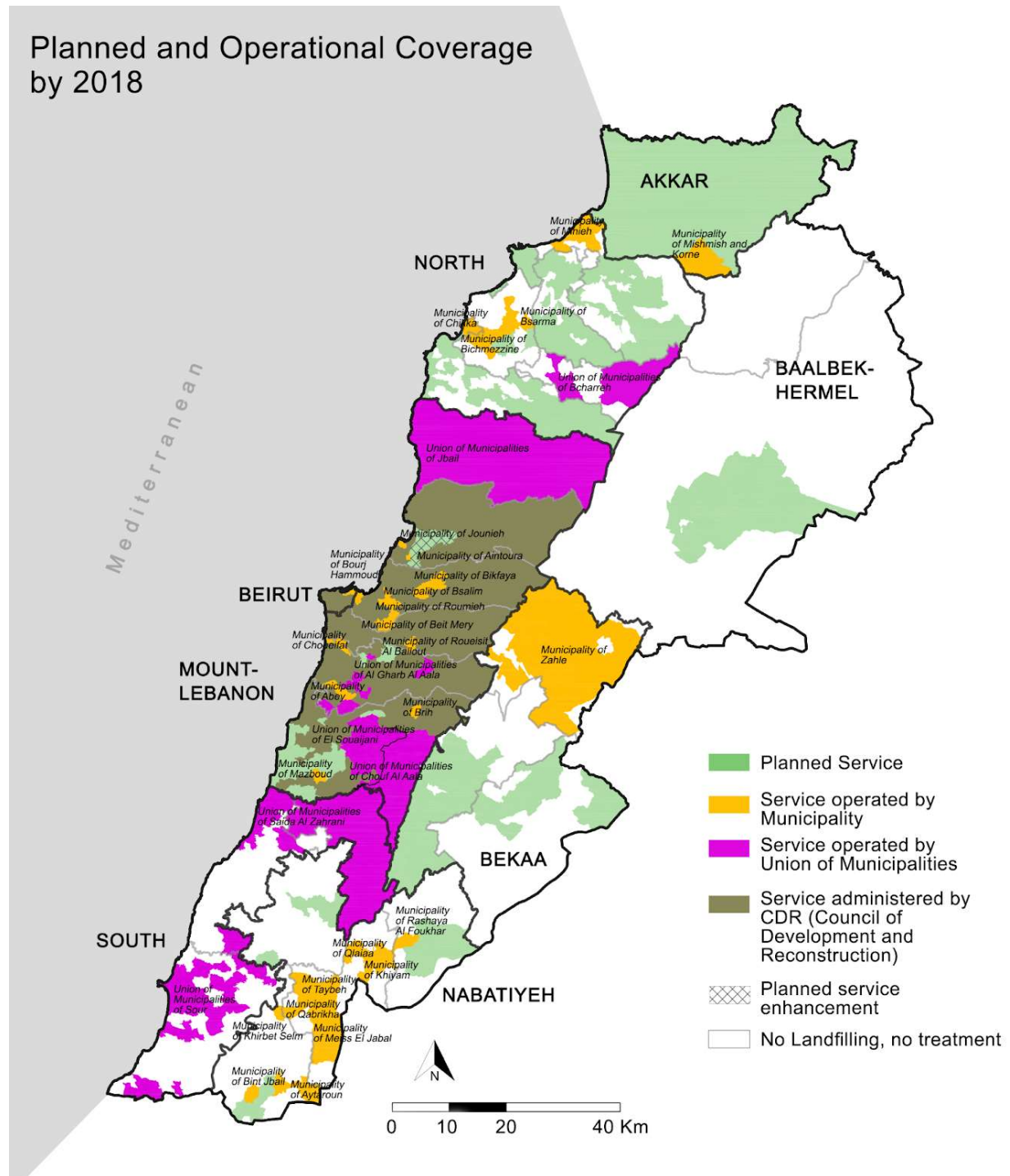
4.1.2 SWM in Lebanon: History and Current Status

The sector's first institutionalized policy was drafted in 1931, by the French mandate dictating that the responsibility of SWM is delegated to municipalities (DRI, 2019). The central government still worked around SWM supporting local authorities to perform their duties until the break of the civil war in 1975. Plans were designed independently without integrating them with other sectors (Chalhoub, 2018). After the end of the Lebanese civil war (1991), municipalities remained responsible for collecting the municipal waste according to the law set in 1977, but due to the lack of finance and proper infrastructure they weren't able to collect the waste (DRI, 2019; El-Meouchy, 2020). As per the first post-war plan two landfills were opened: the "Quarantina" and "Normandie", and two incineration facilities were installed but never used for unknown reasons. In 1994 the Council for Development and Reconstruction (CDR) and the central government signed a contract with a private group, bypassing the role of municipalities to collect the waste. Instead, waste is collected through a private company (Law #1348) and the treatment through a sister company (Law #2378). Sukleen was responsible for collecting, and Sukumi treated the waste in the regions of Beirut and Mount-Lebanon (excluding Jbeil Union) with a collection limit of 800tons/day until the end of its contract (DRI, 2019). In 1994 the first post-war SW crisis in Lebanon took place, which was caused by the closing of the Normandie landfill. After 3 years, an emergency plan was drawn with the opening of a new landfill "Al Naameh" with 2 sorting and disposing facilities Coral and Quarantine accommodating 293 municipalities belonging from the same region (Jadam, 2010; DRI, 2019). This Emergency plan lasted until 2015, and after the closing of the "Al-Naameh" landfill, the waste crisis in the capital and Mount-Lebanon region occurred. Sukleen was relieved

from their services and replaced by RAMCO (DRI, 2019; El-Meouchy, 2020). The new SW collectors almost have the same contract, which could be argued to replace/overlap the initial municipal law for waste collection and treatment responsibilities (El-Meouchy, 2020, DRI, 2019). Contracts in Mount Lebanon and Beirut for a centralized system are diminishing the need for investing in a physical decentralized SWM.

In terms of governance from the public sector; on the national level, many ministries and organizations have an impact and responsibilities in the sector (Jadam, 2010; appendix 7). The ministry of environment (MoE) is the central decision maker for SWM, such as studies and tender documents related to SWM, support and monitoring SW treatment facilities, draw future Master plans, and define environmental value of the waste and its effect on water, air and soil (Jadam, 2010). The Ministry of Interior should provide financial incentives to municipalities that are planning to have a collection and sorting facility and that incentives increase if that sorting or transfer center welcomes 10 neighboring municipalities' waste - Decree No.9093 (Jadam, 2010). The Ministry of Public Health, based on Decree#8377 and Law#546, is indirectly responsible for hospital and clinic waste that should be treated differently than other SW. Licensing of health institutions is coupled by their waste treatment policies (Jadam, 2010). The CDR is responsible for the implementation of the emergency plan in Beirut and Mount-Lebanon. Finally, The Office of the Minister of State for Administrative Reform (OMSAR), which is responsible for developing the SWM in rural areas, is funded by the EU-funded program. The office is responsible for allocation of funds for facilities implementation and operation (Jadam, 2010). Municipalities have their own freedom to collect the waste but lack experience, resources, and support from the central government to execute the job (Abbas, 2017; Azzi, 2017, DRI, 2019). Decision makers from a more centralized governing system under the Central state have a say alongside the confessional distribution of the local administrators “Qaem-maqam” which is a public representative for federal municipal area and the “Mohafez” (governor). (Makdisi, 2013). Many initiatives and NGOs from the private sector infiltrated the sector, to fill the gap of the current public and private actors in the SWM. For example, a local NGO is collecting and treating the Infectious health care waste (IHCW) from 70% of the hospitals in Lebanon. Before that the IHCW was not segregated and was creating a health threat to the community (Maamari, 2015). Activities such as sorting, recycling, composting are being executed by these organizations, since the level of circularity in the country is low (Maamari, 2015; Mahmoud, 2019, Massoud, 2022).

Figure 7: Planned and Operation SW Coverage



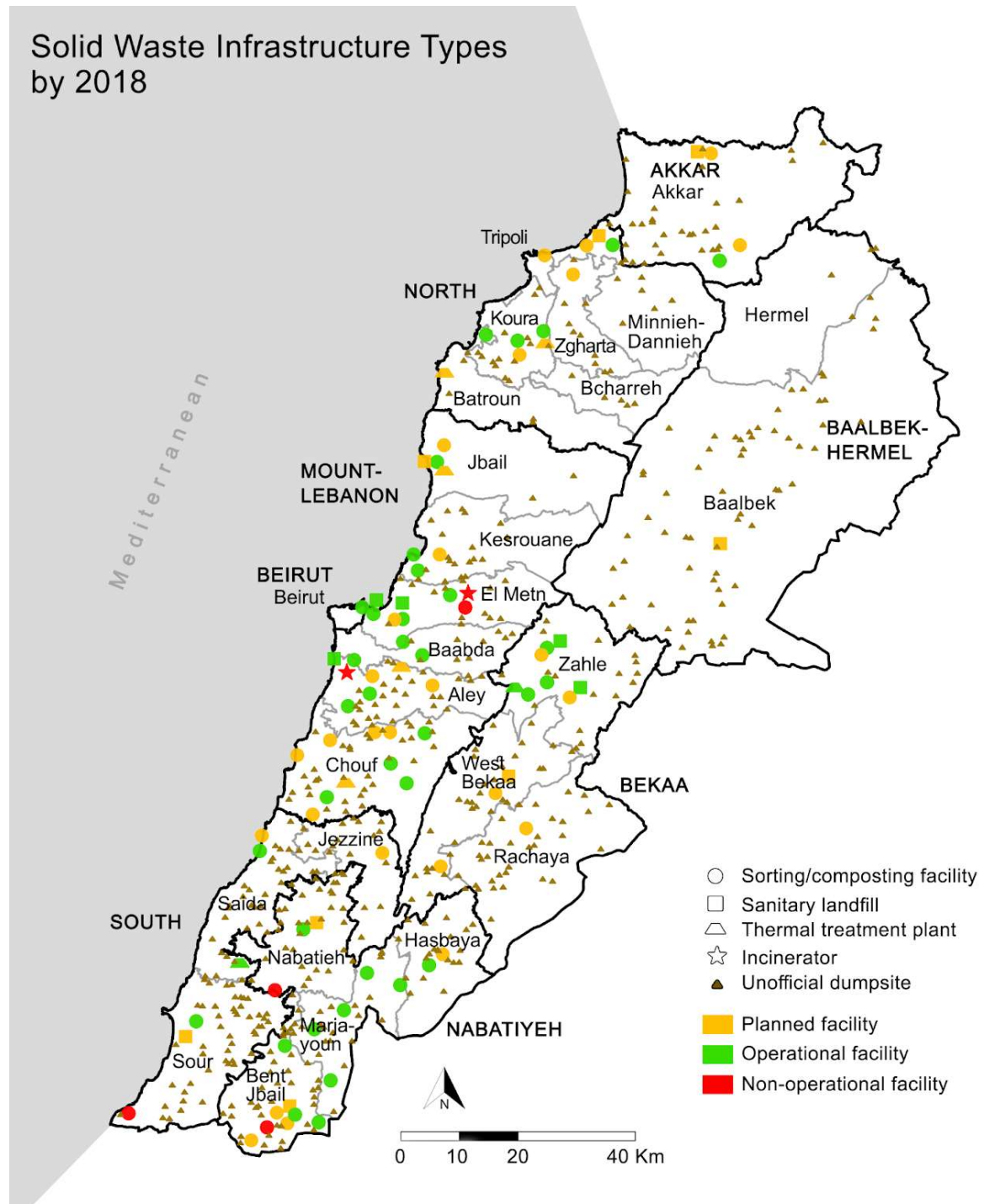
Designed by Rita Nasr

Source: Head of Municipalities, managers and directors in the private sector, 2018

Source: DRI, 2019.

Figure 7 shows the SW physical system across the country, with governance that could be considered as complex, unorganized and hybrid. The sector is not generalized across the country, and every area has its own system (DRI, 2019). The mosaic presented above showcases the fragmentation of the sector geographically. A centralized SW system implemented in Beirut and Mount-Lebanon, with a considerably high fee (around \$155/ton) (DRI, 2019; HRW, 2020). The system was criticized, for lack of consistency (multiple crises) (El-Meouchy, 2020), health and environmental degradation from its operation and Naameh's Landfill (Verdeil, 2013; UN-Habitat, 2015), the high fees for waste collection that pushed many municipalities in those governorates to create their own waste facilities as observed in figure 10, the orange areas in those governorates. In other governorates, different diverse physical systems are taking place depending on the municipal and local union municipal capacities and the local political interference (Abu-Rish, 2016; Giannozzi, 2017). Central government guidance is missing, as well, laws and regulations in the sector are poorly implemented (DRI, 2017; DRI, 2019). This led for municipalities to handle their waste while 'improvising' the suitable solution according to the existing human, financial, technical and knowledge resources (Giannozzi, 2017; DRI, 2019). Mainly the North and Akkar have planned services, where a centralized private sector is handling mostly the waste, except for few places where the municipality or union are the ones handling the operation (DRI, 2019). Baalbeck-Hermel and Bekaa have in some places a planned service, while municipalities are handling the waste for some others, and the rest of the places with no actual plan (white area), where plans are being drawn. For the time being for this last category, waste is informally collected, sorted, landfilled, and burnt. As for the Nabatieh and the South region, waste is handled similarly, except for some villages, where municipalities and union of municipalities are handling the waste (DRI, 2019).

Figure 8: SWM Facilities



Designed by Rita Nasr

Source: Ministry of Environment, Head of Municipalities, 2018

Source: DRI, 2019

Figure 11 shows the facilities distribution across the country, the high number of planned facilities that are still not executed, mainly coming from the Masterplan, 2006 (El-Meouchy, 2020; DRI, 2019). Sorting and composting facilities are present in most governorates, where sanitary landfills are very few and even not present in some governorates. This increases the number of unofficial dumpsites (DRI, 2019; UNDP-Lebanon, 2022). It is widely observed that Baalbek-Hermel & South has the most unofficial dumpsites with no sanitary landfill which are interrelated (DRI, 2019). This map is from 2018, we notice that it has much fewer illegal and informal dumpsites than what we have nowadays, with an increase to more than 1000 dumpsites, caused by the economic situation of the country (UNDP-Lebanon, 2022). Many of the working facilities in 2018, stopped their operation caused by the economic crisis in the country, unable to cover their operational cost, joining the red facilities that are not functioning (UNDP-Lebanon, 2022). Caza de Jbeil has the least number of open dumps as per figure 10. The waste is controlled by the municipal union of Jbeil, which is an example of the local authorities taking charge (DRI, 2019). Nonetheless Verdeil (2019) argues that the SWM in the caza of Jbeil is facing environmental and economic challenges, even after partnering up with the private sector. According to its research, it is due to a lack of national support and allocation of funds, and sorting at source is not well supported. Verdeil (2019) and Jadma (2010) states that the sector is highly politicized, and decisions from the public and private sector were in favor of politicians who have interest in the sector, labeled as 'waste capitalism' (DRI, 2019).

Lebanon generated 7000 tons of waste per day in 2019. Due to the economic, social and political crisis few numbers were studied afterwards, but it is assumed that more than 20% of waste reduction took place, caused by the intensity of the crisis (UNDP-Lebanon, 2022). The governance and physical system are both centralized in major areas in the country (figure 10), where the contractor decides on how and where to collect the waste, while coordinating with the municipality (Abbas, 2017; Boswall, 2019). Landfills are centralized, and waste in some situations has to be transferred from distant areas, increasing the cost of transport, such as the case of Mount Lebanon and the Jdeideh landfill, that could be far (50km) for mountainous regions. Waste collection in general is done through curbside picking from bins in neighborhoods using compactor trucks (Ali, 2018; Azzi, 2017). Other areas have different types of collection machinery such as trucks, pickups, depending on the proximity of the landfills, and the collection system (legal and illegal).

Since the crisis of 2015, many new initiatives and start-ups have been more active in the waste scene. Many incubation programs granted startups that tackled SWM, either in the collection and sorting scene, as well as recycling and composting (Mohamad, 2022). The programs were mainly funded by EU-countries or the US. New players entered the SWM market, trying to fill the gaps. The number of start-ups working on collecting the recyclables are increasing (Mohamad, 2022), while competing against each other, as well as competing with the informal sector, which contains the most dominant sorters and recyclers in the country. Small amounts of waste is being recycled/composted and treated, and mostly is done by the informal sector (Alexander, 2022, Massoud, 2019; Massoud 2022). The informal sector is a powerful stakeholder working independently from the physical sector, with little formal intervention.

Waste composition in Lebanon is mainly generalized, and there are few studies of the waste composition data on the local level across the country. In general, the waste composition is made of 52% organic waste, 37% recyclables and the remaining considered as non-recyclables (Abbas, 2017; Khawaja, 2017, SWEEP-Net, 2014). That data is generalized for the entire country, rural, industrial, and urban areas, and could be outdated with all of the recent changes that happened with the effect of the post-pandemic and socio-economic crisis.

4.2 Academics point of view on the Lebanese SWM

Many studies were conducted on the situation of Lebanon, shedding light on some recommendations for the enhancement of the sector. This section will analyze and highlight on the relevant recommendations for upgrading the SWM in the Lebanese context, based on the findings of past research, either on the governance, physical, or both systems together.

4.2.1 Decentralization a Promising Solution

Past research indicates that decentralization may have several important contributing factors to improve SWM in Lebanon. First, the obvious failure of the centralized system in Mount-Lebanon and Beirut, which is reported by several researchers, in line with their discussion of the related socio-political crisis. The current system is facing a major NIMBY movement (“You Stink”), connected to the current confessionalist central government top-down system (Kraidy, 2016). The centralized SWM is passing through recurring crises, that is creating protests and resistance, demanding for a more accountable and visible performance (Deets, 2016), far from political tension. The movement is challenging the neoliberal and confessionalist regime, by entering the political scene through elections (Beirut municipal elections, 2016), and demanding for a more decentralized system (Abi-Yaghi, 2017; Richani, 2017). The sectarian influence on the central government is hindering progress of infrastructural projects that are leading to those crises, since policies, rules and institutions are influenced by the political and sectarian regime (Abi-Yaghi, 2017).

As well, the literature indicates numerous advantages of decentralization in the case of Lebanon. ISWM is found to be efficient on the local level, where decision makers and practitioners are closer to the contextual background of SWM, reflecting a high rate of sorting, recycling and composting, due to close local participation in the process (Azzi, 2017). On the physical level, SWM proximity in Lebanon is predicted to include resident participation in the decision-making, reducing opposition (Jadam, 2010; Massoud, 2019). Proximity will help for sustainable practices such as sorting at source, while reducing consumption behavior through local awareness campaigns (Jadam, 2010), in schools and universities, safeguarding future generations (Abbas; 2017). Better sorting practices on the local level, will not only increase recycling/composting rates and their qualities, securing Rol from the sector while safeguarding the environment with lower transportation expenses (Massoud, 2022), but reduce the amount of waste sent to landfills

(Khawaja, 2017; Verdeil, 2017), that is a major problem in the sector. A local physical strategy could be drawn using that proximity, for a better waste segregation leading to respect of health norms such as hazardous waste segregation treatment (Khawaja, 2017). Solutions and innovation in decentralization of SWM could be less costly while including more stakeholders. Cheaper, simpler and reliable technologies could accomplish the task, paralleled with a smaller scale of collection and sorting waste. Such investments could be secured by donors and funding from the private local sector with an efficient and effective impact, safeguarding the economic and environmental situation (McCornack, 2012). Operation and maintenance financials remains an obstacle, where McCornack (2012) suggests that they should be included in the plan proposal. Decentralization on the municipal level of SWM operations have limitations in their cost recovery, where a household tax fee for waste collection is needed to cover the MSWM costs (Abdl-Ahad, 2019). In Abdl-Ahad (2019) research, residents in a designated area were more likely willing to pay (WTP) for MSWM. This study was conducted before the economic crisis, and might have a different outcome today, nonetheless, cost recovery remains a prominent and important topic in the success of MSWM. Finally decentralization in SWM could be helpful for private actors from different sectors to have more SSWM. Ghadban (2017), researched the service sector, during the waste crisis, the ability to partner with SW actors on the local level, increasing hotels sorting practices, reducing their waste generation, cost and coming up with easier solutions. All aspects discussed related to the physical SWM, where decentralizing the system will require closer decision-making and policies on a local level to enable them.

Decentralization may be a strategy to pursue improvements in the SWM sector in Lebanon (Giannozzi, 2017; DRI, 2019), and it is fundamentally important to consider the various constraints to local willingness and ability when applying and developing the required institutional work. However some aspects such as environmental protection, landfilling practices could possibly need to be centralized, whereas other situations such as technical physical solutions with tailor-made approaches could have a more decentralized system supported by the central government (Abbas, 2017; Massoud, 2019; DRI, 2019), highlighting below 6 major points from literatures.

First, reduce and institutionalize waste capitalism i.e. give power to local municipalities, favoring a more decentralized system with the inclusion of more actors. Second, a cost recovery tax system is to be implemented for SWM financing. Thirdly, institutional work and an implementation for Law 80 for ISWM is needed, determining the type of recycling and handling organic waste and its integration in the market. Fourth, applying the circular economy approach (3R). Fifth, including the informal sector in the process (Abbas, 2017; DRI, 2019). Finally restructure the ISWM (Law 80) as mentioned above, specifying the recycling and composting methods for example, and this will lead the sector to achieve the concept of CE. The quality of waste sent to landfills is full of resources, and could be used in composting and recycling (Massoud, 2022), increasing sorting and recycling efficiencies.

4.2.2 How far can Decentralization Work in Lebanese SWM?

Despite the failure of the Lebanese central system, we can also see there are limits to what you can do on the local level. Bottom-up movements may be relevant, but are unable to solve legal guidance, landfills, or even to trigger collaboration with the municipalities and the private sector. Therefore it is crucial to seriously reconsider what can be decentralized, and what cannot, and how to balance it (Massoud, 2019). On the governance level, Karakji (2016) based his study on Loorbrach (2007) transition theory on the multi-level perspective to determine barriers towards SSWM. Politics and waste are interrelated, and a transition in the current political system and governance is recommended for that shift toward SSWM, increasing transparency and accountability of the governance and physical system. That transition could be related to Deets (2016), Richani (2017) and Abi Yaghi (2017), away from the sectarian influence on politics, and demands for more political transparency. Transition in governance should be coupled with financial support, institutional work, law enforcement and assignment of responsibility in the sector of SWM (Karakji, 2016), preferably coming from a strong position such as the central government. Policies should be generalized in Lebanon, i.e.. The environmental and health protection for hospitals (Maamari, 2015), and the decentralized incinerators for energy integration to be questioned for environmental and health issues (Khawaja, 2017). Instead, a holistic approach for SWM should be drawn, reducing the discrepancy between areas in the level of service of the sector, having one target and norm (Khawaja, 2017). Institutional work on the (de)central levels, should take place to mobilize that transition, creating a coherent national legislative framework that includes monitoring and evaluation, rerouting revenues and taxes, administrative reformation, role and responsibility definition, environmental and stakeholder's policies and finally training and awareness programs for technical and environmental capacities at the local level (Jadam, 2010; Massoud, 2019). Even though the autonomy for a physical transition (waste collection) is required locally from the national government, it should be coupled with a supporting role from the central government in managing the sector, such as landfilling practices (Massoud, 2019).

This will reflect on the physical aspect of the sector, creating landfilling facilities, on the governorate or district level, and executed by municipalities, turning the system toward a degree of decentralization in both governance and physical systems (Massoud, 2019; DRI, 2019). Municipalities lack financial, technical and land resources that the central government could secure (Abdl-ahad, 2019). Shifting toward sustainability through ISWM, support in technical, financial, human and knowledge resources is needed, that could be secured by the central government as well. This will increase stakeholders' participation resulting in enhanced sorting, composting/recycling and landfilling practices (Abbas, 2017; Azzi, 2017). This needs to be reinforced by policies through governance work (Azzi, 2017).

Landfilling practices currently are in a problematic situation, with unsustainable solutions, lacking integration with urban planning (Verdeil, 2017). For health measures, illegal dumps should be closed and treated accordingly (Khawaja, 2017). Landfilling practices should be reorganized in Lebanon (Jadam, 2010), and environmental protection for landfill practices is one of the most critical physical aspects in the Lebanese context. It's true that decentralization could help reduce the amount of waste streams going to landfills, but it does not entirely solve the problem for

different reasons. Landfills centralized on the governorate or country level could be a smart solution, limiting the landfills number, reducing their environmental risks and facilitating the monitoring process with the decision maker proximity factor (Massoud, 2019). This shift, alongside sustainable practices before sending waste to landfills (3R), will help the sector reduce environmental pollution and water contamination (percolation and leachate) from landfills (Soubra, 2021).

Finally, refugees mostly live in camps across the country, which has internal policies (Yassin, 2016,) (Appendix 6). Stel (2015) focused on the Palestinian camps and informal governance. He described the informal resilience built in the camp, to cope with crises such as waste, as it's handled independently from the Lebanese authorities, pushing them to be more marginalized from the Lebanese context. Waste integration of the Palestinian camp's SW in the Lebanese SWM is a solution to avoid those risks. Informal agreement between municipality unions and camps should be formalized, building trust between the communities: a hard task, considering the political tension between both the Lebanese and Palestinian communities, which does require the intervention and management from the central government.

4.3 Interviews and Results

4.3.1 Public Sector: An Assemblage of Municipalities

Five municipalities took part in the interviews. The municipalities were chosen from different areas and geographic elevations, which affects the transportation. Their population ranges from 2000 to 35000 residents. Three of the municipalities mentioned that their population changes between summer and winter: since they are mountainous villages, the population decreased during winter and increased during the summer, generating less/more HSW. Most coastal regions face the same phenomenon in Lebanon, where some coastal cities and towns decrease in population as well, but the effect in this case might be minimal (Massoud, 2022).

Economies of Scale

Economies of scale play a major role at the local level. The high number of municipalities in the country resulted in small-scaled territories that could be reflected in the SW scene.

On the governance level, managerial capacity strongly relates to the technical, knowledge and financial situation on the local level, and it can be hindered or stopped if one or the three mentioned capacities are missing. For example, M5 changed partnership with several collectors from the private sector, caused by the private sector changing its collection method, moving away from rural areas (high transportation cost) to urban areas. Environmental experts are not always present on the local level, and hiring a staff member exclusively for this task is not a priority.

Three municipalities are located in Mount-Lebanon, where the central government appointed a central private collector to manage the waste. Nonetheless all three municipalities tried to segregate recyclables, and proceeded on establishing informal partnerships with small sorting

startups. However, this puts the municipality at risk of losing their partnerships if the private sector is unable to complete the agreed-on task, without any means of environmental accountability. One of the mentioned municipalities was willing to form a partnership with a local private sorting facility that collects recyclables from 12 other neighboring municipalities, while the two others collect the waste by themselves.

On the physical aspect, the waste scene, handled by the municipalities, could be a burden to them, especially for the ones located in rural areas with low number of residents. M3 and M5 both stated that they were part of coalitions of neighboring municipalities, working under one proposal for a central SW facility, and they felt that it could be the only way to cover the operation expenses. With one facility running, operation and fixed costs will be lowered, by reducing the number of employees and machines. Both plans did not receive funding from the government or international donors and both municipalities were skeptical even if the case plans were implemented, since maintenance and operation could be another constraint.

KR such as waste composition helps collectors working in the sorting, while recycling and composting determine their business model, revenue streams, and the scale of recyclables. As discussed in chapter 4.1.3, data for waste composition in Lebanon is generalized. 2 out of 5 municipalities did try to gather data in the past, but today they are irrelevant with the ongoing crisis that changed the waste composition. All five municipalities believe that proper data gathering across the seasons (demographic and behavior change between seasons) could help the municipality assess the worth of their recyclables. M2, M3 and M5 mentioned that they have low organic waste composition, caused by households having farm animals such as poultry.

As for TR, as mentioned above, only 2 municipalities (outside Mount-Lebanon/Beirut) have their own facilities that suffice for the collection and sorting of the waste, and they are equipped with pickups, conveyor belts, wood shredding machines, compactor etc., all funded by international communities. The other 3 municipalities operate under the central system: M1 excluded themselves from the deal, and decided to partner up with the private sector, operating their own sorting facilities, on municipal land. Composting in rural areas could generate low grade compost, since good organic material is already used in households for domestic farm animals. M3 shared:

“Animal farms are abundant in each household, mainly chicken, this reduces significantly the amount of organic waste with good quality, affecting the composting activity in sorting facilities, thus resulting in financial losses”.

Financially, all municipalities are affected by the current economic situation in the country, and the presence of the private sector could alleviate the issue. Lack of government financial support is affecting the ability of the municipalities to cover the expenses of operating the facility. M3 shared:

“Since the crisis, the municipality has not been able to buy fuel for the generators of the facility, today, we are just collecting the waste, without sorting or compacting them”.

In M1, the private sector is securing the operation cost, but municipalities are compensating the private sector in providing the land for its operation. Nowadays, informal partnerships are being forged between the private and public sector with both parties benefitting from the deal. The private sector takes the recyclables, while the municipality reduces the weight of the waste, resulting in lower collection cost for the central government's contracted collector. Finally M1, M3 and M5 shared that the public sector by law cannot sell the collected recyclables, which complicates the operation further.

Finally, one municipality did mention that many municipalities got funded to build their transfer and sorting facilities, but most of them are not operating at the moment, since the collected recyclables and organic waste does not cover the cost of operating this facility.

Weak Profiles

Awareness campaigns focusing on sorting/recycling were conducted in all five municipalities, but little progress has been made in implementing these initiatives due to the lack of financial and technical support for the source-sorting technique.

Participants shared that the municipality's lack of knowledge and prioritization of SSWM practices on the governance level is impacting its willingness to implement these practices. It appears that the municipality is only willing to take action when informal partnerships with private stakeholders are established. In other terms, the lack of willingness of the national government to support the local sector is affecting the willingness of the local sector to perform in SWM, creating weak secondary informal partnerships on the local level that could stop at any time. For example, the fuel crises pushed one private sector to discontinue the waste collection in rural municipalities, thus the lack of provision of financial resources is pushing the willingness to direct some of the expense to collecting waste, as these funds are being directed to other priorities instead.

In terms of HR, municipalities showed some discouragement in being involved in the SWM on the local level, since responsibility could affect their status in the next elections, reducing the willingness of dealing with waste. Municipalities under the central physical system (Mount-Lebanon/Beirut) are mostly discouraged, since the service is already forced by the central government, a service that is underperforming as discussed previously.

On a physical level, the technical and financial aspects of waste management are impacted by the centralized private contractor in municipalities in Mount-Lebanon. These municipalities do not have to worry about waste collection or treatment, and as a result, they are not willing to participate in waste management practices due to the contractor's presence. Nonetheless municipalities mentioned that the waste collected price per ton is too high, which has caused some municipalities to try and reduce the collected weight of waste, through sorting the organic waste and recyclables in partnership with local collectors, increasing its willingness based on economic targets. The more the weight is reduced, the less the municipality has to pay. The repeated occurrence of waste crises is prompting municipalities to seek out local solutions in order to preserve their environment. One particular concern that has been raised is the

transparency of the weighing process for collected waste, as well as the funds not being released from the municipal treasury (IMF).

External Effects

Municipalities shared that the private sector is involved in the sector either on a national level partnership, or on a local level through informal partnerships with municipalities. The influence of this relationship is creating an unsustainable practice of the SW sector, creating competitions between the municipal and national government, and between the central private sector and startups dealing with the SW on the local level. Participants shared their frustration on the blurriness of the practice, especially when the collection crisis struck in 2015. Reactive and temporary solutions were forced, creating new informal partnerships that are far from being sustainable. M5 shared:

“During the 2015 waste crisis, the municipality had to make an agreement with a private landowner who was also a local sorter to temporarily store the waste on his land. The municipality did not have a clear strategy for reducing the amount of waste at the time. After the crisis was resolved, a new central collector was contracted to clean the land gradually, and the effort of sorting at source was discontinued [...].

On the governance level, a clear structured local plan was missing, a repetitive phenomenon happening in all governorates and occurring in different forms in municipalities, depending on the context. During the crisis, many municipalities had the problem of random dumping from external sources, which had led to major spillovers in some municipalities.

On the physical level, Monopoly of the sector is a major external effect, especially in areas where the centralized system is dominant. Financial and technical resources are limited at a decentralized level, where the focus is mostly on the centralized system. Knowledge resources are poorly shared, since the private sector is not entirely communicating and responding to municipalities requests.

Many towns have Syrian refugees. Interviewees expressed that the behavior of the refugees varies differently than of the locals, including the SW sector. M3 claimed that Syrian refugees were the first to participate in awareness initiatives organized by the municipality, and thinks that they do so to have a sense of belonging. M2 agrees with M3, and added that their presence increased the rate of sorting. The presence of refugees and new stakeholders, even though counted as an external effect, if dealt properly could be an added value on the local level.

Decentralization vs Centralization

From the interviews conducted, most municipalities agreed that decentralizing the sector completely won't be ideal. Shortages in resources are crucial, affecting the municipality's independence. All municipalities mentioned that the absence of the central government is hindering their progress. Support from the national government and inclusion of the private sector

could both be key solutions for these challenges. As an example of support: the allocation of technical and environmental experts to SWM. Funding and financial resources could be another sort of support, either for collection and awareness, or to build, maintain and operate the physical transfer/sorting facilities. National governments could provide policies related to geographic boundaries and PPPs that could solve the issue of economies of scale in the local public sector. Another point is that financial subsidies, or central collaborations are needed to facilitate operation and maintenance of the physical system on the local level. Finally, there is a need for institutional work on policies related to cost-recovery and subsidies for recyclables/organic waste. It is also important to develop policies related to transparency and monitoring of private collectors, whether they operate in a centralized or decentralized manner. In some areas, this support from the central government is crucial for effective waste management.

4.3.2 Private Sector: Sorting, Recycling, and Logistics

The sorting facility that was interviewed has introduced a relatively new concept to the Lebanese SWM. Residents can bring their waste to the facility and exchange it for financial rewards based on the recyclable materials they have. This concept has gained popularity and is now being adopted by waste sorting startups in urban areas. The "cash-for-trash" initiatives are primarily found in Beirut and urban areas of Mount-Lebanon. The recycling facility works with various sorting facilities, including those that sort industrial waste, to obtain recyclable resources. By doing so, they are exposed to the collection and sorting activities of the sector, which leads to a more efficient recycling process. Lastly, the facility offers consultancy services and advocates for clustered solid waste management.

Economies of Scale

At the governance level (P8), the consulting organization is attempting to address the challenges associated with decentralization. To that end, they have launched a pilot project that brings together four municipalities with a combined population of 12,000 residents. The coalition would help minimize the operational costs, having one transfer station, and a higher amount of waste, tackling the disadvantages of economies of scale. The project challenges are more related to the NIMBY effect, governance and policy drawing. Mayors showed positive signs of partnership.

The sorting facility had different challenges, related to the lack of policies in the sector, such as structuring the sector on the micro scale. This created unwanted competition dividing the waste streams between 2 or 3 sorting centers in a small geographic area.

The capacity of the 3 initiatives was based on the funding and training given by international countries, participating in workshops related to their businesses. Support from the public sector is not formally present, only informal partnerships were able to be forged either by collecting, consulting or recycling. The technical capacities of the sorting and recycling facilities are proportional to the funding received from several grants. Their models are profitable, but the scale is relatively small compared to the national scale. Managerial capacity does allow the expansion

of their initiatives, financial resources followed by protective policies (private and public protection) are required for the success of the physical aspect of the initiatives. Support such as land acquisition for sorting facilities, as well as assistance with non-functioning or stopped facilities (Section 4.1.3), could be provided through PPPs. The creation and implementation of policies to standardize the sector and remove unwanted challenges, as discussed in P6, could also be helpful.

On the physical level, the sorting facility is working on a program not only to target residents, but commercial and businesses as well, working on the environmental and social awareness of waste. Several businesses on all scales have already joined this partnership. Finally, in knowledge resources, waste characterization on the local level (per area), is a must in economies of scale, to determine the amount of waste being generated and the type of recyclables and amount that can be extracted. Participants shared that numbers are generalized and outdated, since the waste stream's composition is changing. In his opinion this reflects on the current situation, lifestyle changing and industries looking to reduce the cost of packaging. Data should be collected for better understanding of the market.

The recycling company expressed that few sustainable recycling processes are present, which can create shortages in the demand for recyclables. This could push sorters either to stop or to find export solutions, which is not considered as sustainable. This requires 4 resources from the analytical framework to be targeted.

The informal sector affects the process extensively, decreasing the quality of waste in areas. P6 mentions that the informal sector is well structured. It is hard to fight them, since they are backed by powerful actors in the country. The best way to reduce this informal behavior is to draw policies and let the sector join the system formally quoting:

“They are too strong (informal sector) to be stopped, they are the best recyclers in the country”.

The informal sector is unregulated and uncontrolled and is one of the main sorters in the country. Its presence is somehow controlling the market prices of recyclables.

Weak Profile

On the governance level related to the relation with the public sector on the local level, P7 mentioned that in areas, they are involved in the awareness of sorting, which in their opinion should be the responsibility of the municipalities. The willingness of some municipalities is limited, where you can observe gaps between different towns. P6 Added that urban planning on the municipal level is lacking, with no policies related to awareness, sorting/recycling, or at least they are not implemented.

As for the national government all participants agreed on the standardization of the whole waste cycle. Starting from the local industries and selling points. Waste (recyclables) should be monitored and digitized, it should be treated as a resource and not as waste. The willingness of

the national authorities to apply this standardization, tracking, characterizing and monitoring could increase the transparency and protection of the sector.

The participant believes that clients are primarily from the economic sector, followed by the social and environmental sectors. Finally, he adds if the cash-for-trash companies' stops, people with economic priorities will go back to their past behavior, doubting that there is a behavioral change and people are just adapting. The recycling company shared that people now are more aware of the recycling process, and different types of plastic. The participant believes that recycling and sorting are increasing in the country, possibly due to economic motives.

Resident participation is diverse with the private sector regarding their waste streams. According to the sorting facility (P6), they have 3 types of clients that are willing to participate in the cash-for-trash: first the environmentalist, the people that are eco-conscious. Secondly, the people that want a cleaner neighborhood, not really doing it for the environment (and probably they know little about the consequences). Their participation is based on social inclusion and participation that they believe in. Thirdly, those that aim for economic benefits. Those individuals are basically careless about the environmental and social impact, and their focus is more on the economic revenue.

“Biggest behavioral change is for those individuals, because now they are trying to understand the value of each recyclable ... they went from 0 caring to recycling, sorting and identifying on the spot the 18 types of recyclables... this is huge!!”

External Effects

External effects come forward according to the respondents in a relative lack of bottom-up initiative (first movers) and a lack of societal initiative to engage in behavioral changes. In response, on the governance aspect, a behavioral change in the SW could be influenced by several factors as mentioned by the participants. P6 shared that the implementation of taxes could create a resistance at first, but help structure the sector with time, pushing residents by the public sector to sort at source. A financial incentive for segregating recyclables could be an added value as well. The residents with the right motives (many motives) were influenced and were able to sort at source. The national government could have a major influence in redrawing the sector's organizational infrastructure on the local level. P7 states:

“Drawing policies and backing recyclers to export their products could help the local economy while reducing waste...recycling would help reduce landfilling and increase economic growth”.

On the physical aspect, those policies would influence practitioners to expand their activities, either bottom-up based on more residents being involved or based on actions of implementers (private sector). Which will also influence the local scale from the central government on many topics such as financial gains from the activities to environmental gains in reducing landfill waste volume.

P6 adds that drawing policies on the national scale related to value chain of recyclables, sorting at source, geographic standardization, and policies (for collection and sorting) could influence a major shift in the sector, merging the informal collectors “*the best recyclers*” into the system. The reduction of negative competition and successful collection methods could influence the Lebanese community in participating in a more sustainable SW sector.

P8 stated that the coalition of municipalities of their pilot project could influence other possible and potential coalitions in different areas.

Decentralization vs Centralization

Decentralization in a physical sense could be challenging according to the participants, although P6 & P8 agreed that every area is different and that density, lifestyle and the economic situation are key factors in the process. Nevertheless, technical, financial, and managerial capacities should be assessed in all aspects, as these limit the scope for decentralization. P6 goes back to the standardization of the sector from the source to the end life of the product. This increases transparency and has an indirect positive effect on the informal sector. P8 stresses the degree of decentralization should be strongly linked to the number of residents in km². No accurate number is given, but municipalities in Lebanon are relatively small to have independent sorting facilities. A hybrid system, thus, seems more suitable, where the sector is assisted in creating more recycling activities and a better distribution of small collection facilities across the country.

Related to governance, participants suggested that the central government should structure and standardize the sector, in terms of service areas and data collection constantly updated. Spatial planning and SWM should be more integrated. On the local level, the public sector with the support of the national government should formalize their relationship with the private sector, which will push the willingness and ability to participate in PPPs, while maintaining responsibility and accountability of actions with the government. The private sector is aware of the lack of involvement of the public sector and believes that both state and municipal) levels should have a restructuring role.

4.3.3 Research Center: A Study of Decentralization and Environmental Governance in Lebanon

The research institute has many programs in Lebanon related to public policies and national affairs. One of the programs is related to CC, tackling 4 main topics, and one of them is SWM. Their work is to advise policy makers based on their research. Their focus is on the transition of the SWM into a sustainable integrated sector. In the research process they did several workshops and data gathering in each governorate inviting all relevant stakeholders on the local contexts from the private and public sectors. According to the workshops, all governorates have different struggles, but major ones nonetheless in SWM. The workshop tackled 2 aspects, similar to this research; physical and governance aspects.

Economies of Scale

Decentralization in Lebanon is becoming a political term, used sometimes without proper definition:

“Decentralization now is more political, the idea through our research, you can’t just say decentralization should work. Some things can work, some others won’t. The SW is divided into 3 levels: collection, sorting, recycling-composting-landfilling. In decentralization, some plans work, and some won’t. We have to assess case-by-case”.

In terms of governance, decision-makers should evaluate tasks and their relevance to economies of scale. For instance, waste collection boundaries per transfer station should be based on at least 25 tons of waste per day per facility for cost-benefit and sustainability purposes, as per one expert. This could result in larger geographic collection boundaries than those found in most towns in Lebanon.

The lack of standardization and national laws for the geographic boundaries of the private sector is another governance issue. This is evidenced by the proliferation of small-scale sorting initiatives that compete with each other. Over time, this negative competition may lead to the abandonment of their activities and facilities.

On the physical aspect, clustered municipalities collecting waste on a local level could be favorable, while recycling/composting could be more centralized depending on the type of facility. Finally landfilling should be limited and centralized, reducing NIMBY effects.

Informal pickers are affecting the recyclable market and the business models of the new emerging private sector. The random involvement and spontaneous participation of the informal sector in different areas of the country is negatively affecting the volume and weight of the recyclables of SMEs working in recyclables.

In the roundtable discussions stakeholders from both the local public and private sector participated. Technical capabilities could be created through financial and managerial support from the government. The local actors according to the research do not have the ability to tackle the waste sector alone.

Weak Profile

From the interviews and workshops done, all governorates shared that weakness in the willingness, lies more on the governance of the SW scene rather than with the technical and physical aspects of SWM. In workshops, participants shared that willingness by the unclear governance issues are affecting the physical aspect of SWM.

“[...] Laws and laws implementation, data sharing, transparency and corruption are part of governance. Even while discussing the technical part, they went back and related to the gap in governance”.

The physical aspect of SWM is directly impacted by policies, particularly the lack of standardization and clear laws regarding the role of the private sector. This is damaging the

reputation of the private sector and may lead to a loss of credibility and willingness to participate in small-scale projects among donors and the local public sector. Sorting at source, recycling and composting willingness is highly affected by the governance process and politics in the decision-making of SWM. SWM not only suffers from being less profitable and interesting for municipalities to invest in compared to other local projects, but also from its reputation in relation to the messy governance system.

External Effects

On the governance aspect, refugees' presence in different municipalities could be a burden (financial and technical) on the local sector, where the government is not being able to address it properly. For example, an NGO responsible for collecting the waste in refugee camps, is transferring the waste just outside the camps territory, into a municipality territory. In Beirut, the waste is paid by the weight, which has increased in the mentioned municipalities without having incentives (taxes) from the camps. Policies surrounding refugee camps are still lacking and not being implemented from the central government.

The gaps and influences on the SWM sector are related to governance. While Law80 requires the presence of sorting, recycling, and composting facilities at disposal facilities, whether local or central, there is a gap in the law as it does not specify the required facilities depending on the context.

This will influence the private sector on the physical aspect, to privatize and control the market with no geographical or operational boundaries. The private sector might prioritize their economic sustainability over the community's benefit. At the moment, the presence of the private sector has more positive inputs, but with time the influence of privatizing the whole system could lead to environmental degradation. The public sector has limited influence on the private sector and can only make informal agreements, hoping that the private sector delivers on their promises, with little means of monitoring their work. The only possible action is to stop their collection participation which will reflect negatively on the public sector in other situations (economies of scale).

Finally, the informal sector is not targeted in a policy, but is mentioned in every policy recommendation and the influence that has on the scope of the policy. The informal sector remains a strong SW actor, with an unpredictable and unhinged path.

Decentralization vs Centralization

According to the respondents the degree of decentralization should be determined by many factors: economies of scale, capacity of the local sector at each level, ability, and willingness to implement a physical facility for collection sorting and even recycling/composting). Hybridity of the system could be a best-case scenario, limiting external effects through this hybrid approach. Decision making and physical infrastructure does not have to be contingent (i.e., they may not show a similar degree of decentralization), but should be assessed according to the context while

dissecting it. Hybridity should take place to proactively tackle the disadvantages and challenges of (de)centralization at the physical level.

*“[...]every case should be dissected and analyzed case by case (local government could work on this). Decentralization is not the only solution. **Hybridity** for activities and levels in operation and strategy should take place [...]*

[...] Decentralization should be determined on which scale? Municipality? Union? caza? There are no studies related to this. Sometimes the bottom-up approach does not work, everything should be assessed and dissected, finding solutions in a tailor made approach”.

Which means technical, financial, and managerial solutions could come from different levels and sectors depending on the requirements of the context to be able to have a sustainable and integrated sector. This again relates that governance and physical aspects of SWM should have 2 independent sets of hybridity.

On the governance aspect, the central government should be more monitoring the sector, ensuring good level of service, best recycling/composting practices guidelines, monitoring health and environmental threats and creating a guided safe environment for the local level. The local level should base their decision making on a more tailor-made approach for the best practices of SWM with the best partners from the private sector.

On the physical aspect, the process should be fragmented depending on the task. As mentioned above, collection should be the most decentralized, for proximity in transportation and working closely with residents on sorting at source, while recycling/composting could be more expanded depending on the relevant recycling facilities. Finally landfilling should be more centralized, to limit their numbers, reduce spillovers and have better monitoring.

4.3.4 Summary of the Findings

In appendix 6 & 7, a summary table was drawn, showcasing the findings from the 3 groups of participants. The table will direct the research in determining the main gaps of the Lebanese SWM. Constraints of decentralization were unpacked in appendix 6, suggestions for the balance of centralization/decentralization are showcased in appendix 7.

Chapter 5: Discussion and Recommendations

Lebanon is passing through a transition toward decentralization in its governance and physical infrastructure that is reflected in SWM. Studies have shown that the system needs a shift, and draft laws are being drawn in a more decentralized direction. Nevertheless, the result shows that some parts of SWM need to remain centralized (table 10). The implementation of existing laws has been slow, but many factors have been going on related to decentralization, such is the case of many municipalities that started to manage their waste, partnering up with SMEs on the local level. The focus of this research was based on the constraints of the current system and a discussion of possible benefits and constraints regarding decentralization, built on the 3 phenomena developed by Zuidema (2016): economies of scale, weak profiles, and external effects. In this section, suggestions for a shift towards a degree of decentralization related to the 3 constraints based on the governance and physical system of SWM. Thus, the central government still has a major role and it will be elaborated in 5.4, describing the two separate hybridities in governance and physical aspect of SWM.

5.1 Economies of Scale

Expertise on the local level related to environmental governance and environmental experts might be missing and is considered as a priority in Lebanon. Concerning HR, municipalities have a lack of staff related to those expertises as mentioned in chapter 4.2-3. The central government could assign experts to several smaller areas, to facilitate decision-making related to environmental protection and best practices in the country. Decisions that will reflect on how to collect and treat the waste, reducing the environmental and health threats related to landfills and promote recycling. Laws and institutional work for environmental protection and best practices could be easily achieved on the local level when drawn on a national level, removing the need of repetitively constructing the same guidelines locally. A general policy created on the central level, will eliminate the need to 'reinvent the wheel' on how to have a SSWM.

On the geographical level, the number of municipalities is high, and many rural municipalities have a low population density (Logorep-vng, 2017). Low population will lead to low amounts of waste collected, this will reduce the recyclables/organic waste quantities, with a higher operation cost, affecting the FR. To increase the economies of scale, some municipalities did push for coalitions as per the interviews and figure 8 through union of municipalities. Some policies and laws were made to promote such coalitions. I argue that the central government plays a major role in controlling the peripheries, to secure economies of scale for the collection and sorting of waste. Clustered municipalities should be designated based on waste flows, with a minimum of 25 tons per day (chapter 4.3). Proximity, density, population, political, social and geographical characteristics plays an important role in determining the coalition of municipalities that is best

designed by the central government, communicating with the local level, for combining general data and resources from the local context. Thus transfer and operation facilities will be clustered on the local level, reducing transportation cost from the physical central system, and reducing operation cost from the lowest decentralized system with advanced practices, increasing knowledge resources. Finally, the process, such a clustered system shall handle collection and transfer stations while recycling, composting and landfilling activities should not be bounded by the clustered geographic periphery, which can be reached at a higher spatial scale. A hybrid process would be recommended, increasing the TR, depending on the local context for the availability of land use, recycling and biodigester facilities. Sorting stations from the clustered system will have more means in selling its collected resources. The private sector, including the informal sector are key components filling some gaps of the 4 main resources (Bui, 2022), especially in the TR and FR.

KR such as waste characterization should be structured, for better understanding of waste streams, for future private sector inclusion. Finally, cost-recovery policies (household waste fees) are already drafted and need implementation decrees. This implementation will help municipalities to cover part of its expenses, and potentially upgrade this policy for better efficient practices. One of which, inspired by the Diftar Policy of the Netherlands (VanDerWaal, 2019), where recyclables and organic waste are reduced from the waste fees, empowering policies related to sorting at source.

5.2 Weak Profiles

Municipalities in Lebanon, mostly in rural areas have little means to finance and limited KR for sustainable practices, which will affect their willingness and ability to deal with its waste sustainably. The weak profile of SWM is expressed by ongoing activities such as open landfills, open waste fires in rural areas, lack of sorting practices, lack of infrastructural facilities, etc., which all indicate SWM has low priority. Alternatively, the detrimental effects of these activities (nuisance and health) may also trigger more willingness to act. Nevertheless, the ambiguity of policies and lack of implementation of newly drafted ones could reduce the ability and willingness of municipalities and even the public to act.

On the governance level, decision-makers on the municipal level will have lower willingness to safeguard the environment due to the lack of knowledge and technical resources. The central government on the other hand could draw policies, drawing references for decision-makers on the local level to build their plans sustainably, basically more of an environmental reference, removing the ambiguity of policies to increase willingness. References such as knowledge and technical resources, landfilling practices and techniques, sorting practices dividing hazardous from non-hazardous waste etc. This support should be coupled by financial resources for the local level, especially innovators from the private sector, to increase the willingness to pursue these environmental practices. Another central government involvement in providing technical and knowledge resources in SWM would be more on data, standardization and monitoring of the waste streams, section 4.3.2. For example, industries and agricultural businesses could have a

more regulated production line for responsible consumption that will help their export on the one hand, and help tracking waste and characterizing waste streams for best recycling and composting practices on the other hand.

The landfilling actors should be monitoring and reporting the waste accepted in landfills, according to the parallel regulations discussed above related to standardization and monitoring of waste streams.

As for the NIMBY effect, knowledge sharing resources guided by the central government, collaborating with NGO support, and citizen inclusion, would reduce the resistance of decentralizing the system on the physical level, for movement against nearby transfer stations or new planned ones. The private sector should be empowered technically in some areas by the central government alongside the phenomenon that is already happening through NGOs and Embassies, as stated by the private sector interviewees.

5.3 External Effects

External effects could take the form of random landfilling and open dumps from neighboring periphery in the Lebanese scene. An unregulated sector with limited local control that could result in different practices between areas in Lebanon with different levels of services. Spillovers from neighboring unsustainable SWM solutions could generate informal dumping causing health and environmental degradation.

To avoid such effects, a holistic governance, led by the MoE could take place. Regulations and jurisdiction action on the national level should take place to control unsustainable practices, such as random landfilling, where the country now has more than 1000 open dumps (UNDP, 2022). MoE and ministry of interior, holds a prominent role in securing and deciding on landfills across the country that should receive fewer amounts of waste from the transformation planned for the sector. The national and local governments, with the relevant local private sector, should participate in reversing informal practices in different areas of Lebanon, in deciding how to integrate the informal pickers in the new decentralized model.

In the process, the public and private sector on the national level could affect the FR of the recycling and sorting scene on the local level. Instead of monopolizing the system, the central government may break their dominance and create a more constructive competition in the private sector scene.

Urban areas from the analysis of interviews have the potential to attract more the private sector, for their scalability and business models, leaving little presence of SMEs in rural areas. This shortage should be reserved through protective policies on the micro-scale, where financial subsidies might be needed in particular rural situations.

On the physical level, landfills should be limited as mentioned previously, and handled separately from other processes in the SWM tasks, securing transparency and accountability of landfilling practices.

On the geographical level, clustered systems could include more private stakeholders, compared to the municipal level, thus positively affecting the process of SWM tasks. This inclusion could facilitate landfilling, technologies and practices related to SSWM having higher levels of compost quality and innovative contextual recycling practices, leading to an increase in ownership and responsibility in the sector at a local public level.

In the process, the informal sector could affect the waste management streams and thus the recovery of recyclables from waste, since they are the dominant sorters in the country. Their involvement should be capitalized, next to inclusion of residents in collection, and may assist in creating collection systems that protect high quality waste streams. Many laws are already drafted, but the implementation remains the main issue in the sector, that could be related to the decision-making process, affected by the political instabilities. Another strong point is the reduction of operation cost that will affect the willingness and ability of the local clustered stakeholders to deal with SWM. Municipalities interviewed and literature findings all pointed that most municipalities are not strong enough to deal with its own waste solely. Potential tension between neighboring municipalities are present (political and sectarian tensions), as mentioned by one of the interviewed municipalities, that could be solved through the intervention of the central government in a more communicative approach (De Roo, 2004), coupled with policies and monitoring of the physical process to ensure willingness of this necessary partnership. The presence of the national government is to support action when it is needed in these complex situations, ensuring and supporting the priority of the services that the local government should provide.

Monopoly of the sector on the national level played a negative role, where data and knowledge resources were not available on the local level, coupled by the lack of technical resources in the face of the imposed central physical system that was not delivering a satisfactory level of service. The national government has a crucial role to play in supporting the local SW sector, providing support rather than creating ones in terms of resources, while protecting the possible landfill spillovers of unsustainable decentralized SW practices.

Another point is the presence of refugee camps that could hinder the willingness of the process, where the central government plays a major role in creating a strategy in including their waste streams in the hybrid model.

5.4 Recommendations Summary and Stakeholder Involvement

As described above, the disadvantages of decentralization push for a certain level of control from the central government to overcome key constraints to local willingness and ability. 2 different hybrid systems coming from the governance and physical perspective, could help overcome the mentioned gaps. On the governance level, the national government should draw a holistic approach for the sector, safeguarding environmental targets through assigned environmental experts. Policies and institutional work for private sector control and inclusion of e.g. the informal

sector and local companies preferably should come from a strong profile such as the central government to reduce unwanted privatization, while supporting SMEs that suit this holistic approach. On the other hand the local government will have a greater role in the decision-making on the process of collection/sorting with a central guidance. As for the geographic aspect, a clustered process designated by both national and local decision makers will secure the economies of scale for sorting facilities (minimum 25 Ton/D), while increasing the proximity of the process, coupled with its mentioned benefits (chapter 2&4). Finally the physical process hybridity could play a major advantage, since recycling, composting and landfilling practices from the private sector could not be secured in all clustered areas, thus allowing waste transferring stations to outsource its resources beyond its geographic borders, with a more centralized physical process. PPPs and support from the national government is crucial to promote those geographically hybrid relationships, reducing free riders and external effects, especially in landfilling practices, while including more expertise and resources to the pool, with economies of scale. The momentum of SMEs in the SWM that are rising caused by the crisis should be capitalized, which could be reflected in better compost qualities, enhanced recycling process, and increasing circularity(CE) through the constant interaction of actors on a (de)centralized level.

Table 10 presents a summary of recommendations to respond to the constraints to willingness and ability to perform tasks in a decentralized SWM setting in a Lebanese context.

Table 10: Recommendations Summary

Governance: Degree of Decentralization (Hybrid Governance System)	
<p style="text-align: center;">Role of National Government:</p> <ul style="list-style-type: none"> → Holistic governance approach - main reference → Securing environmental and SWM experts and consultants for clustered areas → Institutional work for environmental protection → Monitoring and standardization policies → Mending partnerships with designated clustered municipalities → Data collection, characterization, and studies → Support of SMEs related to SWM → Financial support to the local level and Investments, coordinated with international donors 	<p style="text-align: center;">Role of Local Authorities:</p> <ul style="list-style-type: none"> → Plans related to the local context → Decision making on type of collection, partnership with relevant private stakeholders in the process, while following the guidance of the central government → Informal sector inclusion plan → Local data collection policy → Decision making on the allocation of funds with the National government
<p>Geographic Aspect: clustered system for collection and transfer stations</p> <ul style="list-style-type: none"> ● Securing economies of scale for the collected waste, more financial returns from recyclables, reduced operation cost - larger municipalities ● Proximity, reduced transportation cost ● Proximity, inclusion of innovative solutions from the private sector ● Proximity, Households communication for best collection and sorting practices ● Formalized and structured private sector participation on the local level 	
<p>Process Aspect: hybrid Sorting, recycling, composting and landfilling</p> <ul style="list-style-type: none"> ● Securing selling markets for collected recyclables ● Monitored and standardized sanitary landfills (limited number) ● Lowering generalized waste characterization ● Better compost quality ● Business opportunities for new stakeholders (recyclers and organic waste treatment) in the country ● Potential waste to energy opportunities 	

Chapter 6: Conclusion

SWM across the world is aiming to change its practices (Bui, 2022), toward SSWM. Examples such as shortages of land use for landfilling, pollution from unsanitary landfills, over-consumption and short lifecycle of products, mainly economic, environmental and social pressure from waste generation (Bui, 2022; Mazzanti, 2009). In this research the focus was on the Lebanese SWM, which has been passing through many crises and facing a deteriorating infrastructure, caused by poor planning and implementation. Many researchers and MoE (law 80/2018 for ISWM) were studying and drafting policies for decentralizing the SWM to make it sustainable such as Massoud (2019) and DRI (2019). Decentralization may have important benefits in transforming the SWM sector in Lebanon. Nevertheless, it is also evident from past studies that decentralization may not be suitable for all aspects of the SWM sector, and that local willingness and ability to deal with SWM in Lebanese municipalities can be seriously constrained. By combining past studies into the reforming of the SWM sector in Lebanon with studies on the (dis)advantages of decentralization in environmental governance (Zuidema 2016), this research targeted the question whether and on what aspects decentralization may help the Lebanese SWM sector to become more effective and sustainable. In doing so, we specifically assess the risks of a low willingness and ability at a local level and which strategies could help respond to this, e.g., through national support or through collaborations locally between municipalities or with market parties.

This research responded to its central aim by targeting five related sub-questions, which were answered in previous chapters. Sub-question 1 and 2 were answered in chapter 2.4/5; chapter 2.4.2/4.2.2 regarding the benefits of decentralization for SSWM, while 2.4.1/4 expanded more on the benefits of centralizing the sector and finally on key constraints on local (decentralization) willingness and ability to cope with SWM tasks were discussed in 2.4.2-3/4. Comparing advantages and disadvantages of both systems were represented in 2.4.3. Sub-question 3 was answered in chapter 2.2 introducing the main actors in SWM, and specifically in the Lebanese context (3.3-4.1), and how they perceive the benefits and risks of (De) centralization (4.2-4.3). The final two sub-questions targeted (1) how hybrid combinations of central/decentralize SWM may allow to ameliorate risks and harvest benefits and what may be the role for the central government and (2) How can we merge the SWM process for several municipalities, considering the high number of municipalities, and how may this help SWM. The answers to these questions are summarized in table 10 in chapter 5 alongside the RQ.

While answering these sub-questions, several central conclusions came forward. The central aim of these questions is to overcome the challenges in Lebanese SWM, this research shows that governance and the physical system of SWM should be separated. Similarly, both systems should rely on a hybrid system, mixing elements that are more centralized and decentralized. Table 10 summarizes the findings of the different systems in SWM (governance and physical), aka 2 types of hybridity.

In the academic debate, on the governance level, a centralized system still has a major role in the decision making process while supporting and reversing the constraints of decentralization,

on the other hand a decentralized system will have a stronger role in deciding and finding solutions relevant to the local level with relevant stakeholders in SWM. Research findings from literature and participants did align with Lemos (2006) related to environmental governance, decentralization and its constraints (Zuidema, 2016), taking a special turn in the SWM scene toward SSWM.

On the physical aspect, for the collection, geographically a clustered system is better suited to overcome economies of scale and increasing proximity of the process. As for the process of SWM, hybridity outside of the clustered geographic boundary should be adopted, to secure the circularity and sustainability of the process (better recycling/composting solutions), see table 10. Findings do agree with articles related to SSWM like Bui (2022); hybridity of the physical system (Shekdar, 2022), holistic integrated approach with many stakeholders included (Mmereki, 2016) and the degree of decentralization of SWM in Lebanon (Massoud, 2019). Nonetheless the findings do not agree with Anwar (2018), favoring a centralized physical system for economic gains, discarding the environmental and social pillars of the sector.

Many studies did favor decentralization of SWM in Lebanon, moving away from the central government as seen in chapter 4.2. This study contributes to lack of data related to the constraints of decentralization of SWM in Lebanon, and potentially filling gaps for decentralizing the SWM. Participants from the research center did mention that decentralization in Lebanon is not clear on what level of decentralization, and the ambiguity of linking the physical and governance system (chapter 4.3). As for hybridity, municipalities all stated that decentralization alone can't secure a good level of service for SWM and that the central government should step in, filling the constraints of decentralization, mentioned in detail in this research.

In this transition, a learning by doing in degree of decentralization (Zuidema, 2016) should be well expected, giving room in terms of policies for customization and adaptation depending on the local context. Appendix 8.

For societal relevance, the author of this research is a citizen of Lebanon, and practitioner in the SWM scene, through his recycling profession. The researcher's experience as a practitioner inspired him to overlap the theory and the implementation in this research. Thus the research was based on the 4 questions from the Flyvberg, (2006) on Phronetic research: Where are we going? Is this development desirable? What, if anything, should we do about it? Who gains and who loses, and by which mechanisms of power? Balancing values and power in the planning of a complex situation (Sbeih, 2022). Answers will contribute to the transition of the system toward sustainable planning and governance in SWM that could be reflected in other sectors in terms of governance. On the physical level, answers found would help the research and people participating in it, to find better practices in this complex system, related to SSWM and how to plan with the private sector, which recently has been building their small businesses in the face of the SW recurring crisis, informally without a structured guidance.

Finally, for limitations, opening a window for future studies from this research, first, interviewed municipalities were from rural areas, since challenges for decentralization will be more relevant in those contexts. Nevertheless, urban areas might have further issues that could be present, especially in availability of land for landfilling and facilities, which might be solved in the hybridity

of the process. A follow up study would be helpful, focusing on the clustered geographical system, and how to develop and support it. This suggests that the central government may need to assign the geographical boundaries of collection, merging many municipalities together, which might be challenging, given the current political/sectarian tension. Second, rural and urban areas differ largely in characteristics of SWM and this should be taken into account in the clustered system. Further research to propose the geographic boundaries, if it should be possible on the union level or a clustered set of municipalities. Third future gap, land use issues. Masha'a' land (see appendix 6) are mainly rural lands with no direct ownership, that if examined by central and local decision-makers could provide solutions for the new required transfer and sorting stations from the clustered system. Fourth, data related to waste characterization is found reliable in just one study, and the lack of data on financial schemes in the local sector could be limiting for this research to give concrete solutions on the physical process.

This research's main focus was to decouple the governance and physical system of SWM. The complexity of the Lebanese system, the lack of transparency, and segregation in communities could play a role in the failure of the system, but few studies tackled this, focusing more on the physical aspect. Thus a strong question might arise from this central system for future research: If relying on the national government would be in place to monitor the sector, or a search for other systems such as the bottom up approach to fill that gap?

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Appendix

Appendix 1: Table of Document Review

Type	Title and Author
Articles	<ul style="list-style-type: none"> ● <i>Khawaja, B. 2017 - "As if you're inhaling Your Death"</i> ● <i>DRI, 2019 - Solid waste management in Lebanon: Lessons for Decentralization</i> ● <i>Abbas, 2017 - Solid waste management in Lebanon: Challenges and recommendations.</i> ● <i>Massoud, M.A. 2019 - Towards improved governance for sustainable solid waste management in Lebanon: Centralised vs Decentralized approaches.</i> ● <i>Stel, 2015 - Environmental vulnerabilities as a legacy of violent conflict: a case study of the 2012 waste crisis in the Palestinian gathering of Shabriha, South Lebanon</i> ● <i>Azzi, E 2017 - Waste management systems in Lebanon: The benefits of a waste crisis for improvement of practices</i> ● <i>Abbas, 2017 - Solid waste management in Lebanon: Challenges and recommendations.</i> ● <i>Jadam, J., 2010. State and Trends of the Lebanese Environment, Ministry of Environments Lebanon..</i> ● <i>Verdeil, 2017 - Des déchets aux remblais: imaginaire aménageur, corruption et dérèglements métaboliques à Beyrouth.</i> ● <i>Massoud & Mokbel, 2022 - Determinants of waste characterization in Lebanon and material recovery potential</i> ● <i>El Meouchy, 2020 - MSW management via PPP in Lebanese Medium-size communities</i> ● <i>Maamari, 2015 - Health Care Waste generation rates and patterns: The case of Lebanon.</i> ● <i>Abu-Rish, 2016 - Garbage Politics</i> ● <i>Giannozi, 2017 - On the Decentralization of Solid Waste management in Lebanon: A Viable Solution to the "Waste Crisis"?</i> ● <i>UNHCR (2021). FACT SHEET. Lebanon. Retrieved on 10-1-2023, through: https://reporting.unhcr.org/document/1262.</i>
Videos and Journals	<ul style="list-style-type: none"> ● <i>Development Matters in Solid Waste Management - UNDP Lebanon (2022) YouTube. YouTube. Available at: https://www.youtube.com/watch?v=MqSeO0B-xu8 (Accessed: January 19, 2023). - Appendix 3: Script and data extracted</i> ● <i>Houry, N. (2022) Lebanon: Waste crisis posing health risks, Human Rights Watch. Available at: https://www.hrw.org/news/2017/12/01/lebanon-waste-crisis-posing-health-risks (Accessed: September 20, 2022).</i> ● <i>UNEP (no date) How one non-profit group is spearheading recycling in Lebanon, UNEP. Available at: https://www.unep.org/news-and-stories/story/how-one-non-profit-group-spearheading-recycling-lebanon (Accessed: September 20, 2022).</i>

Appendix 2: Academic Findings for SWM in Lebanon per Category

Decentralization Findings	<ul style="list-style-type: none"> • Azzi, E 2017 - <i>Waste management systems in Lebanon: The benefits of a waste crisis for improvement of practices</i> • Massoud, M.A. 2019 - <i>Towards improved governance for sustainable solid waste management in Lebanon: Centralised vs Decentralized approaches.</i> • DRI, 2019 - <i>Solid waste management in Lebanon: Lessons for Decentralization</i> • McCornack, A., 2012. - <i>Strengthening local governance through effective waste management</i> • Abed Al Ahad,. 2020- <i>Decentralization of solid waste management services in rural Lebanon: Barriers and opportunities</i>
Physical Recommendation : Technical, Physical, and Knowledge	<ul style="list-style-type: none"> • Abbas, 2017 - <i>Solid waste management in Lebanon: Challenges and recommendations.</i> • Jadam, J., 2010. <i>State and Trends of the Lebanese Environment, Ministry of Environments Lebanon..</i>
Integrated Approach: Environment, Health, Industries, and Tourism	<ul style="list-style-type: none"> • Maamari, 2015 - <i>Health Care Waste generation rates and patterns: The case of Lebanon.</i> • Ghadban, 2017 - <i>Trash crisis and solid waste management in Lebanon - Analyzing Hotels commitment and guests' preferences</i> • Khawaja, 2017 - <i>"As if you're inhaling Your Death"</i> • Massoud, M.A. 2019 - <i>Towards improved governance for sustainable solid waste management in Lebanon: Centralised vs Decentralized approaches.</i> • Soubra, 2021 - <i>Assessing the environmental risk and pollution status of soil and water resources in the vicinity of municipal solid waste dumpsites.</i> • Verdeil, 2017 - <i>Des déchets aux remblais: imaginaire aménageur, corruption et dérèglements métaboliques à Beyrouth.</i> • Massoud & Mokbel, 2022 - <i>Determinants of waste characterization in Lebanon and material recovery potential</i>
Politics, Regime and Solid Waste Management	<ul style="list-style-type: none"> • Abi Yaghi, 2017 - <i>From isqat an-nizam at-ta'ifi to the garbage crisis movement: political identities and anti sectarian movements</i> • Deets, 2016 - <i>Jumping out of the "Hobbesian Fishbowl" and into the fire: Lebanon, elections, and chronic crisis</i> • Karakji, 2016 - <i>Trashing the sectarian system? Lebanon's "YouStink" movement and the making affective publics</i> • Kraidy, 2016 - <i>Transforming municipal solid waste into a sustainable material and energy in Lebanon</i> • Richani, 2017 - <i>This is not a revolution: The Sectarian Subject's Alternative in Postwar Lebanon</i> • Stel, 2015 - <i>Environmental vulnerabilities as a legacy of violent conflict: a case study of the 2012 waste crisis in the Palestinian gathering of Shabriha, South Lebanon</i>

Appendix 3: Development Matters in Solid Waste Management - UNDP Lebanon (2022)

Development matters in Solid waste management UNDP Lebanon environmental expert interview.

What is the real solid waste management problem? SWM expert basma Al Arab Mazen Makki

Open dumping and landfills are still a problem? How can we assess the situation? We have several types of waste: residual, agricultural and industrial waste and hazardous That have organic, recyclables. Lebanon in 2019 will have 7000 tons per day, but number is decreasing, 36% open dumping, 20 recyclables, rest landfills. Services are decreasing: financial crisis, economic and resources, facilities down and open dumping.

What do you mean by factories: Sorting and recycling and composting?

Why is the problem recurring?

SWM is a reoccurring and long problem, in 2015 Naameh landfill was closed which caused the crisis. Plan was drawn from the ministries, but national politics didn't occur, one common plan was not agreed. Institutional work took a lot of time for the management of waste, another problem financial resources and most projects were funded by the international countries, and if funding were to stop municipalities could not close the operation cost of the sorting facilities funded. Another challenge for the sector's financial and economic crisis is affecting the sector. As well as global SWM. As well find ways for return on investments that should be given from policies and decisions for residents and sorting facilities. Environmental hazard from open dumping and as well on the service actor is deteriorating caused by the lack of financial resources for the operation according to the standard practices for operation. Those are the challenges.

Problem more than planning but implementing

Planning was made several times across the country in a decentralized system, per caza and mouhafaza working on it. No implementation was made for the NIMBY effect of land and factories. No allocation of funds for implementing the plans. Return on investments is the most important to make the system self-sustained far from grants for continuation.

Challenges are all waste? And how is this increasing the problem?

The biggest problem is the residual waste which has the highest percentage. From the other types of waste (agri, indus, health). Residual or municipal solid waste that comes from households and organizations and industries that have cardboards papers recyclables. The biggest danger is whenever collection is seized across Beirut and others which increases informal dumping (more than 1000 informal dumps), challenges in financial and implementation.

Do external effects contribute to the change of waste composition?

20% reduction of waste and even more (5000 tons) caused by the economic crisis. Consumer behavior, economic crisis are changing from experts. Yes, external effects are contributing.

What can the resident do in the household? Sort at source? Recycling and sorting the solution?

When we talk about a solution, we should talk holistically from source to solution. Pyramid of things of the swm. From houses, industries and landfills. Sort at source, recycling, transfer, sorting with standards and finally to reduce the amount of landfill. Municipal role to help them sort at source, even with the little means they have. Awareness campaigns and bins for sorting at source with the help of the ministry of environment. We need to sort at source to a certain standard according to organic, recyclables and rejected waste (MoE). Municipalities should draw a plan in the collection and transfer and should be supported to connect to the higher system. Holistic systems sort at source to have an impact.

On the national scale how can we solve it?

On the local level, sort at source is happening in the country with the best practices. But in the end landfills are not sustainable at the moment for disposal. Not everything can be diverted so we need factories for sorting and dumping. On the national level:

- Agreement on one common plan on a national scale in the government. Political agreement for sanitary landfill per caza and governorate. Find a suitable location for landfills.
- Factories are present across the country: sorting and composting mostly stopped because of lack of operational cost to be filled. Opening the factories and renovating them to adapt them again. Beirut as an example 2 big factories stopped from the Qarantina explosion matn kesserwan and Beirut. And as well the composting facilities stopped. ALmroussiye as well stopped even after the renovation, (south of Beirut) lack of financial resources from the government, recycling factory stopped. Those factories take around 60%. Another stopped project costa Brava for composting. Government should work on these factories for renovating and financing.
- Agreement on implementation through policies for return on investment, price of recyclables and standardization to pay back the factories.
- Decentralization on the caza per caza: but economies of scale could be a problem for the decentralized, return on investment, could we cover the operational cost of the sorting facility. Financial resources and maintenance are lacking.

Those points are challenges for a better sector and stop the deteriorating crisis.

Does this sector have a return on investment, such as the CE?

The sector could give back investments first if the factories are working, and a lot of costs are going with the sector machinery, fuel, maintenance and labor salaries are essential for the sector to start first before generating. Yes there are financial gains in this sector through sorting at source either reuse, recycling treatment and today it is happening in some NGOs and private sectors, but on a small scale that should be generalized across the country. As well as composting, if there is no sorting at source or choose organic waste that is not contaminated to have compost grade A and grade B for the agriculture sector, such as enhancement for the soil. Compost is more enhancement for the soil, giving it more richness with some nutrients to add. The agriculture sector can't take the compost from factories because of the low level of compost. Compost is below standards.

Sector has revenues through recyclables and compost but should sort at source to lower contamination and be able to recycle. This sector has financial revenues, but mainly for the sorting

facilities. No big financial gains are there, and were tested through NGOs, government and private sector. Revenues are limited.

Operation and maintenance costs are high. Recyclables and compost can barely cover the cost, no financial support from the government to cover the rest of the expenses on the decentralized system. Awareness campaigns should be generalized across households, municipalities and caza. Most treatment factories, sorting composting are stopped because of financial resources.

How is the undp supporting this sector?

The undp across the years worked a lot in this sector and supported on 2 basis:

- Technical support and opening new sanitary landfills and sorting facilities
- Support the policies for the ministry of environment. Appendix 4: Municipalities Survey and Part of the Interview

Appendix 4: Municipalities Survey and Part of the Interview

	M1	M2	M3	M4	M5
City population?	Population 10,000	Population 5000 Lebanese, 4800 refugees	Population 35,000 (high percentage of refugees)	Population 2000 Winter, 3000 Summer	2000 and there is refugees population is abit high
2. Who collects the solid and plastic waste in the city/ town?	General waste the central system /and Recyclables - a local company in cooperation with the municipality and local associations	The Municipality	The Municipality	Non-recyclables RAMCO (central private sector), Recyclables - SMEs informal deal	Initially central system, initiatives started with an SME(private sector stoped working because of fuel)/ municipality tried with initiatives but failed with time, now they set a deal every Wednesday with another local initiative they pick up the recyclables. municipality helped in spreading the news for the private sector
3. How much plastic waste in tons does the city collect per week, if the information is available?	500 kg of total waste per day	250kg of total waste per day	500 kg of total waste per day	300 kg of total waste per day	2 tons per day winter/3 in the summer
4. Do you sort your plastics by type? Yes or No	No	Yes	No	No	Yes
4.1. If Yes, please specify where each category of waste goes?	No	They sell to replast	-	-	2 categories for the recycling (recyclables, and the rest organic with ramco.) same strategy following through./ local sector communicated with the community/ people are willing to sort their waste
4.2. If No, what are you doing with your combined plastic waste?	Private sector is sorting the plastic waste (private sector)	-	Recylables are being sold	Stocked in a municipality building	-
5. Is there a sorting facility in your city?	Yes	Yes	Yes	No	No
5.1. If yes, is it being used?	Yes	Yes	Yes	-	-
5.2. If yes, who is handling the operations there (Private or public entity)?	Private Sector	Municipality	Environmental department at the municipality (public sector)	-	private sector is handling
5.2. If yes please list the machines available.	-	2 pick up, 1 bobcat, compactor and sorting conveyer	Conveyer belt equiped magnetic machine. Wood shredder and composte area for organic waste. Bobact, balance and 2 waste compactors	-	no machines
6. Is there any stakeholder working on recycled products made out of plastic? If yes, please name them.	GMR	No	No	SME	no there is nothing, small town
7. What are the obstacles that the municipality is facing when it comes to sorting and recycling plastic?	Citizens awarness	Infornal pickers from street bins, sorting the plastic and reducing waste quality	Sorting and recycling awarness	Sorting bins theft and citizens not abiding for sorting at source	land not available for the recycling for any sorting facility, as well municipality can't sell for profit an institution. Nimby effect./ financial resources are lacking./ people are throwing in bins randomly increasing the bulk, only one of the initiative did the infornal picker job taking waste from the bins
8. Is there any data collection done previously through a survey related to plastic waste in the city?	No	Yes	Yes	No	No
9. Please list all the stakeholders and actors working in the collecting, sorting and recycling process of plastics: Awareness campaigns, collection, sorting, recycling, selling point or platforms for recycled plastic products, landfills facilities, volunteering.	Social community and the private sector	municipality, social community, scout and sport clubs	none existent	Private sector	Community and private sector
10. Were there any actions done by the municipality related to sorting and recycling in the past?	Yes	Yes	No	Yes	communicative approach, municipality tried to approach other private sector previously but few people were ready to take the bulk of recyclables.
10.1. If yes, What were the outcomes?	Follow up 25%	Good	-	No commitment from the community. Private sector sorting some of the recycling	Little change, but awarness was building along the way. Municipalities collection fees very little and still people not happy about it.
11. Does the municipality have any plans for the future related to plastic waste? (sorting, recycling or both)	Sorting	Recycling	Both	Other	To explore any potential
12. Are there any obstacles to achieve this plan?	Residents commitmentn	No	Fuel for the sorting factory. Lack of financial resources	-	Financial means/ mtein proposal for the EU but failed as well
Informal pickers presence?	Present	Present	Present	Present	No because of the transportation
Consortiums?	No	No	Yes, but proposal fell through	No	Consortium was made, for municipalities not in the union, neighboring towns and they made a common proposal, and everyone was on board but no fund was there, and the town did not take the initiative and decided to go for 3 small transition center. Nimbv.

Appendix 5: Interview guide

Steps of the Interview:

1. Explain the interviewer background and research purpose: master thesis at RUG
2. Explain the research objectives and limitation: The Case Study of Transitioning Centralized Solid Waste Management in Lebanon: The Devolution and its Limitations
3. Explain the definition of such terminology. Ask if it is clear enough.
4. Ask if there are any questions in advance.
5. Ask if the interviewee would introduce her/himself (name, position, and relevancy)
6. Ask several question and potential follow-up questions related to the research
7. Closing: ask if there are any questions/suggestions.

Respondent:	
Date:	

Thank you for taking the time to talk to me. This interview will last about 45 minutes.

Your answers will help me with my research. I am a student at the University of Groningen, doing my masters in environmental and infrastructure planning, and I am conducting research on how decentralization can help improve the efficiency and sustainability of SWM in Lebanon, while considering key constraints on local willingness and ability to cope with SWM tasks?

I'll be asking questions on your activities, how it is involved in the solid waste sector. The disadvantages and advantages of your work in the Lebanese context. First I would like to know about your organization. Second, I'll have questions related to governance in SWM through your perspective. Then I'll have more questions on the type of waste and resident participation in your model. Thirdly, I'll target more the physical aspect of the sector. Finally questions will be on specific topics such as PPPs and the informal sector.

Questions depending on the interviewee and its sector are to be found respectively for the public, private and Research institute in Table 4,5 and 6:

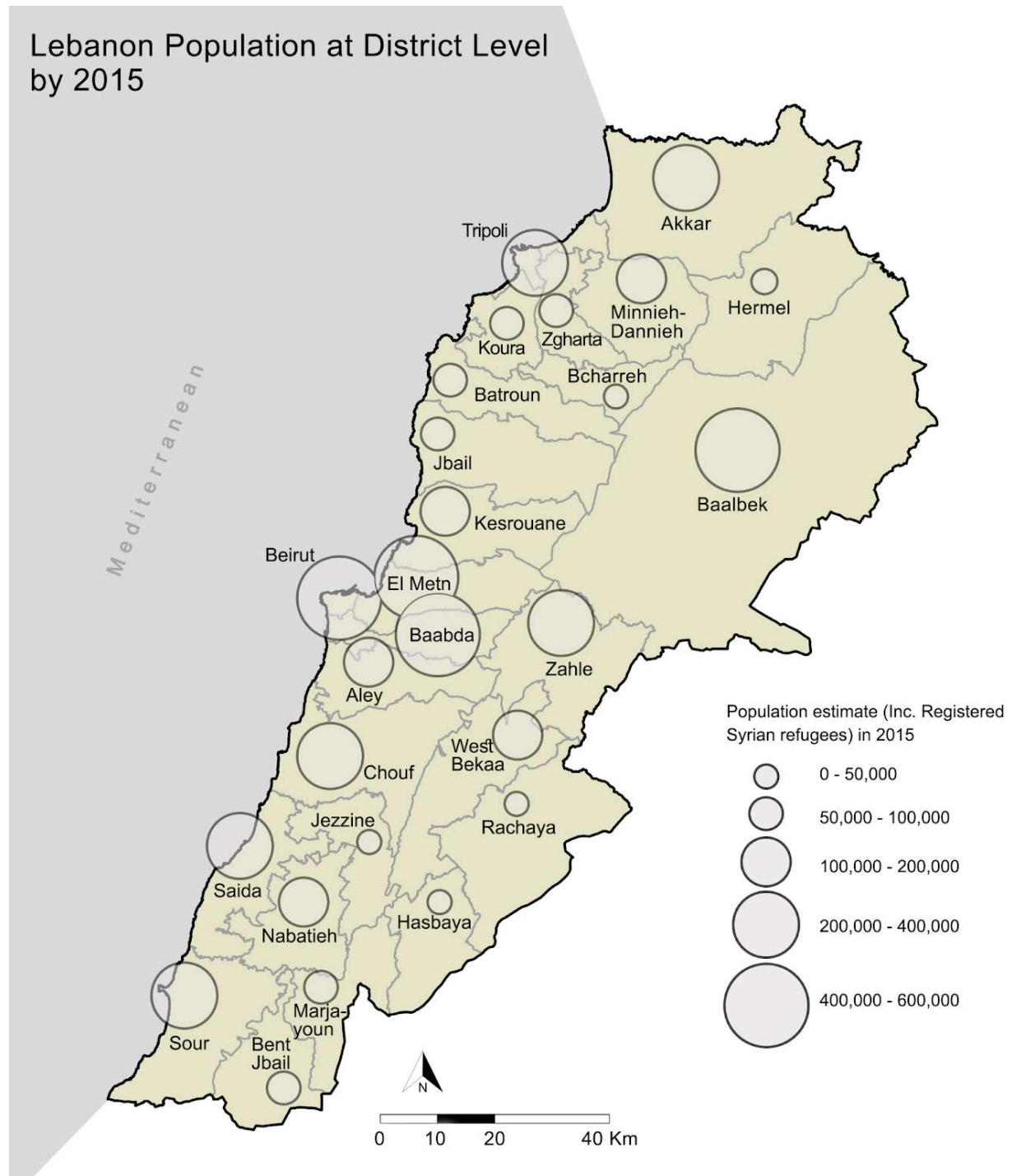
1. Private Sector: general questions on their work, focused on SMEs and their struggles in breaching the SWM scene
2. Public Sector: a survey was prepared before the interview assessing the municipal situation: context, scale, physical aspect of SWM and resident participation, etc. According to the answers, interview questions were adjusted accordingly.
3. Research Center: questions were more based on policy making and recommendation focusing on the implementation of drawn policies, primarily the governance and institutional part affecting the physical environment of the sector.

Appendix 6: Lebanon Historical, Demographic and Geographic Background

Lebanon, a Middle Eastern - Asian country situated in a strategic position between Europe, Asia and Africa is a country with many trading, geopolitical and economic advantages, and disadvantages. Many civilizations came across the country such as the Phoenicians the world first trader and navigators (Zalloua, 2008), the romans, the Greeks, the pharos, Persians, the crusades (Hitti, 1957; Zalloua, 2008), the Ottoman Empire and finally the French government colonized the country until its independence in 1945 (Hitti, 1957). The current governmental and institutional structure is written with an influence of the Ottoman and French institutions forged during their occupation (Hitti, 1957; Zalloua, 2008), that still inspire institutions around SWM pushing for a decentralized system. After the independence the country was passing through its golden age, having one of the best touristic sectors in the area (Makhzoumi, 2016), good governance and urban planning (Bauman, 2019), sectors such as transport and infrastructure were in good shape. The SW sector started its deterioration during the civil war that started after the events that affected the south of the country (The Palestinian Conflict), many Palestinian refugees moved to Lebanon and reshaped the country's demographics. The impact reached its peak between the years 1967 and 1970, where the Palestinian Liberation Organization (PLO), was forced to move out of Jordan and Damascus and have its last Palestinian resistance military base in Lebanon (Siklawi, 2017). The civil war broke down following the incident of "Ain EL Remmaneh" in 1975 and lasted until 1990, dividing the country between its several parties, based on international political pressures, indirectly related to the cold war, left-wing supporting the Palestinians against the Lebanese army supported by the right wing (Siklawi, 2017). The civil war disrupted the progress and stability of the country, and turned the capital into a war scene, dividing and destroying most of its infrastructure (Sadek, 2000). At the end of the war, the country's SW sector had poor, malfunctioning and deteriorating infrastructure. The restructuring of the SW sector started through Neoliberalism that rose after the war (1990's), as a counter effect of the war. The presence of the private sector helped the reconstruction of the capital and its infrastructure, shifting away from the public sector (Makhzoumi, 2016). Even though the capital was being renovated, the decline of the state affects the environmental (Mol, 2016) and social aspects of the context. The involvement of the private sector thus also has many disadvantages that will be discussed later on in section 4.1.2 (Harvey, 2005; Makhzoumi, 2016).

Household waste in countries experiencing a demographic boom might create challenges to adapt the system fast enough to growing waste streams (Song, 2015). Demographically Lebanon's population grew rapidly this past decade and reached around 6,750,000 inhabitants, on only a land area of 10,452 km² (Skaf, 2019; WorldBank, 2021; Worldometers, 2023).

Figure A: Population Distribution of Lebanon per Caza



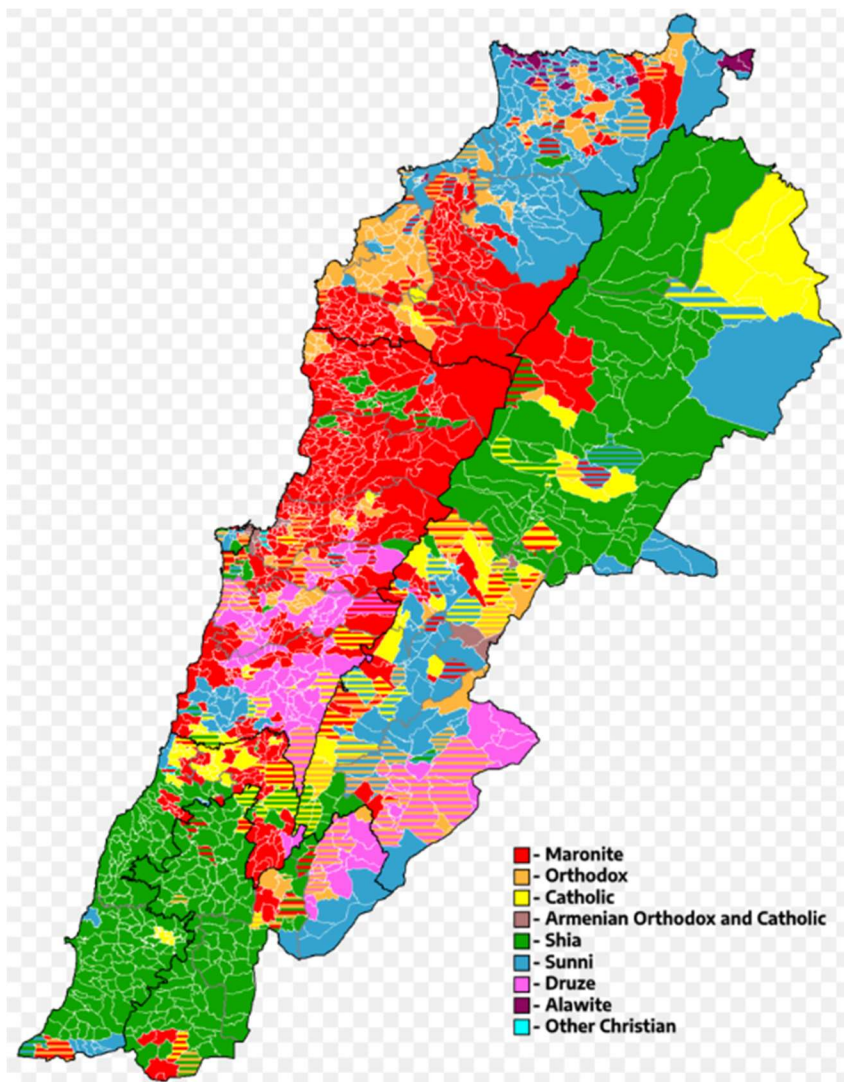
Designed by Rita Nasr

Source: Ministry of Public Health, Lebanese Republic (web), UNHCR (web), 2015

Source: DRI, 2019.

This increase is caused by the refugees' crisis: More than 1,000,000 residents are Syrian refugees (registered) (Blanchet, 2016). 460,000 Palestinian refugees are living in camps across the country (Reynolds, 2013). According to UNHCR (2021), 21% of the country's residents are refugees. As well, the oldest group of modern refugees belongs to the Armenian community, who are not included in the 21%. As for the sects in Lebanon, there are more than 18 sects across the country divided mainly between Muslim Shia 31.9%, Muslim Sunni 31.2%, Christians 32.4% and Druze 4.5% (CIA, 2023). Figure 7 showcases the majority of sectarian distribution across the country. Some areas are shared by more than one religion. Politics and religion are intertwined (Faour, 2007), which affects the type of governance, where a religion plays a major role in the governing system. This has impacts on infrastructure projects such as SWM, related to the many cultures in a small geographic area, which will require different practices for the sector (Stel, 2015; Yassin, 2016).

Figure B: Lebanon Geographic Population Distribution per Religion

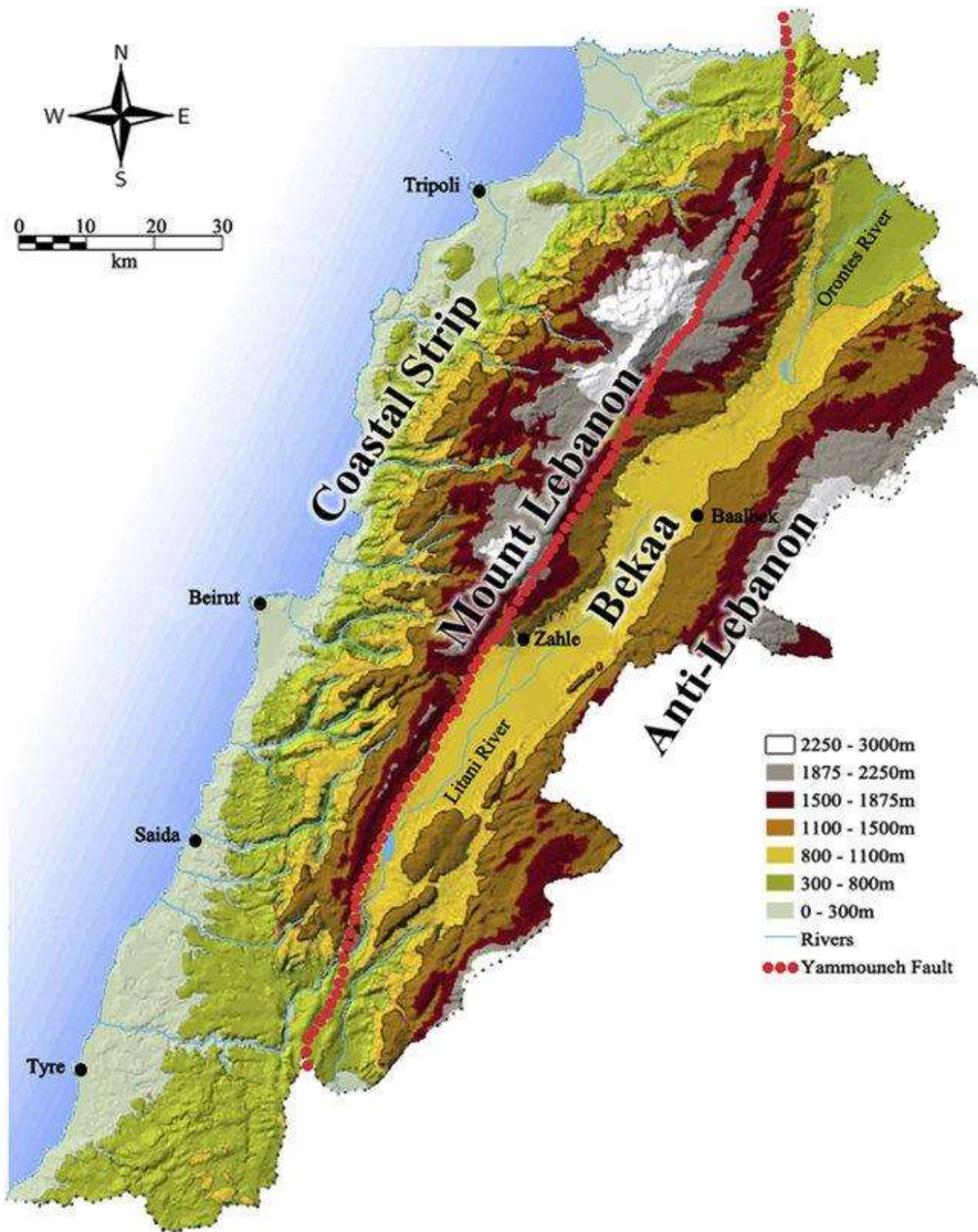


Source: DRI, 2019.

Finally, geographically, Lebanon has 9 Governorates, 24 districts, 56 municipal federations and 1,108 municipalities. One of the issues of small municipalities is found in SWM and economies of scale. Compared to other countries it is argued that the number of municipalities is big compared to its small area and population, which leads to most towns having a population lower than 30,000 residents. (Logorep-vng, 2017). This could showcase the fragmented nature of Lebanon even at the local level, with religion playing a major part in this fragmentation (Baadan, 2020; Faour, 2007), that affects SWM in economies of scale on the local level.

One of the major financial costs in the SW sector in developing countries is found in transportation of waste (Ogwueleka, 2009), which could arise when geographical elevation differences are high from the collection point to transfer stations and landfills (Höke, 2020; Lopp 2015). Lebanon is famous for the proximity of its steep mountains and sea (figure 8). It has two mountain chains (west and east chains), with the formed Bekaa Valley between them (Makhzoumi, 2016). The highest peak is as high as 3000 meters (Makhzoumi, 2016). The country has a total length of 225 km, stretching across the Mediterranean Sea, and a maximum width of 56 km, which makes it a relatively small country. The west-side the country has a subtropical coastal climate (Mediterranean climate), while on the east-side, specifically in the Bekaa Valley, the country has a semi-arid climate (Dal, 2021; Karam, 2022; Makhzoumi, 2016). Waste generation and disposal differ between areas (DRI, 2019), cities are found on the coast such as Beirut, Tripoli, Jounieh, Saida, Jbeil and Sour. Its rural landscape is mostly a mosaic of networked villages, towns, diverse woodlands and arable farming (Makhzoumi, 2016). This reflects on SWM, where the centralized SWM has a high transportation cost, especially to landfills from dispersed rural areas (Höke, 2020). Uninhabited Lands availability in urban areas is limited, but abundant in rural areas. In land plots, village communal lands in Lebanon are a disputed public right also known as *mashaa'*. During the Ottoman period, those lands were managed by the Ottoman to secure woodland resources for the colonized empire. *Mashaa'* lands are situated in the mountainous areas of Lebanon. During the French Mandate, the authorities tried to eliminate the communal land and transform them into properties, but it failed. This resulted in having these lands' (*mashaa'*) with unclear registry, state owned under the control of municipal villages (Makhzoumi, 2016). In blurry situations, political interventions and legal loopholes, *Mashaa'* could be turned into real estate projects. Small municipalities could counteract this pressure, but the lack of transparency and high level of corruption is pushing them to lose their rights (Makhzoumi, 2016). The *Mashaa'* arguably could be used by actors to solve the problem of lack of plots availability for transferring waste, facilities for recycling and composting and landfilling sites. This work requires the actors on all levels and scales to participate to overcome legal issues and NIMBY effects.

Figure C: Geographic Map of Lebanon



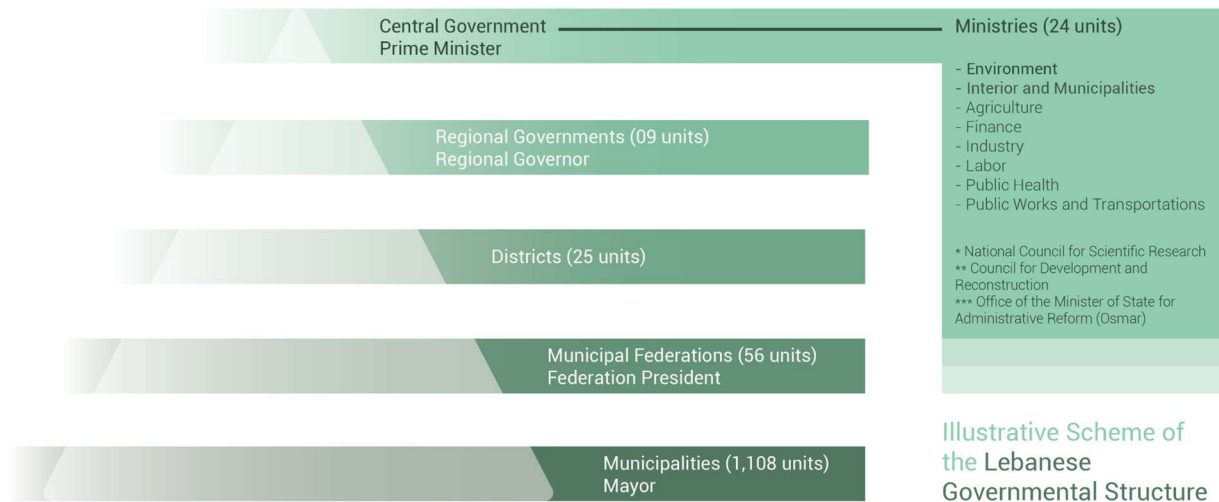
Source El Zaatari, 2018.

Appendix 7: Post-civil War Governance

After the end of the civil war, Lebanon developed a free-market, and service-based country. The liberal economy was highly dependent on foreign capital (Makdisi, 2008), coming from Lebanese expats working outside of the country. The economic growth was fast, and it led to an unbalanced development in regions and between societies. During the civil war, informal urban planning and economy took place, coming from international invested profits, which can relate to the Neoliberalism that Lebanon had as a system (Krijnen, 2010). Privatization was widely encouraged after the war for the reconstruction of big infrastructure projects, such as the international airport, the port and the center of the capital. The government supported the privatization of infrastructures through developers to rebuild across the country (Krijnen, 2010; Makhzoumi, 2016), such as the Solidere Group (see Solidere Projects). In short, 'neoliberalism' and the new public management (Dickinson, 2016; Stoker, 2006) took center stage in the governance of the Lebanese scene after the war. The public sector gave room to 'selected' private actors to privatize much of the public infrastructure (Makhzoumi, 2016). Environmental and social governance could be shadowed by this governance type, chasing economic targets from the powerful private sector (Baldwin, 2019; Stoker, 2006), and can be seen across the country and its infrastructure. The SW sector followed that trend, and is to a certain extent privatized in Mount Lebanon, Tripoli and Beirut and other cities (DRI, 2019).

As for the Lebanese political regime, Lebanon is a parliamentary democratic country, with consociational democracy (Calfat, 2018), specifically, confessionalism takes place, where sects and social groups agree on their presentation in the Lebanese regime. Parliament and government seats are divided between 18 sects through a proportional representation (Salamey, 2013). The government is on the top of the pyramid of the governmental structure Figure 9.

Figure D: Lebanese Government Structure and Major Ministries and Organizations Related to SWM



Source: Sbeih and Marques, 2023.

The SWM system is facing further deterioration with the economic crisis passing through Lebanon (El-Meouchy, 2020), and after the Beirut blast in 2020 (Al-Tawil, 2023), the focus of the government is more on the economic aspect of the country losing interest in the social and environmental aspect. Among the challenges in Lebanon, is the corruption affecting the functioning of governance, which was aggravated with the current refugee and economic crisis (Haykal, 2022). On the lower levels of the pyramid, the 9 governorates are responsible for their relative districts. And finally, governorates and districts are responsible for the 1108 municipalities, all falling under the ministry of interior responsibility (Haase, 2015). Even though there is a law for decentralization that has some gaps in its implementation, it was not implemented after the war for many reasons, such as financial, capacity and technical resources after the war having weak profiles and the willingness and the lack of ability of municipalities to perform (Haase, 2015). Until our days, nothing has changed, due to the political instability and consistency, with many governmental resignations and presidential and governmental voids emerging (Cortés, 2023). A call for reform in the governmental system is taking place, against the sectorial and confessionalism regime in order to face the economic crisis, refugee crisis and other emergent crisis, which was translated through the “revolution of 17 October” in 2019, which resulted in several governmental resignations. This was further materialized in the 2022 parliamentary elections where 11 members were elected against the current confessionalist regime (around 9% of the parliament) (MO, 2022). Since 17 of October 2019, the country is suffering from one of the biggest economic and political crises in its history, and it is affecting most of its public departments and infrastructure (Haykal, 2022). Hence, the average incomes and GDP per capita have both seriously dropped, with many people and companies no longer able to access either their savings or having seen their wages and capital evaporate due to the heavy inflation.

Appendix 8: Summary of the Interviews Constraints in Relation to the Four Resources: HR, FR, KR and TR

Economies of Scale	
HR	<p>Governance:</p> <ul style="list-style-type: none"> • Lack of Environmental and waste experts • High competition in some urban areas between startups, caused by lack of structuring policies of service areas/ reinventing the wheel <p>Physical:</p> <ul style="list-style-type: none"> • Rural areas low level of population, generate low waste streams • Lack of environmental experts and policies
FR	<p>Governance:</p> <ul style="list-style-type: none"> • Amount of recyclables does not cover the operation cost • Lack of funding for facilities implementation, operation, and maintenance • Many sorting centers in same service area • Waste characterization generalized <p>Physical:</p> <ul style="list-style-type: none"> • Policies for informal sector, affecting flow of recyclables • Lack of investment on the local level
KR	<p>Governance:</p> <ul style="list-style-type: none"> • Waste characterization needs to be update it/ collected <p>Physical:</p> <ul style="list-style-type: none"> • Waste characterization
TR	<p>Governance:</p> <ul style="list-style-type: none"> • Some municipalities have facilities, but lack operation and maintenance financing • Missing sorting, collection, and transfer stations • Low compost rate • Lack of recycling initiatives <p>Physical:</p> <ul style="list-style-type: none"> • Lack of technical equipment on the central level • Lack of decision making in task's best practice • Lack of standardization

Weak Profiles	
HR	<p>Governance:</p> <ul style="list-style-type: none"> • Lack of holistic governance and unified decision making on the local and national level <p>Physical:</p> <ul style="list-style-type: none"> • Lack of involvement of the local private and public sector, limited willingness • Discouragement and unwillingness to take responsibility where the central government is forcing the service
FR	<p>Governance:</p> <ul style="list-style-type: none"> • Lack of transparency push donors to restrict financing the sector • Little willingness investment in the sorting and recycling facilities <p>Physical:</p> <ul style="list-style-type: none"> • Little financial resources reserved for the collection on the local level, not a priority.
KR	<p>Governance:</p> <ul style="list-style-type: none"> • Waste characterization generalized and monitoring process and guidelines missing <p>Physical:</p> <ul style="list-style-type: none"> • Waste characterization and monitoring could increase transparency and willingness to work
TR	<p>Governance:</p> <ul style="list-style-type: none"> • Lack of recycling initiatives • Sorting at source and sustainable practices lacking <p>Physical:</p> <ul style="list-style-type: none"> • Municipalities not willing to sort and recycle

External Effects	
HR	<p>Governance:</p> <ul style="list-style-type: none"> • Little control on spillovers. • Weak position of the local public sector, subject of external effects on the decentral system from national government and private sector <p>Physical:</p> <ul style="list-style-type: none"> • Public sector missing in some SWM practices either local or national • Refugees' presence disturbing the sector
FR	<p>Governance:</p> <ul style="list-style-type: none"> • Cost recovery taxes not imposed from the central government, push for sort at source best environmental practice • Privatization of the sector <p>Physical:</p> <ul style="list-style-type: none"> • Informal sector controlling the recyclables market process and price • Little resources for spillovers protection • External dumping
KR	<p>Governance:</p> <ul style="list-style-type: none"> • Blurry Boundaries between municipalities in rural areas, affecting collection and bins location • Lack of recycling and composting guidelines <p>Physical:</p> <ul style="list-style-type: none"> • Policy blurriness on PPPs and private participation on the micro-scale • Lack of waste characterization
TR	<p>Governance:</p> <ul style="list-style-type: none"> • Missing policies drafting and implementation on clustered municipalities would increase the efficiency of the technical aspect. • Lack of decision making in task's best practice <p>Physical:</p> <ul style="list-style-type: none"> • Waste crisis on the national scale can not be handled currently on a local scale • Lack of technical equipment on the local level, shadowed by the central sector • Lack of mitigation policies • Central collection process unorganized and costly

Appendix 9: Interviewees Suggestion for the Degree of Decentralization of SWM

Decentralization vs Centralization	
Decentralization	<p>Governance:</p> <ul style="list-style-type: none"> • Support from the national government in drawing policies • Local policy drafting for illegal landfills • Waste characterization data on the local level • Spatial planning integration <p>Physical:</p> <ul style="list-style-type: none"> • Support from the private sector in each decentralized task • Clustered decentralized waste collection system • Sorting at source • Local PPPs related to sorting, recycling and composting • Awareness campaigns on sorting at source • Sorting and transfer facilities if needed on the local level • Recycling and composting facilities on the local level • Local tailor-made approach
Centralization	<p>Governance:</p> <ul style="list-style-type: none"> • Policies supporting local decentralized level for the clustered level of collection • Policies merging the informal sector • Financial subsidies for O&M of decentralized facilities • Cost recovery Law • Standardization and monitoring of industries and waste streams • Clustered area designated per waste/area and density alongside geographic and political obstacles • Spatial planning integration • Insuring equal good level of service across the country <p>Physical:</p> <ul style="list-style-type: none"> • Funding decentralized SWM infrastructure projects, on the clustered level. • Landfilling tasks, monitoring management • Support of recycling and composting facilities

Appendix 10: Main Points from Table 7

Main Ideas from Table 7 Supporting these Changes
Holistic governance system for the country, the support from the central government of decentralizing the sector (degree of decentralization).
Standardization and monitoring for waste streams and products, starting from sorting at source. Implementation of policies on the local level with national support.
Institutionalizing and policy drawing on the presence and intervention of the private sector in the process. Collection, sorting, recycling.
Structuring and formalizing stakeholder participation on the local level. Support of new SMEs with needed sustainable practices by the central government.