DEGREE PROJECT IN THE FIELD OF TECHNOLOGY
CIVIL ENGINEERING AND URBAN MANAGEMENT
AND THE MAIN FIELD OF STUDY
THE BUILT ENVIRONMENT,
SECOND CYCLE, 30 CREDITS
*STOCKHOLM, SWEDEN 2017*

# Waste Management Systems in Lebanon

The benefits of a waste crisis for improvement of practices.

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# Abstract

Municipal solid waste management is a public service which, when it fails, can rapidly become overwhelming for communities and authorities. It is also during the deepest crisis that incentives change and new practices emerge. Lebanon went through an 8-months waste crisis after the closure of the country's main landfill. Facing the incapacity of restoring basic services, the monopolistic centralised system was questioned: civil society, social businesses and municipalities organised, at a smaller scale, their own waste management. The thesis aims were to identify the role of the new waste stakeholders in the broader picture, assess the efficiency and needs of municipal projects and suggest some priorities for the country's solid waste policies. The use of process-flow diagrams and a contextualised classification of actors were used to describe the Lebanese system. Case studies of recent initiatives were made using an adapted ISWM framework. The investigations have shown that, since the crisis, waste management is organised around three complementary systems, with their own legitimacy, supporters and challenges, but overall lacking of cooperation and mutual recognition. The nascent decentralised waste management tends to achieve better than the traditional central system, especially in terms of landfill space saved, resource management and inclusivity of users. However, it faces issues when tackling final disposal, energy recovery and financing. Any future waste policy should include all waste actors, set clear targets and reject any "one-size-fits-all" solution benefiting private corrupted interests.

*Keywords: waste management systems, ISWM, process-flow diagrams, decentralisation, Lebanon.*

# Sammanfattning

Hushållsavfallshantering är ett offentligt verktyg som, när det misslyckas, snabbt kan bli överväldigande för samhällen och myndigheter att hantera. Det är också under de djupaste kriserna som incitament förändras och nya metoder utvecklas. Libanon gick igenom en avfallskris som varade i 8 månader, efter stängningen av landets största deponi. På grund av oförmågan att återställa grundläggande tjänster, blev det monopolistiska centraliserade systemet ifrågasatt: det civila samhället, sociala företag och kommuner organiserade, i mindre skala, sina egen avfallshantering. Examensarbetets mål var att identifiera vilken roll nya intressenter av avfallshantering får i ett brett perspektiv, bedöma effektiviteten och behovet av kommunala projekt samt föreslå prioriteringar för landets politik gällande fast avfall. Ett processflödesschema och en kontextberoende klassificering av aktörer användes för att beskriva det libanesiska systemet. En fallstudie gjordes med hjälp av ett ramverk för integrerad avfallshantering över de senaste initiativen som tagits på området. Undersökningarna har visat att avfallshanteringen är organiserad kring tre kompletterande system, som har de egna rättigheterna, anhängare och utmaningar, men det saknas tydligt samarbete och ömsesidigt erkännande. Den nya decentraliserade avfallshanteringen tenderar att uppnå bättre resultat än det traditionella centrala systemet gjort. Det gäller särskilt när deponiutrymme kan sparas, resurshantering förbättras och användarna integreras i processen. Dock kvarstår problem när det kommer till att hantera slutförvaring, energiåtervinning, och även finansiering. Framtida avfallspolitik bör inkludera alla avfallsaktörer, fastställa klara mål och avvisa alla "one-size-fits-all" lösningar som gynnar privata intressen.

*Nyckelord: avfallshanteringssystem, integrerad avfallshantering, processflödesschema, decentralisering, Libanon.*

# Acknowledgement

Having the opportunity to write my thesis in Lebanon is the result of many contributions. First, I would like to sincerely thank Assoc. Prof. Cecilia Sundberg who has been supervising the project and without whom nothing could have started. Then, I express my gratitude to Hady Farah, CEO of Hiram Finance, who kindly accepted to host the thesis and accompanied me on the journey with sharp advices and sincerity.

I am also grateful to all the persons who opened their doors to me and took time to consider my questions. In particular, I would like to thank Mrs Moussallem, Senior Advisor at the Ministry of Environment, and her colleagues, but also Mr Abi Rached, President of Terre Liban, and his wonderful team, Sara, Josiane, Mirna, Ralph and Shady.

I kindly thank Mr Khoury and Mr Ghanem, from Elard Consulting, for the administrative base maps they have allowed me to use for this thesis.

Thanks to a multidisciplinary working environment, the discoveries went beyond the thesis's work. These special thanks go to Cyril, Tracy, Noémie, Antoine and Diana, from Fondation Diane and Compost Baladi, for their constant support.

Finally, I could not forget to mention my family in Lebanon who had to cope with my unusual recycling habits.

# Property

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# Glossary

| | |
|---|---|
| **ALI** | Association of Lebanese Industrialists |
| **BML** | Beirut Mount-Lebanon (region) |
| **CBO** | Community-Based Organisation |
| **CDR** | Council for Development and Reconstruction |
| **CoM** | Council of Ministers |
| **CSR** | Corporate Social Responsibility |
| **EPR** | Extended Producer Responsibility |
| **GBA** | Greater Beirut Area |
| **IMF** | Independent Municipal Fund |
| **ISWM** | Integrated Sustainable (Solid) Waste Management |
| **MBT** | Mechanical-Biological Treatment |
| **MoE** | Ministry of Environment |
| **MoIM** | Ministry of Interior and Municipalities |
| **MSW** | Municipal Solid Waste |
| **NGO** | Non-Governmental Organisation |
| **NNA** | National News Agency |
| **OECD** | Organisation for Economic Cooperation and Development |
| **OMSAR** | Office of the Ministry of State for Administrative Reform |
| **PFD** | Process-Flow Diagram |
| **PSP** | Private Sector Participation |
| **SWM** | Solid Waste Management |
| **WMS** | Waste Management System |

# 1. Introduction

In modern societies, municipal solid waste (MSW) despite being generated by everyone, is rarely a visible problem. Like for other public utilities, such as power, water supply and sanitation, systems have been built to minimise the users' effort. Discarding items which are no longer considered as useful, one of the definitions of waste, is often taught at an early life stage. Thus, when relating to waste, most people act with habits established by the system, until the system fails, and change is required.

## 1.1. The Lebanese crisis and emergency state

In July 2015, a solid waste crisis erupted in Lebanon after the closure of the country's main landfill in Naameh, putting an end to a 17-year long emergency plan. Even if the closure was expected and the Ministry of Environment (MoE) had been preparing a solution for more than a year and a half, no political consensus was found and the collection service simply stopped. The crisis lasted eight months, during which the population of Beirut and Mount-Lebanon (BML) had to cope with mountains of waste and wait for governmental action. This unprecedented crisis has triggered several local initiatives, from NGOs, private companies and the civil society, to deal with municipal solid waste (MSW).

In March 2016, the government eventually announced a plan to end the crisis and phase out of the emergency state. The transition plan, adopted by the Council of Ministers (CoM) is designed for 4 years and relies on the construction of 3 coastal landfills which shall receive the MSW of half the country's population living in the dense and urbanised BML region. After a series of public tenders, prepared by the Council for Development and Reconstruction (CDR), the former waste operator lost its contracts, to the benefits of an oligopoly of contractors which are to take over the existing facilities and upgrade them during the years to come.

While the terrains reclaimed on the sea are meant to be given to the concerned municipalities, the plan also sets decentralisation of waste management and waste-to-energy technologies as the basis of the future strategy. However, no practical decisions, incentives nor guidelines have been approved, leaving the future of multiple grassroots and entrepreneurial initiatives uncertain. The actors behind both business-as-usual and alternative solutions have been reshuffled, but solid waste management (SWM) remains one of the country's most urgent challenges alongside with other public utilities such as energy, water supply and sanitation, and which benefits from a dynamic atmosphere.

## 1.2. From Sweden to Lebanon: an opportunity

As part of the Master's degree in Civil Engineering and Urban Management at KTH, I decided to seize the opportunity given by the current Lebanese context to prepare a thesis on the outcome of the waste crisis. The project plan was prepared at KTH with Assoc. Prof. Cecilia Sundberg, the thesis coordinator, based on my perception of the situation in Lebanon and her experience of waste management systems (WMS) in developing countries. The goals and objectives were then further adapted, with more practical goals, when the thesis started, to both fit the needs of local co-workers and the changing situation in Lebanon.

Choosing the right place to write the thesis was not obvious and multiple options were available among the diversity of waste actors. Through alumni networking, the thesis was eventually hosted at Hady Farah's offices, consultant in finance and risk management. The company, Hiram Finance, offered a range of advantages which other Lebanese organisation specialised in waste management had not been able to provide. The company provided (i) technical and financial support, while Hady provided access to (ii) Fondation Diane, a foundation which supports various projects in the field of waste and civic awareness, (iii) his network of acquaintances, within the Ministry of Environment, industrials and contractors, and last but not least (iv) neutrality. Since the Lebanese waste sector is strongly politicised and competition is fierce even between associations, neutrality appeared to be an essential advantage when meeting various interlocutors.

## 1.3. Aim, objectives and boundaries of the thesis

While the Lebanese government has, in a way, taken the responsibility of dealing with final disposal using coastal sanitary landfills, and thus restoring a basic service and public health; decentralised actors have started to take care of their own waste locally with higher diversion from landfill rates.

The ***aim*** of the study is to understand the role and ability of decentralised actors in building a better WMS, more sustainable and resilient, less corrupted and vulnerable, to exit business-as-usual. A secondary aim is to provide a better mapping and understanding of the Lebanese WMS and all its actors, including the informal sector. The findings are meant to help decision-making, both at municipal and national levels, to support the so-called *decentralisation movement* and reduce the dependence on landfills.

More precisely, the ***objectives*** were formulated as follow: (i) provide a mapping of the WMS, its key factors and its actors, including geographical distribution; (ii) understand the role of decentralised actors, through case studies; (iii) assess the changes in the aftermath of the 2015-crisis and (iv) suggest priorities for the country's waste policy.

The study focuses on ***municipal solid waste*** (MSW) in the region which has been affected by the recent crisis, that is to say the service area of the former operator, Sukleen. This area is usually referred to as ***Beirut Mount-Lebanon except Jbeil***, or BML except Jbeil. With respect to time boundary, the study focused on post-2015 events, but still recalling the country's waste history.

The geographical boundary is relevant in the sense that it is where the system collapsed, and where most initiatives have appeared. Waste management is also most challenging in this region due to its high urbanisation and density: 55% of the Lebanese population is concentrated in 20% of the territory, mainly living in dense urban areas near the shores. However, this geographical boundary should not hide the fact that waste management is a national problem, and that the BML region is connected to the hinterlands for at least the two following reasons: (i) during the crisis, trucks have been hired to transport waste away from the region and illegally dump it in the hinterlands; (ii) the high cost of waste management in the BML region has reduced the budget share allowed to the hinterlands for this purpose.

The restriction to MSW appeared to be difficult to respect mainly because the country only has, for now, one single stream of solid waste which includes mainly municipal waste (90-95%) and industrial waste (5-10%) (MoE Interview 2016). Besides, industrial, abattoirs, medical waste and radioactive waste, electronic waste, end up at the same final disposal facilities if not mixed with sewage or dumped. Construction and demolition waste is mostly dumped (Elard, 2011).

It is worth noting that Lebanon has already received more than 110 million dollars in international aid for waste management projects and is still receiving aid for the same purpose over the past decade (lately project Swam I & II by the European Union). Most of these projects were carried out outside of the monopoly's service area, that is to say outside of BML. Unfortunately, some centres are not operational, as highlighted in a recent report (StREG, 2016). An additional 12 million dollars of grants and loans were used over the last five years for waste strategic studies. Therefore, the ambition of this thesis is not to solve the Lebanese waste problem in six months but to provide an original and neutral system approach, using former studies and the fruits of the recent crisis.

The rest of the thesis report is divided in five chapters. Background information about waste management systems and the Lebanese waste management history have been summarised in Chapter 2. Then, the methods of investigation and analysis are described in Chapter 3. Results are presented and discussion is carried out in Chapters 4 and 5. A brief conclusion constitutes Chapter 6.

# 2. Background and supporting literature

This chapter gathers information about solid waste management systems from academic research and the integrated sustainable solid waste management (ISWM) framework. It then summarises the Lebanese history and sets the baseline of its waste management practice.

## 2.1. Solid waste management systems

### 2.1.1. Historical and recent drivers of SWM

The way waste has been managed by societies progressively adapted to new demands. Three main steps can be outlined. At first, in primitive waste management systems (until 1920's) the main concern was *public health and cleanness*. To minimise nuisance, the main strategy was to collect and transport waste to remote dumpsites. Those places attracted unprivileged classes who would live on recycling and reusing, materials found at dumpsites.

As waste generation increased (through population increase and affluence), as industrialisation changed the waste composition, as urbanisation concentrated waste in cities, and as awareness increased (60's, 70's environmental movement débuts), the impact of waste practices on the environment had to be taken into account. Contamination from dumpsites affected ecosystems, air quality, water resources and subsequently human health. Engineered solutions for waste appeared to be necessary, offering increased treatment and safer disposal. *Environmental protection* became the second driver of waste management.

The third driver, *resource management*, which always existed at least informally, comes back into play after a few decades of decreasing recycling rates in developed countries. Consumption of natural resources is reaching unprecedented levels, making reuse and recycling of materials a viable option. Waste management systems now consider *waste as a resource* in order to landfill less and recycle or reuse more.

The historical drivers on which today's waste management practices were progressively built are (i) public health and cleanness, (ii) environmental protection and (iii) resource management (Wilson, 2007).

To a lower extent, other drivers of change have been put forward in literature. Climate change is related to waste management for several reasons. Landfill gas emissions, even though they account for less than 5% of global GHG emissions (IPCC, 2007), has been tacked via gas recovery systems and composting plants under the Clean Development Mechanism of the Kyoto Protocol (UN-Habitat, 2010). Waste management can also help cutting emissions in other sectors either through waste-to-energy technologies or savings of fossil fuel consumption for extraction and transport of virgin materials.

Increased public awareness is also seen as a tool for better practices (Marshall and Farahbakhsh, 2013). In developed countries, increasing efforts are put at diminishing the quantities of waste generated, in accordance with the prevention principle, and shifting towards a circular economy closing the loop of resource management through improved design of products (cradle-to-cradle concept). This trend is also supported by the so-called "zero-waste" movement, aiming for both high recycling and lower generation.

### 2.1.2. Integrated Sustainable (Solid) Waste Management

Integrated Sustainable (*solid*) Waste Management (ISWM) is a framework developed in the 1980s by WASTE, a Dutch NGO, formalising its work on the solid waste issue. ISWM takes the opposite stance of waste management being only a technical problem to be solved by engineering skills. The now broadly adopted framework presents SWM systems as a physical system and a governance system, embodied by a set of actors.

The physical system relates to how waste is actually generated, sorted, collected, transported, treated, recycled, recovered and disposed of. It is the technical aspect of waste management. The governance system is the set of rules and institutions which regulates, finances, guides the physical system and its mutations.

Far from offering a single-facetted approach of western modernisation (Scheinberg *et al.*, 2010), ISWM promotes general principles, examples of good practices around the globe and decision-making based on sound local knowledge and balance between short-term interests and long-term goals.

According to UN-Habitat (2010), any improvement or change of the SWM system of a city or region shall answer all the following key aspects of the physical system and the governance system: public health via proper collection, environment via safe disposal, resource management via recycling and prevention; for the physical system, and stakeholders' inclusivity, financial sustainability and institutional coherence, for the governance system.

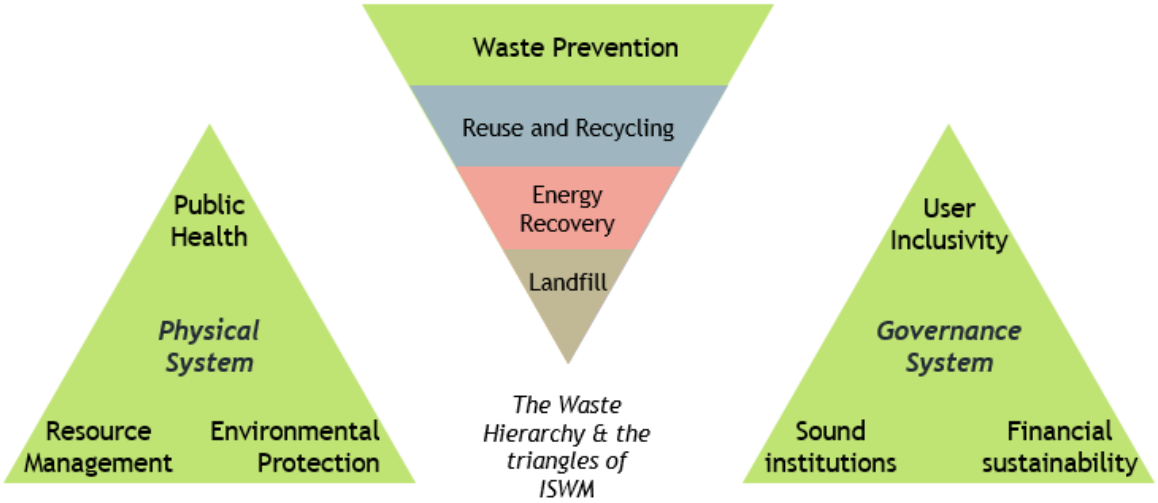


*Figure 1 - The two triangles of drivers in ISWM and the waste hierarchy.*

Sound governance refers to inclusivity of stakeholders, both service providers and users. All users should benefit from the same reliable service, be involved in the physical system (e.g. through sorting) but also in decision making and planning (e.g. through consultation, satisfaction surveys, seats in decision committees). Another aspect, especially important for developing countries, is the financial sustainability. The backbone of financial sustainability is about knowing the costs and revenues, in order to set a fair and transparent cost recovery system. The technologies selected should also be affordable in the local economy. Sound institutions are also a broad topic which includes having clearly defined responsibilities,

policies, strategies and plans, and coherence between them. Cooperation between the levels of management, municipal, regional, national, is also key.

In addition, ISWM often refers to the waste hierarchy and moving up the ladder of waste treatment. This concept is now well adopted worldwide: it is part of the EU WFD, but also part of many NGO's advocacy and municipal strategies. The hierarchy puts waste prevention on top, followed by recycling, recovery, sanitary landfilling and open dumping, as shown on Figure 1.

### 2.1.3. Post-normal science for waste management

Building on the historical drivers and the ISWM framework, recent research suggests that waste management should be analysed under the scope of post-normal science (D'Alisa *et al*., 2010; Marshall and Farahbakhsh, 2013).

Post-normal science has been developed at the end of the 20$^{th}$ century to tackle complex problems which the traditional scientific approach failed to solve efficiently (Funtowicz and Ravetz, 1993). Such problems are characterised by high uncertainties, high social-ecological risks and multiple legitimate stakeholders (Marshall and Farahbakhsh, 2013). Successfully applied to waste management (Waltner-Toews *et al.*, 2005; D'Alisa *et al*., 2010), post-normal science stresses the importance of the overall context to understand a problem and design locally accepted solutions. The overall context comprises institutional, social, cultural and political features, but also technical, economic and environmental ones. (Marshall and Farahbakhsh, 2013).

This concept is especially important for waste management in developing and transition countries.

### 2.1.4. A challenge for developing and transition countries

MSW is a challenge in many developing countries which went through rapid changes over the last decades. Namely, rapid urbanisation, population growth, economic growth, consumption pattern changes have strong effects on SWM systems. Coupled with limited financial resources to undertake structural adaptation, poor governance and planning, MSW can become a burden for societies, especially in large urban areas. The country's political-economic-social context, with other development goals and stability issues, might diminish the priority of waste management on the political agenda.

As a general trend, MSW composition in developing and transition countries contains larger fractions of organic waste and has lower calorific capacities than in OECD countries. However, the waste generation rate, per capita, tends to be lower (Wilson *et al.*, 2012) and, in some areas, recycling rates can be surprisingly close to, or higher than, OECD rates, thanks to *informal* waste actors (necessity and business driven). A definition of informality in waste management has been given by Scheinberg *et al.* (2010) in her research report on *Economic aspects of the informal sector in solid waste*: informal waste actors are all persons involved in managing waste who operate without recognition from the official or formal waste management system. In particular, informal actors can be registered as companies, paying taxes, as transporters for

instance, but not directly waste related (Wilson *et al.*, 2012). This definition will be used in this report.

International organisations, such as the United Nations (UN) or the World Bank, prioritise in such situations the need to guaranty public health and safe disposal of MSW (Brunner and Fellner, 2007). Many development programs (in the 1990s) were carried out to improve waste collection and disposal in controlled dumpsites or sanitary landfills. Waste collection involved technology and material transfer such as large compactor trucks (Wilson et al., 2012; Sundberg, 2016). Until 2015, financing has been partially incentivised through carbon credits under the Kyoto protocol and its Clean Development Mechanism.

However, many authors (Wilson, 2012; UN-Habitat, 2010; Marshall and Farahbakhsh, 2013) highlight that technology transfer is not always adapted nor suitable. For instance, cutting-edge compactor trucks induce higher maintenance and operation costs, which questions affordability of the service, but also affects recyclability of waste which has been compacted and subsequently has socioeconomic impacts on informal actors. In addition, the utility of compacting trucks is questioned when waste is mainly organic and already has a high density. Likewise, incineration technologies can be of limited interest, not mentioning the necessity of sound governance, local acceptance and financial means required for operating and maintaining such facilities in the long run.

For such reasons, the ISWM framework points out the importance of baseline information and historical review: knowing how the system works in order to design adapted solutions. Besides, as Marshall and Farahbakhsh (2013) and Wilson (2007) suggest a WMS cannot move from basic dumping to ISWM without some intermediary steps, progressively changing the way waste is perceived and managed in a complex overall context. For developing countries to not follow the path of industrialised countries, one additional challenge is to "decouple waste growth from economic growth" (Marshall and Farahbakhsh, 2013).

## 2.2. The Lebanese case

### 2.2.1. General figures and context

***Location, area, population and human development***

Lebanon is a small country of 10 452 km² in the Middle East, surrounded by Syria (376 km of border), occupied Palestine (79 km of border) and the Mediterranean Sea (220 km of coastline). The country's population has not been censed since 1960. However, it is estimated that 7 million persons live in Lebanon, including displaced populations (around 2 million). Most inhabitants (55%) are located in the Beirut and Mount-Lebanon governorates which account for only 20% of the territory. The large majority (80%) live in urban areas. For the sake of comparison, Lebanon has size and population similar to the Italian region of Campania (13 670 km², 5,7 million inhabitants in 2000, at the time of the Napoli waste crisis). Lebanon's Human Development Index (HDI) was of 0,769 in 2014, with high contrasts within the population.


*Figure 2 - Map of Lebanon, showing main cities, borders, river and mountains. Source: CIA (2017)*

### *Geography, climate and land use*

The geography is a permanent mix of coastlines, mountains, and high-altitude plains. The Mount-Lebanon chain divides the coastline, which concentrate most of the large cities, and the hinterlands known for its vast agricultural plateau, the Beqaa, comprised between 900 and 1100m. The second mountain chain, Anti-Lebanon, sets the border with Syria.

The country, due to its location between Europe, Asia and Africa, benefits from unique climatic conditions. In the coastal BML region, temperatures vary between 0°C and 40°C, with a yearly average of 20°C. Average humidity is rather high, around 70%. Winter is cold and rainy, while summer is hot and dry (UNDP and MPWT, 2005).

According to the FAO (2011), land use is split between forests (137 kha, 13%), total agricultural land (651 kha, 64%) and other land, including urban areas and mountains (235 kha, 23%). In the BML region, urbanisation has been striving since the end of the war in the nineties. According to the authors of l'Atlas du Liban (2016), urbanisation has been driven by the post-war reconstruction, increase in population, a lifestyle heavily reliant on car mobility and little regulation and urban planning.

### *The Republic of Lebanon: administration and brief history*

Lebanon has three levels of territorial administration. It is divided in 8 governorates (*mohafaza*) which are themselves subdivided in several regions (*26 caza*). The third and smallest level of administration are municipalities, which can be independent or associated in unions of municipalities. There are 51 municipal unions and 1 108 municipalities, of which 314 are in BML region with an average of 9 500 inhabitants/municipality[1]. Lebanon has a high number of municipalities compared to its size and population (LCPS, 2015).

The central government is composed of the Council of Ministers (CoM), the Parliament and the Presidency of the Republic, where at all times the equilibrium between religions is guaranteed by the Constitution. The balance of power between central government and decentralised authorities is seen as rather unequal by academics (Harb and Atallah, 2015): most decisional and financial powers are still located in Beirut.

The country's structure dates back to the French mandate, between 1920 and 1943. In 1943, France recognised the country's independence and contributed to the establishment the first

[1] Estimated average value. For the sake of comparison, Sweden has 290 municipalities (34 000 inhabitants/municipality) while France has 36 000 municipalities (1 800 inhabitants/municipality)

republic. From 1975 to 1990, Lebanon is known for the war which involved all national factions and all regional forces. In 1989, the Taëf agreements updated the constitution and instituted the religious equilibrium. Since the 1990s, the country is making efforts to erase the war's political, economic and social wounds. These efforts have benefited from the withdrawal from the country of the Syrian forces in 2005.

It is worth noting that several organisations have been created in the 1990s for managing the reconstruction and state reform: mainly, the Council for Development and Reconstruction (CDR) and the Office of the Minister of State for Administrative Reform (OMSAR). Today, these institutions play the key role of planning, designing and building the country's facilities, through public tendering, and following the CoM's decisions.

As part of the reconstruction, providing public utilities is still a challenge: the country is struggling with water supply and waste water disposal, electricity, solid waste and public transportation (ENPI, 2011). Parallel networks have built on these inefficiencies: for instance, the majority of households pay two electricity bills, and in summer months, they pay for extra water supply.

From an economic perspective, banks, finance and services are thriving. Tourism is also an important source of income, despite its correlation with the MENA region instability. The industrial sector, and subsequently the waste generated, is rather small.

### 2.2.2. Waste management history

This section attempts to describe the general waste practices in Lebanon since the beginning of the 20$^{th}$ century. It is deliberately brief since more quantitative details will be given about the current status in the next section. Some focus is made on the events which took place in the BML region as it is the main study area of this thesis.

***1900 – 1975: the pre-war era***

Under the French mandate, as administrative divisions were being established, responsibilities for public cleanness were given to municipalities while supervision of open dumping was attributed to the Ministry of Public Health (Decision 188, April 1920). Municipalities were performing waste collection and disposal, either themselves or by engaging private companies. It was common that small municipalities would group together to achieve economy of scale. Waste quantities were much lower than today and the composition was mainly organic. Thus, it was common in rural areas to bury organic waste. Traditional recycling also existed, such as glass recycling in the southern city of Sarafand. It corresponds well to the global practices in the 19$^{th}$ and 20$^{th}$ centuries described by Wilson (2007).

A few years before the war began, in the 1970s, Beirut, a city of about half a million inhabitants generating about 600 tons/day (Nuwayhid et al., 1996), improved its treatment and disposal infrastructures. A composting plant was built in Karantina in 1972, with a capacity of 600 tons/day (presumed to be a sorting and composting line) but whose quality was already discussed. Similarly, an incinerator located in Amrousieh was built with a supposed capacity of 240 tons/day in two furnaces (5 tons/hour each). For collection, the city was equipped with

"refuse collection trucks", not necessarily compacting the waste (World Bank, 1995). The locations dedicated to waste facilities in the 70's still host the main facilities today.

***1975 – 1990s: during the war***

The WM infrastructures suffered from the war: budgets were cut, collection trucks were used by armed forces and destroyed (World Bank, 1995). SW facilities were no longer operated and waste disposal was organised by the different belligerents. In Beirut, for instance, waste, both municipal and destruction waste, has been transported to the Normandy and Bourj Hammoud areas, creating two coastal dumpsites. Outside of the capital, the general practice remained heavily reliant on municipal collection and uncontrolled dumps.

The war period is also known for its illegal waste imports from Italy. Between 1987 and 1988, several thousands of barrels containing chemical waste were shipped in the country. These operations allegedly contributed to financing the war (Holder, 1995).

*Figure 3 - Normandy dumpsite under rehabilitation, 2001-2005. Source: hydromar-sal.com*

*Figure 4 - Bourj Hammoud's dumpsite in the 2000s. Source: ejatlas.org*

After the war, the Normandy dumpsite (Figure 3) was rehabilitated between 2001 and 2005 as part of the reconstruction program of Beirut's downtown, driven by former Prime Minister Rafic Hariri. The Bourj Hammoud mountain[2] has remained until today an eyesore of Beirut's skyline (Figure 4).

***1990s – 2015: the post-war era or Sukleen's monopoly***

During the first years after the war, the same dumpsites were used and the collection system was close to non-existent: due to the absence of bins, waste was gathered in bags at streets corners and episodically picked up by trucks. The piles of waste were often put to fire because of non-regular waste collection. It is also reported by the World Bank (1995), that mixing of domestic waste with hazardous and hospital waste was common practice.

Thanks to international aid and the efforts of the CDR under the NERP (National Emergency Recovery Program), proper collection of waste resumed in 1994, relying on private sector contracting. The next priorities for the NERP were to implement a cost recovery system and safe disposal techniques. The contract for waste collection in Beirut was awarded to a new company: Sukleen, part of the Averda group, led by the Lebanese business man Maysamar Sukkar. This is the company which would rule waste management in the entire region. At that time, academics such as the American University of Beirut were trying to design the best

[2] The current waste emergency plan is using the Bourj Hammoud mountain as backfilling for the construction of two new landfills on the same spot.

practices for the Greater Beirut area: options were ‘landfilling’, ‘sea filling’, ‘incineration’ and ‘composting’ (Nuwayhid et al., 1996).

*Waste crisis #1 1997*

Three years later, civil protest against the Amrousieh incinerator’s black smoke and the disposal practices at Bourj Hammoud, led to destruction of the incinerator (NNA, 1997). These events interrupted the plans of doubling the incinerator’s capacity with a third furnace and upgrading of its flue gas treatment system to answer the World Bank’s environmental assessment mentioning incomplete oxidation.

*Waste emergency plan #1 1997 – 2015*

To face the crisis, the Ministry of Environment, Akram Chehayeb, designed a 7-year emergency plan, to allow time for building a sustainable solution. Tenders for waste collection, treatment and disposal as well as street sweeping were awarded to the Averda group and its companies, Sukleen for collection and sweeping services, and Sukomi for treatment and disposal. The area of service was extended to BML, except Jbeil, the polemical dumpsite of Bourj Hammoud was closed and the sanitary landfill of Naameh (in the Chouf caza, south to Beirut) was opened.

Over the two following decades, the Sukleen contract was repeatedly extended and the size of Naameh landfill grew beyond its initial design capacity as the government failed to provide new sites for landfilling and for increasing treatment capacities (CDR, 2014).

Waste management has not been a priority for the various governments, despite significant plans in 2006, 2010 and 2014 for ISWM, waste-to-energy and decentralisation. At the national level: a dichotomy persisted between the monopoly in BML and the hinterlands, where all international aid is going to finance Mechanical-Biological Treatment (MBT) plants with commingled waste collection, achieving low diversion rates from landfills.

*Waste crisis #2 2015 – 2016*

On January 17th 2014, the government extended once more the lifetime of Naameh for one year, further extended 6 months. In the meantime, public tenders were carried out by the CDR[3] to find new operators for the country, divided in 6 service areas with identified potential sites for landfills in each area. The tendering process is repeated three times to finally meet the validity requirements. However, on July 17th, 2015, civil protests lead to the closure of the 17-year-old landfill and in August 2015, the tender results are rejected by the Council of Ministers (CoM).

*Figure 5 – Scenes of waste storage during the 2015-2016 waste crisis in Beirut. Source: Reuters. Photographer: Aziz Taher.*

[3] The CDR was supervised by a committee headed by the MoE.

The dormant crisis turned public: all waste services stopped, triggering eight months of waste collection interruption and terrifying scenes of waste mountains, dumping and burnings, broadcast by the media (Figure 5 and Figure 6). Civil protest took unprecedented proportions: movements against the presumably corrupted political class were created and demonstrations gathering several thousands of citizens repeatedly took place in Beirut. During these events, the press highlighted the high collection and disposal costs compared to the treatment efficiency, political corruption and lack of transparency in the contract signed in 1997. The government (ruling without President since May 2014) envisaged several solutions: decentralisation with two temporary mega landfills in Srar and Bekaa regions (September 2015), waste export to Africa or Russia (in December 2015) and general incineration.


*Figure 6 - Scenes of waste piles in streets (left) and protest at the MoE (right). Source: Reuter. Photographers: Joey Ayoub (left), Mohamed Azakir (right), (2016).*

*Waste emergency plan #2 2016 – 2020*

On March, 12th, 2016, the CoM adopted a new emergency plan designed by the Minister of Agriculture, Akram Chehayeb (formerly Minister of Environment in 1997), to put an end to the crisis and set the basis for the transition towards sustainable waste management. The plan gave three immediate actions: (i) reopen the Naameh landfill for two months, to get rid of the accumulated waste, start the construction of three new coastal landfills in the Beirut region, and plan a fourth landfill for Chouf and Aley cazas; (ii) resume investigations (which had started in 2010) for developing waste-to-energy in the country; (iii) reaffirm the possibility for municipalities to adopt their own way of managing waste (CoM Decision n°1, dated 12/03/2016, updated 17/03/2016). It is worth mentioning that one of the new landfills is located on the spot of the former Bourj Hammoud dumpsite, closed 20 years ago. The material from the former dumpsite is being used to reclaim land on the sea for building the new landfills and create land for the municipalities. The second landfill is located on the shoreline next to the airport near a spot where demolition waste was dumped in 2006 after the summer conflict between the Israeli army and the Hezbollah. The vicinities of the airport (Maramel area) had already been used as temporary dumpsite in the 1997 summer crisis, before opening the Naameh landfill (NNA, 1997).

If this decision allowed to end the waste "crisis", defined as MSW piling up in streets, it did not put an end to the emergency situation. As highlighted by interlocutors, basic services have been restored, despite high controversy, and opposition (at both sites, with judiciary procedures, and other construction complications), but for only up to four years. Besides, if Beirut and the

cazas of Kerserouan and Metn have implemented the emergency plan, it is not the case of the Chouf and Aley cazas which still mostly rely on dumping.

The Syrian refugee crisis, representing around 10% of the population, also has a significant impact on solid waste generation across the country (+15,7%), mostly in the Bekaa region (+37,7%), according to the EU/MoE/UNDP assessment of the Syrian refugee crisis (2014).

### 2.2.3. Waste Management System at the dawning of Sukleen's monopoly

To conclude this section, it is worth describing how waste has been dealt with under the first emergency plan (1997-2016) since it gives insights on how waste is perceived and because any new strategy has to be built on the remains of the former system, by for instance reusing facilities and involving the informal actors. The purpose of this baseline description is also to gather the results of various official reports, and present the whole system using (i) process flow diagram and (ii) description of the main governance factors, under the ISWM framework.

***Process-flow diagram during the Sukleen Era***

The process flow diagram of solid waste in the BML region, except Jbeil, is shown on Figure 9. It is described below.

*Waste generation and composition*

According to the Sweep Net (2014) report on SWM in Lebanon, the average MSW generation per capita is of 1,05 kg/day, with variation between rural areas (0,8 kg/day) and urban areas (0,95 – 1,2 kg/day). In 1997, Sukleen was processing about ***2200 tons/day***. In 2014, the total generation of MSW in the country was estimated to 5600 tons/day, ***2850 tons/day (51%) in BML except Jbeil***, with a 1,65% yearly increase. The latest tender documents from the CDR (2015) required bidders to consider a daily quantity of waste generated of 6455 tons/day, with 3155 tons/day (49%) for BML region, of which 1550 tons/day (24%) for Greater Beirut [4]only.

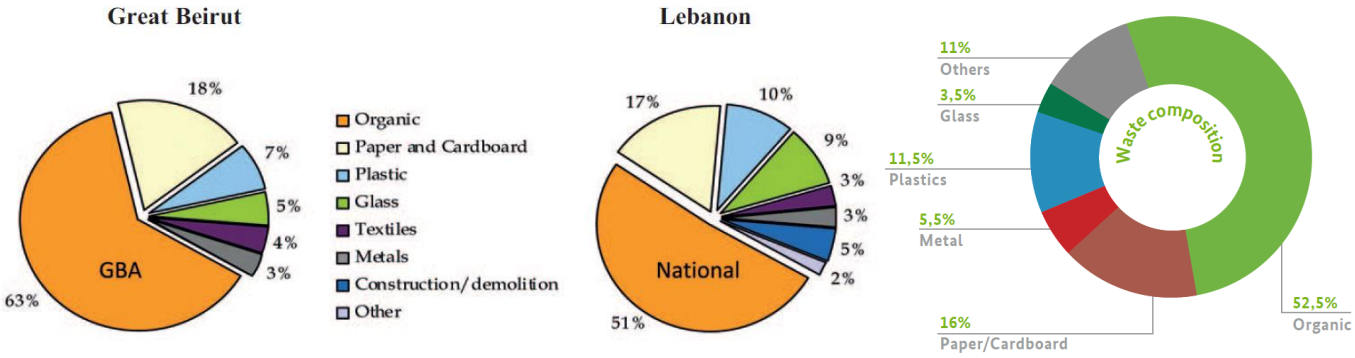


*Figure 7 – (left) Solid waste composition in Greater Beirut and nationwide, reproduced from CDR (2014); (right) Solid waste composition nationwide, reproduced from Sweep-Net (2014).*

The solid waste composition has been estimated in several reports, reproduced in Figure 7. Despite differences of methodologies and results, it appears that more than half of the waste is

[4] Greater Beirut Area is defined in the tender documents as the "district of Beirut and its suburbs: Ghobeiry, Chiah – Ain el Remmaneh, Bourj el Brajneh, Haret Hreik, Furn El Chebbak, El Mreijeh, Hadat, Bourj Hammoud, Sin El Fil and the neighbourhoods of Hail el Sollom and Amrousieh and Lailaki located in Choueifat Municipality".

organic, a large third is either paper, plastic, metal or glass, and around 10% are other waste, including textile and electronic waste.

It should be noted that waste composition measurements are usually made after collection by the formal system, not taking into account the scavenging and diversion operations, introducing a common bias in waste data (Wilson, 2012). Besides, seasonal variations also exist (CDR, 2014), due to consumption and population changes, but are not quantified.

*Collection, sorting, treatment and disposal of waste by Sukleen* [label A, on Figure 9]
Sukleen's process chain is close to the Mechanical Biological Treatment (MBT) which thrived in the 1990s in Europe. It is illustrated in Figure 8.

The waste is disposed by households and companies in open-containers placed at specific locations on the road (in total, around 19 000 $m^3$ installed). Street sweeping is either manual or mechanised. Waste is then collected by a fleet of 220 compacting trucks and transferred to two sorting centres, Qarantina (2000 tons/day, 5 sorting lines) and Amroussieh (1000 tons/day, 4 sorting lines), undergoing first manual sorting and then mechanical sorting (magnetic separation and rotating sieves) (Sukleen, 2015; CDR, 2015). Part of the organic fraction, from the Qarantina (200 tons/day) and Amrousieh plant (100 tons/day), is transferred to the nearby Coral composting plant (300 tons/day) to produce a low quality compost or Compost-Like Output (CLO). The product is either sold or given to farmers or landfilled. The fraction of recyclable material collected is sold to industrials, at prices fixed by contract (StREG, 2016). The residual fraction, still containing a large amount of organics is baled and sent to the mega landfill of Naameh (300 000 $m^2$). Bulky items and inert materials were sent to the Bsalim landfill (60 000 $m^2$).

*Figure 8 - Sukleen's system: (left) compactor truck collecting from overflowing bins, (centre) Qarantina sorting plant, showing manual sorting lines, (right) Coral windrow composting plant. Source: own picture (left), Sukleen 2015 (centre); CDR, 2014 (right).*
*Note: employees in charge of driving trucks tend to be Lebanese, while street cleaners, garbage men and facility operators tend to be foreign workers.*

Over the years, Sukleen implemented on a voluntary basis new recycling programs: (i) the Red&Blue campaign for sorting at source respectively glass/plastic/metal and paper/cardboard, with bring stations and partnerships with institutions, schools or buildings; and (ii) reverse vending machines in supermarkets for recycling of plastic bottles (Sukleen, 2015). Dedicated trucks were used to collect these recyclables. The impact of these measures is however limited to some areas and tends to not be much recognised by the majority of the population.

*Collection, sorting and treatment by other actors* [label B, on Figure 9]
Benefiting from a certain laissez-faire and the inefficiencies of the central system, many actors have started an activity related to recycling, whether it is necessity-driven or socio-

environmentally driven. They form the informal sector operating at the margin of the central system.

On the one hand, waste pickers or scavengers exists in the BML region but have not been studied in detail. Their number is estimated to be between 1000 and 4000, mostly Syrian workers (not linked to the Syrian refugee crisis). They process between 100 and 500 tons/day in BML, mainly GBA. This figure surely includes industrial waste such as scrap metals. Unlike other landfills in Lebanon (Tripoli especially) and abroad, scavenging on landfill does not takes place in the BML region and is limited to bin and street scavenging. The workers are exclusively foreign workers, selling their products to Lebanese brokers who further process or sell it to industrial or export companies.

On the other hand, recycling programs by NGOs date back to 1995 when Terre Liban NGO started paper recycling in schools and institutions. Since then, all established NGOs are involved in recycling activities. Arcenciel NGO is even involved in sterilisation of hospital waste since 2003.

According to the Lebanon Environmental Pollution Abatement Project (LEPAP), direct channels for recycling of industrial waste exist, bypassing the Sukleen system. However, the audit conducted was too small to have statistically relevant data (StREG, 2016).

The waste diverted from landfill is either entering the local recycling industry or exported. Compost by Sukleen used to be given away to farmers, with low satisfaction, contributing to the bad reputation of compost today. Until now, except for landfill gas recovery in Naameh, waste is not yet being used as a source of energy in BML region.

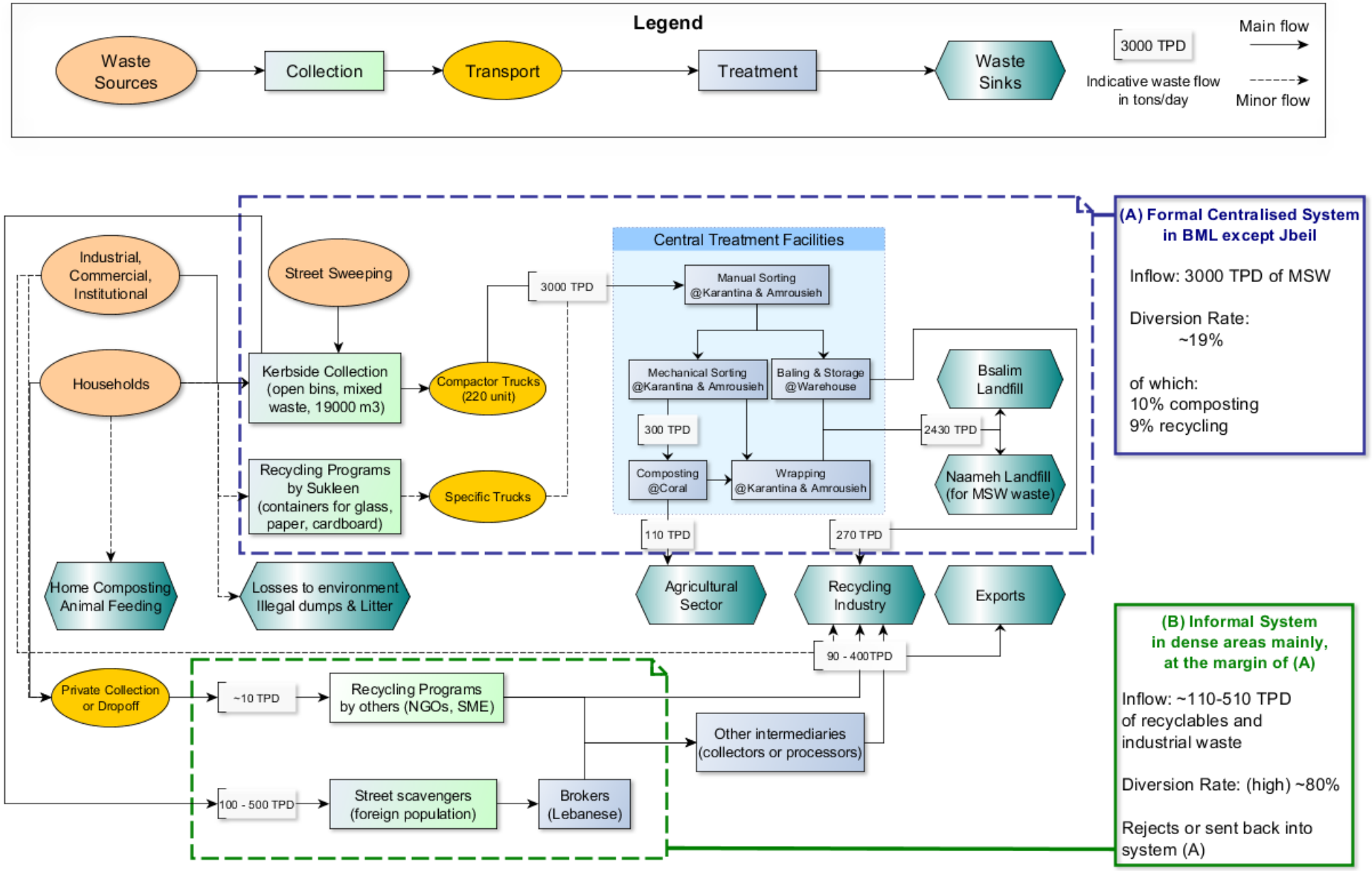


*Figure 9- Process-flow diagram during the Sukleen Era. It shows (A) the official system (blue square) and (B) the complementary systems of informal recycling, by scavengers (picking from bins) and recycling organisations (picking at the source or at drop off. Quantitative figures from various sources: CDR, 2005; Sweep Net, 2014; StREG, 2016.*

### *Governance features during the Sukleen Era*

*Institutional context*

*a. National laws, regulation, responsibilities*

Laws and regulations linked to solid waste do exist in Lebanon since 1920. However, most of them are outdated and hardly enforced. For instance, since 1974, the use of non-closed containers is banned. However, the bins used since 1997 in the entire BML region are open. A detailed list of laws and decrees is given in appendix A. The latest law prepared by the MoE in 2004 on ISWM has been sent to the Parliament in 2012 but has not yet been adopted.

Lebanon also joined several international conventions about waste and environmental protection, such as the Barcelona (1976), Basel (1994) or Stockholm (2001) conventions. However, enforcement is as well limited, as suggests the repeated use of coastal landfills.

Officially, municipalities are responsible for public cleanliness, waste collection and disposal (Law 118 dated 30/06/1977) but their direct involvement has been limited due to the permanent emergency state established in 1997. Outside the Sukleen area, municipalities have strongly relied on foreign aid and projects led by CDR and OMSAR. From the people's standpoint, the responsibility of the crisis lies in the hand of the government.

*b. Monitoring & supervision*

Contracts for monitoring and supervision by a third party have been signed to overlook and record data during the Sukleen's era. However, it had no significant impact on plans and decisions, as the system is missing effective feedback mechanisms. In addition, the data is not easily accessible.

*c. Planning*

At the national level, three waste management plans have been prepared, in 2006, 2010 and 2014. The first plan was to create 6 service areas in the country with renewed disposal and treatment capacities. It was never implemented, due to the 2006-conflict between Israel and Hezbollah, which reshuffled interests and priorities, but also due to disagreements between institutions. The second plan's single achievement is the consulting work which started in 2010 and continues today about opportunities of building incinerators in the country. The third plan again intended to divide the country in service areas with new treatment capacities. The plans' failure to be implemented entailed, at least for the BML region, extensions of Sukleen and Sukomi's contracts, and reclamation of land for the physical extension of the Naameh landfill (CDR, 2014).

An SEA on waste treatment technologies was prepared but never completed nor made official. At the municipal level or regional levels, waste planning and knowledge is near to non-existent in BML region.

*Financial sustainability and affordability*

*a. Financing system (cost recovery, investments)*

The centralised waste system is financed by the Independent Municipal Fund (IMF) and the Government's budget. More precisely, the contractors are paid depending on the number of tons handled, by the Government of Lebanon who debits the money from the IMF. This fund which is supplied by multiple taxes collected by the Government is meant to be allocated to the municipalities following various complex and not always coherent rules (LCPS, 2015). The price per ton is set by contract (Sweep-Net, 2014) and municipalities cannot control the number of tons they have been charged.

Investments in large infrastructure, maintenance, consulting and monitoring are issued from various sources: the government's budget, others national institutions' budgets (CDR, MoE, OMSAR) and international aids (among others EU, the World Bank, USAID, UKaid). Most of the international loans and grants benefitted to regions in the hinterland, especially South Lebanon and the Beqaa (Rizkallah, 2013; StREG, 2016).

*b. Corruption factor, transparency*

The media, the civil society and public persons often claim that the waste sector has suffered from slightly overestimated costs which have ended-up in some politico-private interests. This is strengthened by the lack of transparency around the historic and kept-secret Sukleen contract. However, the problem of corruption in Lebanon is not limited to the waste sector. It is present at all levels of the society. The latest government includes a new state ministry for corruption, thus recognises the high corruption factor in the country.

*Inclusivity (users & providers)*

The stakeholders of the Lebanese waste sector are numerous and range from politico-religious leaders, international and national institutions and all sizes of waste recyclers. There is a clear lack of cooperation between associations, central government and municipalities.

*a. Users: public awareness, participation*

Public awareness regarding environmental issues is highly heterogeneous. People living in well-to-do neighbourhoods are usually more concerned about environmental issues such as water and air contamination. With respect to waste management, these people are aware of recycling but do not necessarily implement it, since large bins are available in the streets. Some however decide to contract a private service for collection of recyclables. In less rich neighbourhoods, people are aware of the health risk that mountains of waste represent.

This level of awareness undoubtedly rose during the 2015-2016 waste crisis. However, the public willingness to start sorting at source or change behaviours in a way is undermined by the government's inability to convey a clear message.

In comparison with recyclable materials, the fate of organic waste is less known by households and is mostly seen only as a problem and not a potential resource. Awareness events about

composting are carried out in places such as museums, universities and schools. Similarly, waste prevention, which is on top of the waste hierarchy, is not often mentioned in the media.

Overall, the participation of the users in the formal state system is limited to Sukleen's recycling initiatives. Even though a hotline was available, no satisfaction surveys were carried out.

*b. Provider*

The unique service provider benefited from close relations with officials. However, its repeated calls for new facilities and warnings of limited capacity at the Naameh landfill remained unheard (Sukleen, 2015).

In a nutshell, waste management is closely related to the country's history, its wars and inter-clan conflicts. Both the physical and governance systems of waste management were built at the end of the war, in the 90s, tackling the needs of the reconstruction era. Several attempts to modernise the system failed to produce any results, leading to today's crisis. One can suggest from the history, that the causes of these failures are low prioritisation of the solid waste issue, private interests overcoming the national ones, but most importantly non-liability of decision-makers in a permanent political chaos or hybrid-political order which characterises Lebanon (Stel, 2012).

# 3. Methods and materials

## 3.1. Work-time division

To meet the objectives set for the thesis, work time was divided in three dimensions: field work, governance work and scientific work.

***Field work*** took the form of participation in meetings and other activities of a company supported by Fondation Diane, namely Compost Baladi, whose aim is to promote decentralised quality composting in the country. Working with Compost Baladi helped to focus on organic waste which seems to be one of the most problematic aspects in the Lebanese context. Field work also included visits to solid waste treatment facilities, landfills and other municipal projects across the country. It was an essential dimension of the thesis since one can hardly work on waste issues without handling some.

Waste management does not only rely on technical means to achieve waste collection, treatment and disposal but also on non-technical factors or governance factors, such as planning, financing, laws and regulation. In Lebanon, it is clear that the emergency states and various crisis are linked to poor governance. Thus, ***governance work*** was aimed at understanding the key factors, at both the central government and municipal levels, and how they have changed after the 2015 crisis. The opportunity was given to work with a senior advisor at the Ministry of Environment, NGOs and academics with whom some planning work was done.

Besides, keeping a link with governmental institutions was an important component to counter the tendency of the Lebanese people to act independently from the state, a fact which has been documented by Stel (2012) and might have adverse effects in the long-run.

Finally, the ***scientific work*** or prospection work consisted in analysing different examples of decentralisation and identifying the keys of success and resilience, provide mapping tools for the waste sector, especially the recycling industry and decentralised waste initiatives. Data collected on the field and with various interlocutors served as a basis for building the reflection.

## 3.2. Literature, press review and desktop studies

In order to prepare the six months in Lebanon and understand the roots of today's crisis, an extensive review of the existing literature was performed, with the focus on the waste management history in the country. This led to the description of the waste management system under the Sukleen era, including the process flow diagram (PFD) presented in chapter 2.

The main written sources of daily information, covering the current crisis, have been the French-written newspaper *L'Orient le Jour*, the English-written newspaper *The Daily Star Lebanon*, and the *National News Agency (NNA)*.

As a result of meetings with representatives of the Ministry of Environment and in order to address some resilience issues raised by decentralised initiatives, two short desktop studies were realised about refuse-derived fuel and compost potential markets in the country. These studies led to brief reports and a presentation and a summary is provided at the end of the results chapter. They have been prepared using literature, interviews and some modelling.

## 3.3. Mapping tools under GIS

Since the very beginning of the thesis, it has been a goal to provide a tool for storing and sharing the data collected during the six months in Lebanon. It took the form of maps and databases, developed using a GIS software and data files. Maps have also been useful to visualise the geographical distribution of actors, more specifically the recycling industries, the state waste facilities and the decentralisation projects.

## 3.4. Classification of waste actors

***Motivation***

A waste management system results from the interaction of a large variety of actors. In the Lebanese context of crisis and emergency states, numerous changes occurred in the ecosystem of waste actors: the main operator changed, new local actors emerged, responsibilities were redistributed. Besides, cooperation between actors and groups tend to define the main trends in waste management practices. The classification was built to illustrate the changes entailed by the 2015 waste crisis, and the polarisation between centralised and decentralised approaches of waste management which appeared to characterise the Lebanese case.

***Meeting with actors and data collection***

To understand the role of each category of actors on the waste management stage, the goal was set to meet actors of all categories. This is especially important under the post-normal science approach of waste management (D'Alisa *et al*., 2010; Marshall and Farahbakhsh, 2013) because each have a standpoint that is legitimate. Besides, since the thesis aimed at having both theoretical and practical results, it was necessary to understand the interest of stakeholders and the compromises they could accept.

Interviews were semi structured – with questions and topics prepared in advance – but also flexible to allow free speech. Meetings, which led to the redaction of brief reports, were valuable sources of information and documents, complementing the written literature. Despite the failure to obtain meetings with the largest operators of the central system, most doors were open and some interviews led to further joint work and visits. The list of entities and persons met is reported in appendix B while Table 1 shows the type of entities (underlined) met during the thesis.

*Table 1 - Examples of actors behind the classification. Names underlined have been met during the thesis.*

| ***Primary actors*** | |
|---|---|
| National authorities | Council of Ministers, Relevant Ministries (MoE, MoIM, MoA, MoPH, MoPWT, OMSAR), CDR |
| Local authorities | Municipal Councils, Presidents of Municipalities and Unions |
| Private sector *formal* | Contractors, operators, supervisors and consultants |
| Private sector *informal* | Street scavengers, companies, social businesses |
| NGOs, CBOs, Civil society | |
| Service users | Households, companies and institutions |

| ***Support actors*** | |
|---|---|
| Private sector | Equipment and service providers, recycling industry, agriculture sector, energy sectors |
| Academics | Universities, Research institutions |
| Influential | Politicians, Media & Lobby |
| Financing organisations | International and national institutions, regional funds |

## 3.5. Benchmark for waste management initiatives

***Motivation***

Looking at the initiatives which stemmed from the 2015-crisis, very few actors were taking time to analyse the outcomes, or even monitor the results. StREG report[5], published in early March 2016, recognised that it was too early to evaluate source sorting results. For the thesis work, which started half a year later, the motivation was to identify the elements of success and the factors which would contribute to the survival of decentralised waste management. The visits done in collaboration with Fondation Diane, Terre Liban and other actors allowed meeting the most advanced of these initiatives, in BML and outside. This contributed to understanding the potential place of these actors in the future national strategy.

***Two types of initiatives***

The main difference between initiatives is the degree or extent of independence they provide from the central waste system. On the one hand, ***Partial Extent (PX) solutions*** take care of specific streams of waste (e.g. dry recyclables, glass, food waste) and divert it from the centralised collection system. Most of these solutions can also be labelled as informal activities, surfing on the inefficiencies of the central system. Some of them are new (Recycle Beirut, Zero Waste Act, Compost Baladi), other are well established (Terre Liban NGO since 1995, Arcenciel NGO since 2008). On the other hand, ***Full Extent (FX) solutions*** aim at taking care of the whole waste stream, and provide full independence from the centralised system. These more ambitious solutions have often been initiated thanks to the cooperation of various actors: civil society, willing municipalities, association/NGOs or experts for consulting, private sources of investment. Several examples of both PX and FX solutions were studied.

### 3.5.1. Benchmarking of FX solutions

Each project is an autonomous waste management system, with its physical and its governance sub-systems, as described in Wilson *et al* (2012). For each project, a description of the physical and governance system was performed. Then, indicators were built to assess the initiatives' impact on local waste management practices. This did not include a detailed analysis of the environmental impact of each solution (air emissions, ground water contamination) as it was not the aim of the study.

[5] Support to Reforms for Environmental Governance, *Economic instruments to create incentives for recycling in Lebanon*, is a report financed by the EU and published in March 2016. It dwells on the economics of recycling in Lebanon and the sorting capacities.

*Sample analysed*

The six initiatives analysed are all taken from the BML region, formerly operated by Sukleen. They were selected on data availability and project advancement. These are all municipal projects varying from 1 to 20 thousands inhabitants, namely, from smallest to largest population: Brih, Antoura, Dhour Choueir, Mokhtara's Union of Municipalities, Beit Mery, and Bickfaya.

*1st phase: data collection and organisation*

First, six projects were identified and data was collected by different means: online sources, press articles, interviews and field visits. Multiplying sources and double-checking was especially important for cases where visits were not possible, because misinformation is common, and precise quantitative data usually lacked.

The raw data was then processed to fit a "project description" canvas made of three parts: (i) general information, (ii) the physical system, and (iii) the governance system. The tables below show an example of the canvas.

*Table 2 – Project description canvas used to collect data for municipal projects*

| **Table (i) - General Information** | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| *name* | *name* | *number* | *in tons/day* | *date* | *(lat,lng)* |

| **Table (ii) - Physical system** | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br><br>*Others:* | *Vehicles:*<br><br>*Frequency*: | *Facility description:*<br><br>*Waste streams:*<br>*Recyclables*<br>*Compost*<br>*Residual* | *Waste streams:*<br>*Recyclables*<br>*Compost*<br>*Residual* |

| **Table (iii) - Governance system** | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*<br>*Opex*:<br>*Revenues*: | *Operator*:<br>*Human Resources*:<br>*Consultancy:* | *Measures to involve users* | *Type of awareness sessions* | *Future plans* | *Compliance with national law* |

*2nd phase: analysis and comparisons*

Then, two indicators were used to analyse each case and compare them. The first indicator, is the ***diversion rate*** (DR). It is a way to measure the efficiency of the initiatives in building independence from landfills, which has been identified as a priority in the country, but also to assess whether or not the project performs better than the centralised system (which benefits from economy of scale and 20 years of experience). However, it was difficult to get precise figures about the DR because most initiatives lacked equipment for proper monitoring (no

scales, no volume estimations) or because data about recyclable materials sold was not disclosed.

The second indicator, the ***resilience grade***, was built to assess the likelihood of the initiative to survive crises but also prevent them. It is indeed common that initiatives do not survive once business as usual resumes: it has been the case in the municipalities of Araya, Beit el Chaar, Baskinta and others. The grade varies between 0 (lowest probability to survive) and 5 (highest probability). Five items enter it the grading system, with the same weight: (i) the existence of a physical solution for residual waste, (ii) measures to ensure financial sustainability, (iii) inclusivity of users and providers, (iv) the diversion rate, (v) the existence of plans for the future (showing dynamism of the project).

The indicators have been inspired by the six benchmark indicators (Table 3) used by Wilson's team (2012) to assess ISWM in the 20 cities of the UN-Habitat programme (2010). The diversion rate provides information similar to Wilson's indicator 2 and 3, while the resilience grade assesses indicators 4, 5 and partially 6. Indicator 1 (waste collection coverage) did not appear to bring valuable information because collection coverage, under Sukleen and under the new initiatives, is considered as high (>99%). The institutional coherence was also less relevant at the small scale of the study since municipalities are acting in reaction to an institutional gap and in the absence of a clear national strategy.

*Table 3 - Benchmark indicators as described in Wilson et al. (2012).*

| |
|---|
| ***Drivers for SWM – Quantitative indicators*** |
| 1. Public health: waste collection and sweeping coverage (%) |
| 2. Environmental control: controlled disposal (%) |
| 3. Resource management: material recycled or valorised (%) (excluding incineration even with energy recovery) |
| ***Governance strategies – Composite qualitative and quantitative indicators*** |
| 4. Inclusivity of users and providers |
| 5. Financial sustainability: population using and paying for collection |
| 6. Institutional coherence: with national policy or strategy |

The result section presents a synthesis of all above parameters and highlights the main differences between the initiatives and the centralised system. The description canvas developed here has also been used to prepare infographics for communication purposes.

### 3.5.2. Benchmarking of PX solutions

The PX solutions is a second type of initiatives which has increased in number of actors and quantity of waste diverted thanks to the crisis. The purpose of their analysis was to understand the rationales and processes of these actors, their place in the waste system.

The four main examples (Arcenciel NGO, Terre Liban NGO, Recycle Beirut, and Zero Waste Act) were described using a simpler canvas: (i) general information (team, clients, date, motivation), (ii) physical system (area of collection, types of material collected, processes, sinks) and (iii) governance (origin of revenues, plans).

This shorter analysis, mainly descriptive, provided information regarding their competition with informal actors and Sukleen's recycling program, as well as their role in introduction sorting at source in households of dense areas.

## 3.6. Difficulties encountered

*Lack of quantitative data*

In most European countries, data of all kind is becoming more and more accessible through annual reports or even web portals. France has for instance a well-developed information system on solid waste (Sinoe). European member states participate in the Eurostat data gathering system. This is not the case in Lebanon: the population has not been officially censed since the 1960s which makes population and density figures rely on estimates made by various institutions. Likewise, national soil quality data (organic matter contents, pollutants contents) is not available, according to academics interviewed. When it comes to the waste sector, there is only one source of official data, which are the consultants contracted in 1997, whose data has sometimes been questioned.

*Changing political context and protests*

As said in the introduction, the solid waste issue is extremely politicised and the political context has been unstable over the last years. During the 6 months, several events influenced the solid waste case.

In August and September 2016, civil society, associations and a political party blocked the construction of the Bourj Hammoud landfill, entailing another political party to block the temporary storage area, eventually leading to 21 days of waste piling up in the streets.

On October, 31st, 2016, the President of the Republic was elected, after 2 years of vacancy, giving a new impulse to the country, with institutions expected to resume normal operations.

In December 2016, the new Government was formed, after a 45-day delay. New ministers of Environment and Agriculture were appointed. The former Minister of Agriculture, who oversaw the waste issue, is no longer in the Government but is still at the head of the parliamentarian committee for environment.

In early January 2017, seagulls seriously threatened the airport security, so the Costa Brava landfill was closed for two days and hunters were hired to solve the problem while machines were installed at the airport. After some twists and turns, a judge ruled out, on the 31st of January that the landfill had to close within 4 months. This was simultaneous with the President's announcement that an alternative national plan for solid waste is under preparation.

# 4. Results

Investigations during the thesis brought results both at the system scale (broad picture) and the project scale (local scale). This chapter will first present some of the changes entailed by the crisis in the system (physical, governance, actors), before looking at the models of decentralisation and their dependencies in terms of market sinks.

## 4.1. System view and actor classification

### 4.1.1. New dynamics created by the crisis

The 2nd emergency plan or March plan presented in chapter 2, despite all the critiques it received, implicitly sets the baseline of the future strategy. There would be a form a balance between a centralised WMS, built on the former Sukleen infrastructures, and a more decentralised management, meaning municipalities and regional authorities taking back part of their responsibilities. The overall goal would, of course, be to get better results in terms of public health, environmental impact and resource management.

Building on this statement, it entails that the WMS, as a whole, has to shift from its current centralised form to a mixed form by planning and developing decentralised features (integrated to an upgraded central system). Mechanisms for such a transition have emanated from three levels: the national government *(through its policy, strategy, planning, projects*), the local authorities with the civil society, and the private sector, seeing business opportunities.

Until now (01/03/2017), in the BML region except Jbeil, the action of each level can be summarised as follow and are depicted in Figure 10.

The *central government*, via the CDR, the CoM and their contractors, is mainly working at modernising the central system with little done for encouraging the decentralisation. More precisely, the main tasks are managing a smooth phasing out of Sukleen, supervising the construction and acceptance of the landfills, upgrading Coral treatment plant, and preparing the waste-to-energy options with Ramboll's consultancy.

*Local and regional authorities* under the pressure of the crisis, and their civil society, have started pilot projects (community based) to manage their waste locally. One should note that the crisis pressure is still present in two caza (Chouf and Aley) which did not execute the March plan. These pilot projects are also advocating for change, provide proofs of concepts, and thus increased awareness levels.

The *private sector* is contributing by creating new businesses, to provide services either to municipalities or directly to users (households, restaurants, hotels), or to create new recycling capacities (e.g. green glass reuse in construction tiles).

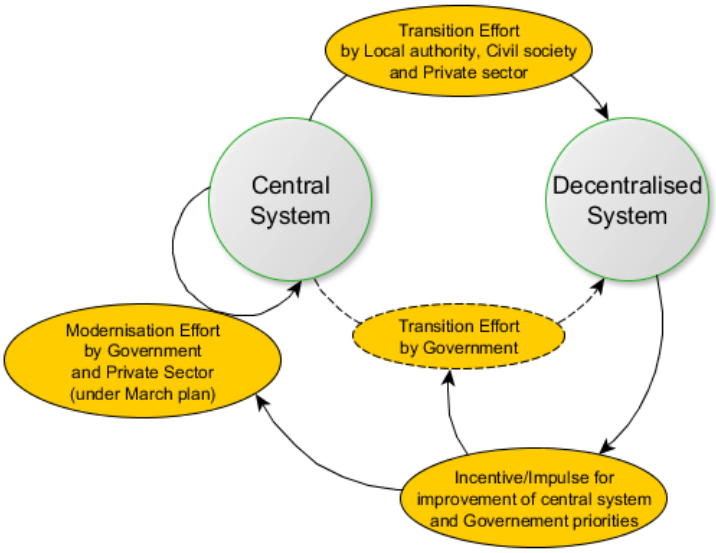


*Figure 10 - Current dynamics of the Lebanese WMS. Arrows all indicate a positive impact.*

The duality sought of the WMS in the study area, after the crisis, with an established centralised system required to modernise itself, and a nascent decentralised one, is the scenery on which all waste actors evolve. It has led to a (i) new distribution of waste actors and (ii) new waste flows in the region, which will be presented in the next two sections.

### 4.1.2. New process-flow diagram in Beirut Mount-Lebanon

The updated process flow diagram is shown on Figure 11, with sources of waste on the left and sinks mostly to the right. Waste sources have remained unchanged (neglecting the limited impact of behaviour change in favour of waste prevention), but the flow of waste is importantly disturbed compared to the Sukleen era.

First [*see label D on Figure 11*], in the two regions of Chouf and Aley, municipalities have to dispose of their waste relying on their own means. Estimating the population living in these areas, it means that approximately ***200 to 400 tons/day*** are no longer managed by the central system. This translates in the resurgence of wrong practices, namely open dumping, burnings and transregional transport, which was significantly lower under the former system[6]. In the framework of ISWM, this practice affects negatively all three primary drivers: public health, safe disposal in the environment and material recovery. The opposition of these regions to the March plan may suggest that inclusivity of stakeholders, which is a key element of ISWM, is rather low.

Then [*see label C on Figure 11*], about ***100 to 200 tons/day*** of waste have been attracted by new decentralised municipal initiatives, scattered around the region. They try to provide better collection systems and reduce their dependency on landfills. This stream is increasing as the first pilot projects start to be replicated in other municipalities. In the absence of agreement with

[6] A study (Elard, 2011) prepared for the MoE made an inventory of illegal dumpsites. Their number is significantly lower in the BML region (most populated) than in the rest of the country.

the centralised landfills, the residual waste of these cases is either stored, dumped or sent to landfills outside the region.

When it comes to the informal recycling system [*see label B on Figure 11*], it already existed prior to the crisis but grew with the arrival of new actors, social businesses, NGOs and CSR programs. Scavenging still takes place prior to official waste collection and is not allowed at the new landfills. If the accumulation of waste piles hindered street scavenging during the crisis, the activity has now resumed but is still difficult to quantify. Overall the sector might have experienced a slight increase, mainly in the Greater Beirut Area where most of these actors are located. Based on various sources of information (gathered in StREG, 2016) about the informal sector, estimations vary from **150 to 550 tons/day** of recyclable materials, probably including metal from non-MSW origin.

Finally [*see label A on Figure 11*], the central system still collects around ***2500 tons/day*** and processes it through the sorting centres of Amrousieh and Qarantina. However, the transfer from one operator to another, has seen the Coral composting plant been shut down for upgrading to 750 tons/day. This entails that the composting capacity of 300 tons/day, which contributed to volume reduction of waste landfilled and diversion towards agricultural sinks is temporary stopped. On the 1st of February 2017, work had not started at the composting plant and is expected to last seven months once it does. More waste than expected is sent to the new landfills of Bourj Hammoud and Costa Brava. Besides, the fate of the Bsalim landfill for bulky and inert waste remains unclear: a new operator is taking control of the facility, but capacity extension has not yet been approved as it is reaching its current design capacity. No decision has been taken nor announced, for now, to change or upgrade the way waste is collected in the central system, perpetuating overflowing of open-air bins in dense areas and compaction of comingled waste, as shown in the background chapter. So, undoubtedly, the recycling rate of the formal central system has dropped since the beginning of the crisis: if 80% of the waste collected by Sukleen used to be landfilled, the current figure (February 2017) is likely to be around 90%.

To a marginal extent, the crisis entailed more interest in home-composting (and vermicomposting), but also clean-up activities.

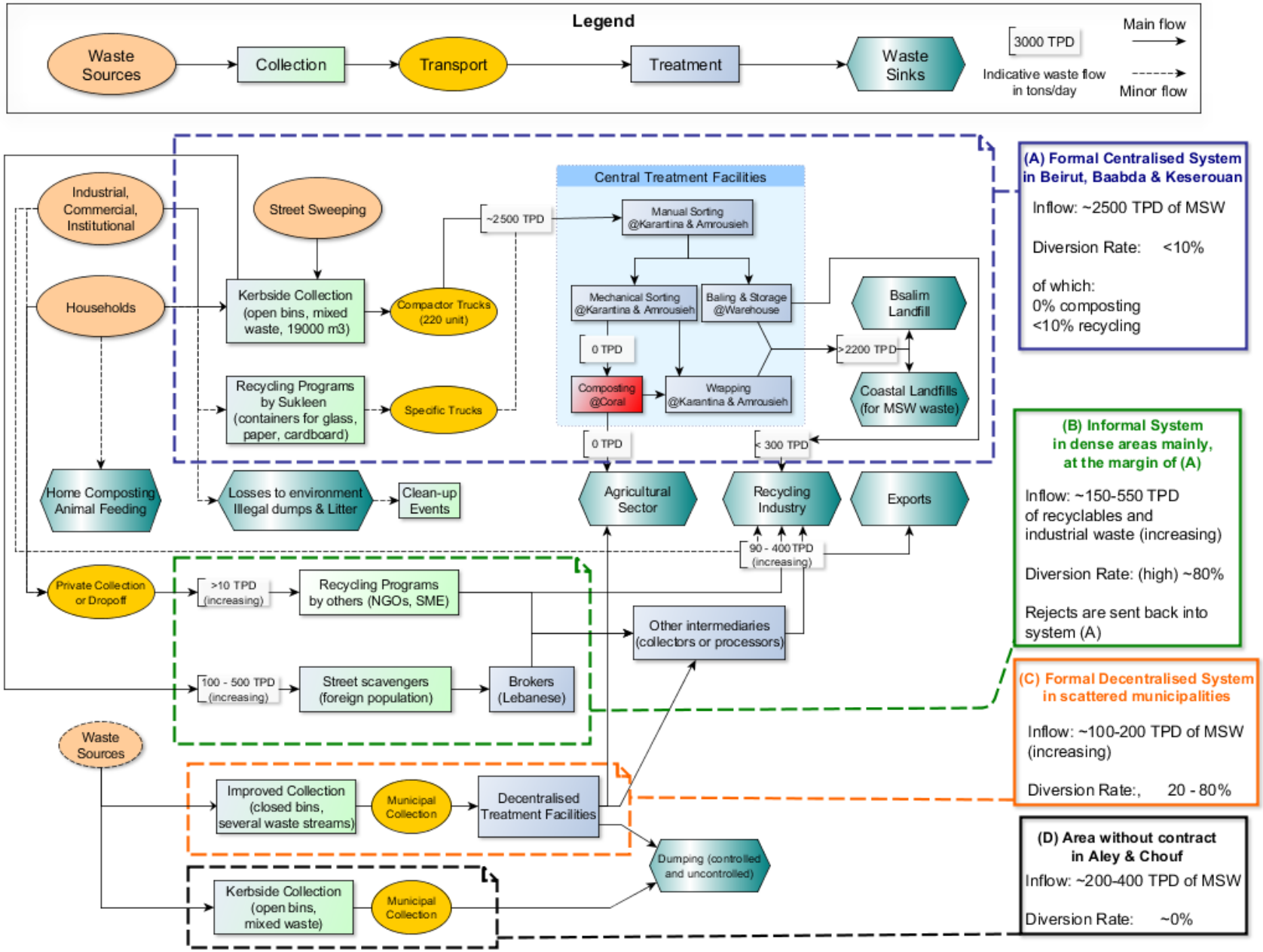


*Figure 11 - Process flow diagram in BML region under transition plan: (A) Formal Centralised System; (B) Informal System; (C) Decentralised 'Formal' System and (D) uncontrolled dumping in region still in crisis. Solid lines: main flow; Dotted lines: marginal flows. In red: non-operational composting plant.*

### 4.1.3. Waste actors: a changing scenery

The waste actors can be divided in *two main groups of actors*: the ***primary group***, i.e. actors who have a direct role in waste management (operators, decision-makers), and the ***support group*** which gathers actors having a support function not directly related to the waste service (other industries, import/export, financing organisations, academics, media).

***Primary group***

Actors are divided between public authorities, formal and informal private sectors, NGOs, CBOs (community-based organisations) and civil society.

A distinction is made within the primary group based on the contribution of actors to either central or decentralised waste management. Differences between the two approaches is defined in Table 4. In essence, the central system provides a 'one-size-fits-all' solution, with large facilities (handling thousand tons per day), in a market controlled by few companies directly contracted by the national government through the CDR. The decentralised approach promotes smaller areas of service (municipal to caza level), with facilities handling less waste and empowering local authorities and communities, with a diversity of solutions and actors.

*Table 4 - Core differences between the centralised and decentralised approaches, using SWOT tables.*

| **Central System** | |
|---|---|
| ***Strengths*** | ***Weaknesses*** |
| - Long distance collection and controlled landfilling<br>- Economy of scale<br>- Equal basic service for all | - Low diversion rate and treatment quality<br>- High inertia and investments<br>- Proven corruption |
| ***Opportunities*** | ***Threats*** |
| - Optimisation potential<br>- Unique framework and monitoring | - Repetition of crisis<br>- Business as usual, lack of change |
| **Decentralised System** | |
| ***Strengths*** | ***Weaknesses*** |
| - Sorting at source<br>- Quality treatment<br>- Driving change, with user inclusivity | - Handling and disposal of residual and toxic wastes<br>- Economy of scale<br>- Multiple facilities to control |
| ***Opportunities*** | ***Threats*** |
| - Local jobs<br>- Empowerment of communities<br>- Flexibility in treatment solutions | - Diffuse environmental pollution<br>- Potential diffusion of corruption<br>- Inequalities of service<br>- Lack of expertise and training |

***Support group***

The ***support*** function is split in three categories. The ***related industries*** reunite all industries which are necessary for any waste management solution to exist. On one hand, this includes actors which provide material, equipment or even services. They make technology available but have a limited ideological impact. On the other hand, this group includes actors who consume recovered materials from the waste stream. That is to say manufacturers, recycling industries, the agricultural sector or the energy sector. The ***advocacy group*** gathers actors which

contribute to waste management in a non-technical manner. It includes academics who build up knowledge, associations, politicians and media who contribute to awareness rising and lobbying. Last, the ***financing*** sources include national and international institution who provide grants or loans.

Many actors do not only have one field of activity and could enter in several divisions of this classification. This is for instance the case of Arcenciel (NGO) which raises funds, makes advocacy, build and operate sorting centres, and even provides consulting services to municipalities.

***Changes entailed***

The waste flow changes are associated to new waste actors and cooperation for each sub-system. Most changes appeared in the primary group of actors, i.e. those who deal with waste, who are at the basis of the physical system. The support group has not seen major changes but an increase in interest for the topic and opinions expressed publicly.

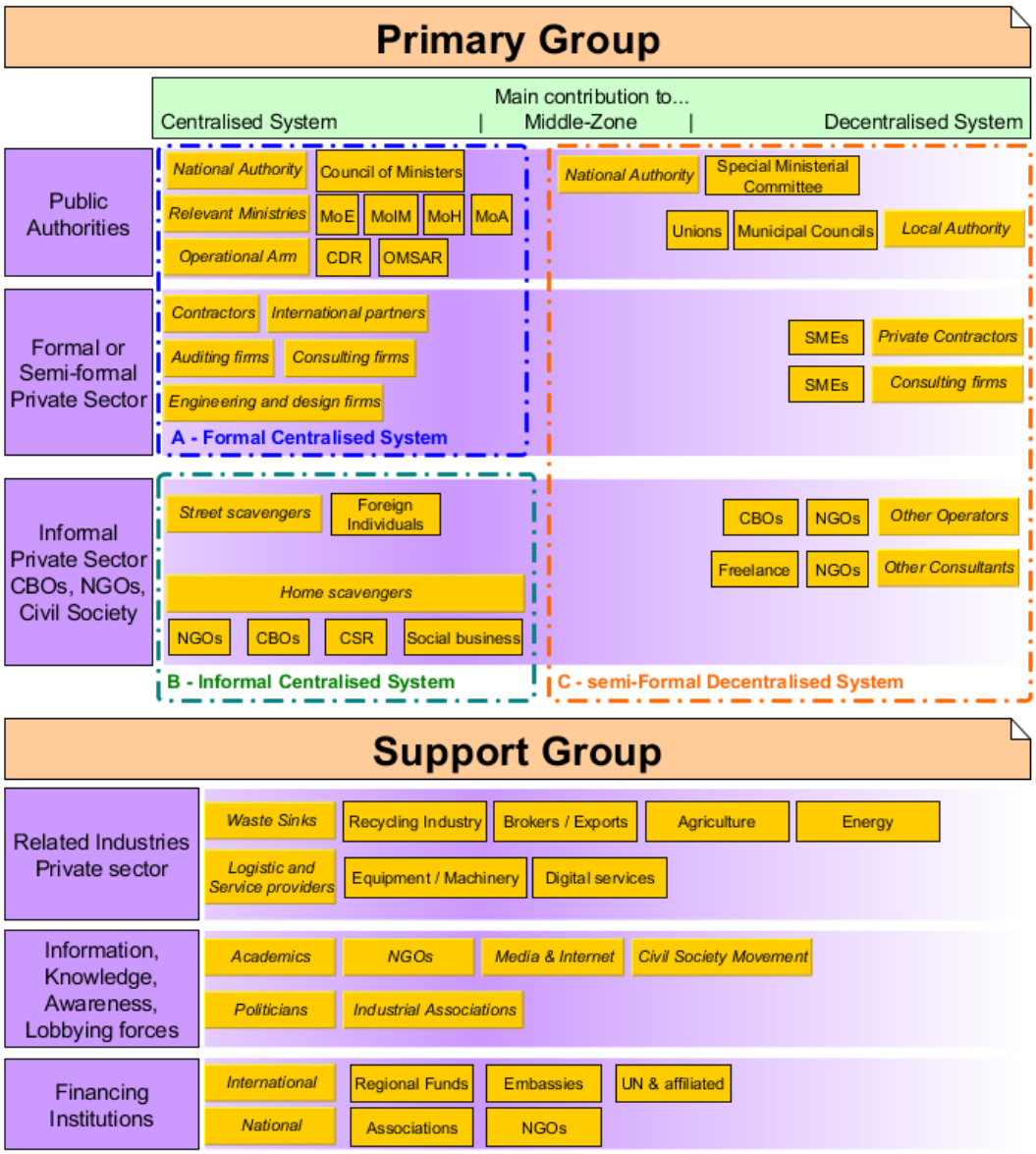


*Figure 12 - Waste actor classification: (i) primary actors: dotted squares highlight sub-systems (A) Formal Centralised System, (B) semi-Formal Decentralised System, (C) Informal Centralised System; (ii) support actors, distinguish information actor, financing actors and related industries.*

The upper part of Figure 12, presents the waste actors according to two parameters. The actor's *type* is shown vertically, under purple labels. It distinguishes between: public authorities, the formal private sector, informal private sector, NGOs, CBOs and the civil society. The second parameter is the actor's *main contribution*, shown horizontally. On the left are located actors who contribute most to the central system, and on the right to the decentralised system.

In addition, three of the four sub-systems identified in section 4.1.2 according to the waste flow (A, B and C) are shown on this figure. The dotted blue square gathers actors from the formal central system; the green one is for the informal sector living at the margin of the central system; and the orange one, correspond to the 'formal' decentralised system. The last sub-system (D), which corresponds to regions still in crisis with no sophisticated waste management service, is not shown: it would only gather local decision makers using their own trucks or hiring haulers to transport and dump waste in remote places.

*Formal central system – A group in restructuration*

In the formal central system, waste actors are mainly *national authorities* (the Council of Ministers taking decisions, on advice of CDR and consultants, and influence of politicians) and *large contracting companies*, specialised in public works (often backed up by foreign companies for the waste expertise). There is few to no inclusion of end users and communities in this group. Its cohesion is strong, i.e. showing the proximity between the private sector and officials.

The main change which has affected this group is the end of Sukleen's monopoly in the region and the sharing of Sukleen's former contracts, but also manpower, between a new set of contractors for the four years. More precisely, there are now six new contracts for operations and six for supervision of works, which are detailed in appendix C. They have not all been attributed. One can see this change as the formation of an oligopoly of centralised actors, which is for now doing business as usual with some restructuration. Indeed, even if the CDR's tender documents stated that new operators "*might* be requested by the CDR and *during the duration of this Agreement* to include separate collection of recyclables under this Collection and Disposal Service Agreement." (CDR, 2015), there has been no clear communication on the future plans, tariffs or contracts since March 2016.

*Informal system, at the margin of the central system – A group in expansion*

The informal sector specialised in recovering recyclables from the MSW stream benefitted from the crisis as new actors emerged and others increased their services. The conventional actors who existed prior to the crisis are *street scavengers*, mainly foreign individuals, and *home scavengers* or *door-to-door collection* by NGOs.

The new actors have mostly developed home collection networks, of sorted at source recyclables, which users can access by paying a fee. If this activity used to be done by some NGOs, it has expanded to others forms of organisations: social businesses, community-based organisations (CBOs) and even corporate social responsibility (CSR) programs of private companies now take part in collecting and recycling waste from end-users. Some of them stemmed out from contestation movements of 2015 and were willing to dive into action.

Among the new actors, Recycle Beirut is a social business, providing work to both male and female Syrian refugees, by collecting door-to-door, sorted recyclable materials. In December 2016, they had reached more than 1000 points of collection in their area of service (Beirut), collecting between 2 and 3 tons/day.

Overall, these actors get from little or no recognition from the formal central system, but are strongly connected to international organisations and private sources of financing.

*Formal or semi-formal decentralised system – The new group*

As said earlier, this sub-group is new in the BML area. Despite its limited waste flow, it gathers the widest range of actors, from local authorities to civil society.

The *local authorities* involved are essentially presidents of municipal councils or municipal unions, who are either willing to, or under the pressure of, taking back their waste responsibility. This is an effort demanding knowledge, time and financial means. The most committed ones operate their own facilities, such as Bi*Clean* in Bickfaya or Chou*Clean* in the Higher Chouf region.

Other projects are more reliant on *private sector operators*, such as Cedar Environmental in Beit Mery. The company took over the service and invested in the infrastructure. The private sector is also involved when it comes to *consulting*. Multiple firms offer EIA or feasibility studies. Similarly, *NGOs* and *CBOs* are also involved in this system with multiple tasks, including operation, consulting, supervision. They usually work in cooperation with municipalities.

In ISWM terms, this sub-system is more inclusive than the others since all types of actors, decision-makers, users and service providers, cooperate to build their solution.

This sub-group is also connected to the informal recycling sector through NGOs acting in both fields. For instance, Arcenciel (NGO) has several centres where it processes recyclable materials, from its drop-off points and pickup services, but is also using these centres to channel waste collected in municipalities (from new decentralised projects) and who have not yet build their whole process chain (missing equipment, too small volumes). Generally, it shows the willingness of the ‘established’ NGOs who have been involved in informal recycling for years to contribute to decentralised waste management, and scale up their projects with composting platforms.

A link with the national authorities exists through the inter-ministerial technical committee, created in August 2016, with the task of regulating the decentralisation projects. In practice, most projects by-pass this committee.

Finally, one should not hide the fact that some competition or divisions exists between these providers (NGOs and private companies). It takes the form of competition for projects and lack of unity regarding for instance the advocacy for sorting at source.

*Related industries and sectors*

Looking downstream, achieving recycling is not possible without sinks for recovered materials. Sinks can be found abroad through exportation of materials, but also locally. Lebanon has a set of recycling industries[7], well developed, receiving fluxes from all the primary actors. Approximately thirty of the largest ones have joined the Association of Lebanese Industrialists (ALI) which lobbies in favour of recycling. Their main areas of expertise are paper and cardboard, plastics, white glass and metal recycling. However, StREG (2016) concludes that recycling of metals is hindered by high energy costs, making export a preferable option.

According to several persons interviewed, but also a documentary produced in summer 2016 (A Zero Waste Lebanon) putting forward the recycling capacities of the country, there is a demand for more recyclable materials and a readiness of the industries to expand in response to an increase in supply. In addition to the large industries, for which a mapping is presented in appendix D, hundreds of smaller manufacturers of recycled goods are mentioned by local experts but are difficult to map.

Other sectors which represent a potential sink for waste in Lebanon are the (i) agriculture and forestry sector, seen as a consumer of organic waste products, and the (ii) energy sector, seen as a consumer of waste derived fuels. This includes industries which have a high energetic demand. Finally, the (iii) construction sector is also discussed as a potential consumer of residual waste, whether is it for ashes used in roads or residual waste (non-incinerated) processed into construction material.

Looking upstream, industries also support the waste sector by providing equipment: various technologies, compressors, machines are available locally, but also through imports. When available locally, machines are usually more expensive than imported ones but also easier to maintain as spare parts are available.

Notably, the digital sector is trying to contribute to the waste sector. Indeed, at least five teams have been developing web platforms or mobile application to assist municipalities in their recycling strategies, including easier transaction with waste dealers but also awareness modules for citizens (Recycle Leb, LimmApp, Fakker Abel Mat Keb[8]). Some applications are trying to 'uberise' the collection of recyclables both in dense and remote areas (GreenBin, LimmApp). Even though these projects are not yet mature, it highlights the importance of the solid waste issue even among groups of young software developers.

*Financing institutions*

The source of financing of the centralised system has not changed: it is still managed by the central government. When it comes to the other systems-actors, sources of finance are more diverse. It includes international development aid, from international financial institutions (IFIs); regional funds and foreign embassies. National sources of financing exist through NGOs and associations, such as Fondation Diane. Their financing is mainly for investment in the form

[7] A recycling industry is defined by ALI (Association of Lebanese Industrialists) as a company of more than 5 employees producing marketable products (or goods) from recovered materials.

[8] *"Fakker Abet Mat Keb" means "Think before throwing"*

of grants or soft loans. There are discussions on the optimal way to finance solid waste projects among these institutions. Usually financing options are specific to each project.

*Knowledge, Awareness, Media and Lobbying forces*

The groups having an influence on waste management are numerous as well. In the aftermath of the crisis, most entities have taken a stance on the issue. Such forces have a strong influence on decision-making, often disrupting the normal process. This is exemplified by EIA reports often being prepared after decision have been taken or operations have started.

***Mapping of the actors***

As part of the classification process, actors of the primary group have been mapped when relevant. This mapping focused on (i) the facilities from the *formal centralised system*, in blue, (ii) the projects of *decentralised* waste management, in orange, distinguishing between the pilot projects which have started operations, and other projects which are under preparation, and (iii) the projects of collection of specific streams, such as recyclable materials, *at the margin of the centralised system,* shown in green.

What first comes to sight when plotting the map (Figure 13), is the distribution of the primary actors: the centralised facilities (sorting centres, composting plants and landfills) and the informal actors' facilities (drop-off and sorting centres) are located around and within Greater Beirut Area. On the contrary, the decentralised projects are, for now, scattered around in the mountains. This may appear logic as it is easier to start implementing small-scale projects, in less dense areas, with smaller communities. Likewise, focusing on specific streams of waste which do not require daily waste collection, might be more profitable in dense areas where the stream is larger and collection happens on shorter distances.

In addition, approximately 16% of BML's small and medium municipalities (50 verified cases out of 315 municipalities) have started a discussion[9] or a project for developing their waste management capacities. It is likely that other projects are missing from this inventory, either because they are new or because they have not been in contact with NGOs involved in waste management. Besides, larger municipalities such as Beirut and other large coastal cities do have plans under discussion for their waste management, but have not been included here because of their specificity.

[9] Discussion here meaning that stakeholders got in touch with NGOs or academics, demanding assistance for waste management projects, awareness campaigns, sorting at source and treatment of waste.

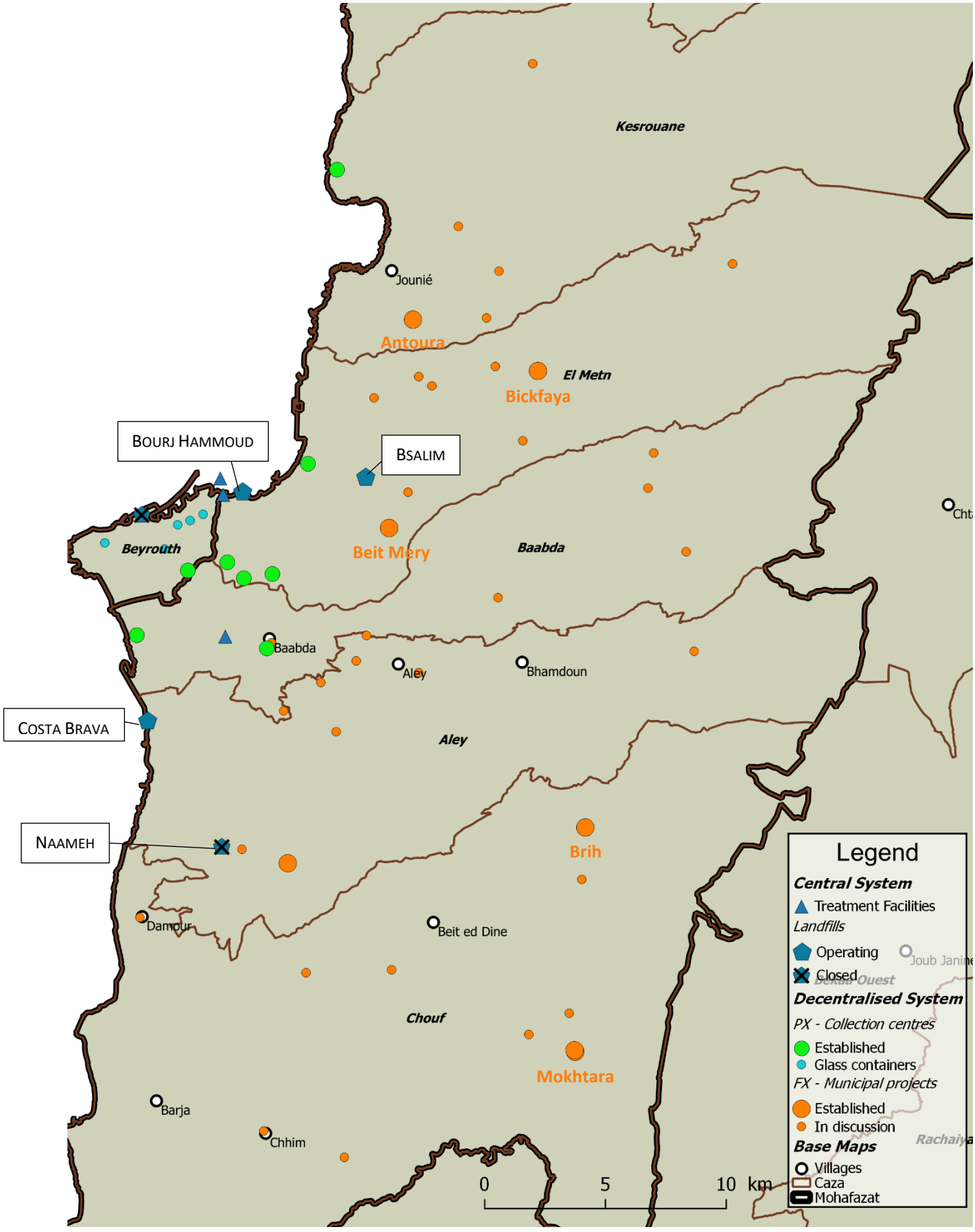


*Figure 13 - Central system facilities (blue); informal recycling (green) and decentralised waste facilities (orange)*
*Data based on interviews with NGOs and field visits (last update 01/2017).*

## 4.2. Models of decentralisation and informal recycling

This section looks in details at actions undertaken by the new actors presented in the previous section, both the one living at the margin of the central system and the one developing alternative small-scale waste management.

### 4.2.1. PX solutions: informal recycling

Partial Extent (PX) solutions take care of specific streams of waste or part of the stream, and divert it from the formal centralised system. As a matter of fact, all projects focus on recyclable materials, leaving aside organic matter and non-recyclable items. As seen previously, they mainly operate, informally, in GBA and more generally in dense urban areas.

**Street scavengers**

Street scavengers represent the oldest form of informal recycling but also the least studied. Undoubtedly, the recycling rate caused by informal recycling is much lower than in other developing country cities such as for instance Cairo in Egypt.

The profession is exclusively done by men or young boys. Ethnically speaking, the operators are mainly Syrian but not necessarily refugees. Prior to the beginning of the Syrian war, men were alternating between waste picking and fruit picking according to seasons. The activity is necessity-driven.

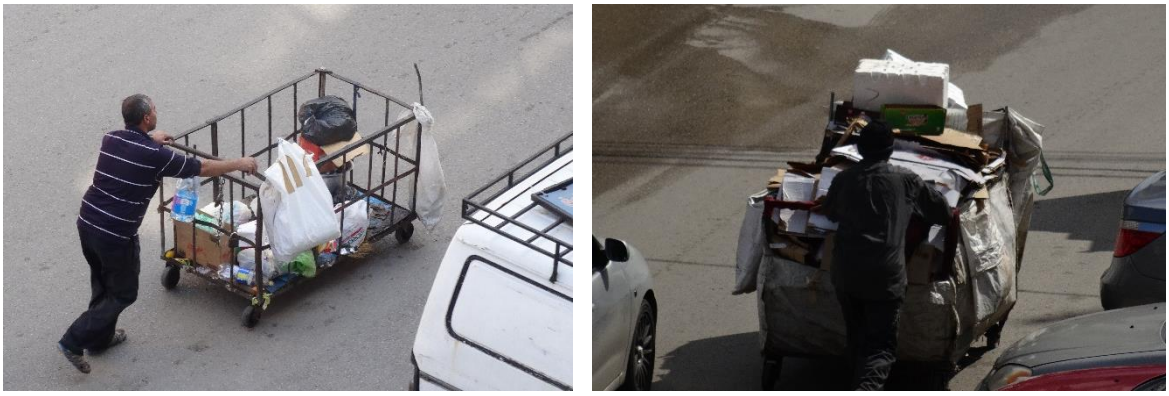

*Figure 14 - Street scavengers with carts operating in Beirut suburbs (February 2017).*

Scavengers (Figure 14) are equipped with a self-made cart, often divided in several compartments with bags[10]. They go from bin to bin in a specific neighbourhood. Once the cart is full, they go back to a gathering point where all scavengers empty and sort the contents of their carts. Then, sales take place with brokers, of Lebanese citizenship, large trucks are loaded and the materials are sent for further processing, recycling industries, manufactories or export.

Even though street scavenging is happening in the public space, allegedly anyone has seen scavengers at work, there is little to no recognition of the positive impact the activity has. Only, the StREG report (2016) recalled the results of former studies: there are between 1000 and 4000

[10] A student project reported a cart including divisions for items the scavengers would like to bring home. (AUB, 2014).

men involved, collecting between 100 and 500 tons/day. In other words, the quantities of waste recycled by scavengers and by the formal centralised system are of the same order of magnitude.

**Private recycling services**

Unlike street scavengers, the private recycling services are more diverse and do not operate in the streets but directly in contact with citizens or institutions. They have different organisational structures: social businesses *(*Recycle Beirut), NGOs and associations (Arcenciel, Terre Liban, L'Ecoute, Tabarja Drop-off, Soils, Beatoona), Corporate Social Responsibility programs (Zero Waste Act). New services regularly appear. The activity is not only necessity-driven but includes social and environmental drivers.

*Waste flows*

The services provided are of two types: door-to-door pick-up services, at a variable frequency, in exchange of a fee, or access to the drop-off centres for free (even if registration may be required in some cases). It is worth noting that some of the pick-up services used to be free of charge prior to the crisis. An inventory carried out in January 2017 in collaboration with Terre Liban NGO showed that the five main private recycling services collect from more than 3 000 addresses in GBA, for an estimated 10 000 households (or equivalent) served.

After collection, materials can be either (i) directly sold to a broker or recycler, who will further process it, or (ii) processed by the entity which collected the waste. Processing steps remain basic: secondary sorting by material and colours; compacting, especially for PET bottles, paper and cardboard; and shredding, especially for wood and some plastics.

As for scavengers, materials are sold to other companies, either manufacturing industries consuming recycled materials, or other broker/processor specialised in one type of material, who will then further sell to manufacturers or export.

*Business models*

The number of private recycling programs has increased significantly with the crisis and new projects regularly appear[11]. This is partly due to the idea, widely conveyed during the crisis, that recycling of material is a profitable activity.

The free recycling programs were not able to continue their operations because raw material prices were not covering their expenses. In addition, average raw material prices are low due to the current conjecture: (i) low oil prices affect the value of plastic pellets, (ii) reduction of exports due to the war in Syria, (iii) higher prices for exports through the port.

Profitability is improved when (i) users pay for the collection service, (ii) users bring their waste to the facility, reducing the collection expenses. The prices for pick-up of recyclables varies according to the number of collection per month. On average, it is around 10 USD per month per household for a varying number of collections.

[11] Lately, Ganatch has started operating in North to Beirut, proposing services similar to Recycle Beirut.

*Competition between actors*

The multiplicity of actors in recycling creates different types of competition. First, competition is created between all informal actors and the central system. Indeed, even if the recycling rates of the central system are low, recyclable material represent a source of additional income. The activity of informal recyclers diminishes the stock of easily recyclable waste in the stream arriving at the central facilities.

Interestingly, in some areas of Beirut where Sukleen's recycling bins are available (both in streets and buildings), users prefer to pay for a private service. This can be the result of several factors: lack of information, lack of confidence in the system, preference for the social impact of private services.

Then, competition is also generated between street scavengers and organisations. Since organised services collect door-to-door, recyclables are diverted from the street bins. However, in the case of Recycle Beirut, which employs Syrian refugees, this can be seen as a semi-formalisation of Syrian workers. Indeed, the workers receive an income no longer directly dependent on the quantities collected, with additional services such as a safer working conditions or even English classes. Besides, women are also given job opportunities and new products are developed from the waste materials, using the workers' skills.

### 4.2.2. FX solutions: municipal projects

The other type of projects are the municipal initiatives trying to become independent from the central system. The table below gives basic information about each project. The detailed tables, on which results are based, presenting the physical and governance systems of each initiative, are given in appendix E.

*Table 5 - Description of the six sample municipalities. MR: Material recovery, ER: Energy recovery.*

| Municipality | Population (thousands) | Dominant Model | Daily waste flow (tons/day) | Initial Initiative |
|---|---|---|---|---|
| Brih | 1 | MR | 0.6 – 0.8 | Civil Society, Mayor |
| Antoura | 4 | MR | 4 | Civil Society, Mayor |
| Dhour Choueir | 5 | ER | 5 | Private person, Mayor |
| Beit Mery | 10 – 15 | MR | 15 | Mayor, Contractor |
| Chouf's Union | 10 – 15 | MR | 15 – 20 | Mayor |
| Bickfaya | 20 | MR | 20 | Private person, Mayor |

Due to lack of demographic data, population figures are based on interviews with various stakeholders. If no information about the daily waste flow was available, the average value of 1 kg per person per day was chosen.

*About the sample*

The sample comprises 6 projects from the region formerly operated by Sukleen. It concerns rather small municipalities or unions, from 1 000 to 20 000 inhabitants, i.e. generating between 0.8 and 20 tons of MSW per day. Only one case, in Dhour Choueir, is testing energy recovery through incineration of mixed waste but its EIA has not yet been cleared by the MoE

(10/01/2017). The incinerator, with a capacity lower than 10 tons/day and apparently no flue gas treatment, has been imported by a former minister. Outside BML, there is one similar case which has been reported (Tyr, in South Lebanon). There as well the incinerator seems not to be operating. Small-scale energy recovery, with presumably poor quality equipment, does not seem to have brought its expected relief for the concerned municipalities.

All other initiatives put *material recovery* (MR) first, meaning that sorting and recycling of material is their core principle, to diminish their dependence on landfills. During the crisis, the belief that recycling of plastics, glass and metal would be *enough* has triggered several municipal projects for sorting. MR projects were also more easily implementable than ER ones, as they require smaller investments of capital. Several have however stopped their activity when the central collection system resumed.

*About the physical system*

In all MR-projects, the MSW undergoes similar processes: easily recyclable materials are extracted and sold, while organics are (or will be) recovered by composting and (to a lower extent by) animal feeding. In Antoura's case, organics are sorted and mixed with soil near a piece of land where the compost plant is going to be built. All projects have a facility for post-collection sorting or secondary sorting. Small differences appear in the complexity of the sorting and the equipment used. For instance, Brih (1k inhabitants) only has manual sorting but separates its batteries and light bulbs from its residual waste; while Moukhtara Union (10-15k inhabitants) does not make such a difference yet but has access to more sophisticated material (conveyors, 60mm trommels, compactors). In essence, ***treatment*** is similar to what is theoretically performed by the central system (manual and mechanical sorting with stabilisation of some organic materials), allegedly with different quality and percentages.

However, the crucial difference between the central system and the decentralised initiatives is the way ***collection*** is performed. Indeed, all projects collect waste in small trucks or pick-ups, *without compaction*. In comparison with the central system and its fleet of compactor trucks, this type of collection is possible due to lower volumes of waste to collect by one truck and shorter transport distances. In Moukhtara's Union, which is one of the most widespread example, all the collection sites are within a 10 km radius from the sorting centre. More importantly, in all 5 MR-projects, *sorting at source* is part of the solution: 4 of them have a sorting at source in two or three bags, while the last project (Mokhtara's Union) is in the process of implementing sorting at source (in December 2016, sorting had begun in 7 of the 12 municipalities of the union). From one place to another, the collection calendar varies: the different streams are collected all at once in 4 cases (Brih, Beit Mery, Antoura, Mokhtara's Union), or following a calendar in Bickfaya *(but also Beit el Chaar, an initiative which stopped operating in March 2016*). Separate collection allows higher recycling rates of higher value material. If composting is implemented, the compost is also of higher quality, though testing has only been performed in Beit Mery (where they obtained a compost between grade A and B of American and European standards).

Last, the projects also differ by the way they deal with their residual waste and occasional waste (including hazardous): to not rely on the central system and its coastal landfills, the municipality

of Bickfaya temporally sent its residuals to the Hbaline controlled dump in the Jbeil caza; Brih is sorting and storing batteries, light bulbs (small quantities) and disposing in a 'sanitary hole' all tissues, hygienic paper, and diapers (the choice has been made to not compost them, unlike Beit Mery) and the residual fraction is partly sold or stored; Beit Mery through patented technology (ecoboard) of its operator claim being landfill free (information which could not be verified by site visit). Finally, the Mokhtara's project is simply storing its residual waste, which may be either dumped or sent to a landfill outside BML (Zahlé or Hbaline accept occasionally in exchange of a gate fee).

*About the efficiency*

The 5 initiatives still operating account for approximately 60 tons per day of MSW diverted from the central collection system. This is a small share of what is still collected by the centralised system (2,4% out of 2500 tons). This share is increasing as the first pilot projects are being replicated.

If, as highlighted in the previous paragraph, the treatment is the same in the central system and in the decentralised projects, the interest of the latter only exists if higher diversion rates are achieved at affordable costs. The diversion rates of the five case studies are presented in Table 6.

The investigated projects were characterised by a lack of monitoring or transparency, in the quantities of waste received and treated. It may reveal lack of means, methodology or the fear of being a SPOF (single spot of failure), on which opponents could communicate. This might be detrimental to the initiatives in the long run, and had also an impact for the thesis on precisely assessing the diversion rates. In addition, these rates vary over time as the projects further develop and sorting at source improves. The ambition of the figures in Table 6 is not to highlight these facts, but to show a fairly representative diversion rate from landfill.

*Table 6 - Diversion rate from landfills in the 5 MR-projects and the historic system. Percentages are given with respect to the total mass of MSW generated or collected.*

| **Project** | **Recycling (%)** | **Organic valorisation (%)** | **Total diversion rate (%)** | **Comments** |
|---|---|---|---|---|
| *Sukleen* | *7 – 9* | *0 – 10* | *7 (post-crisis)*<br>*19 (pre-crisis)* | *Source: StREG, 2016. Sweep-Net, 2014. Interviews in early 2017.* |
| Brih | 20 -30 | 50 | 70 – 80 | Field visit. Interview. |
| Antoura | 15 – 20 | 0, currently<br>50, future | *15 – 20*<br>65 – 70 | Interview. |
| Beit Mery | 30 (includes residual) | 50 – 60 | 80 – 90 | Interview; Visit refused. |
| Mokhtara's Union | 10 – 20 | 0, currently | < 20 | Field visit. |
| Bickfaya | 15 – 20 | 20-30 | < 50 | Interview. |

It appears that all projects achieve higher rates of diversion than the post-crisis Sukleen system where organic waste is no longer composted. When compared to the diversion rates pre-crisis (19%) the initiatives which have not yet implemented organic valorisation perform similarly

(up to 20% diversion rate), however with a higher quality of products. Only the municipalities having organic valorisation can claim to provide a significantly higher diversion rate than the centralised system.

*About the financing: OPEX & CAPEX*

The budget of any project is split between capital expenses (CAPEX) and operational expenses (OPEX).

The CAPEX, or initial investment, is used for land acquisition, construction and equipment. It has very diverse sources, often multiple: *private person investment* and *municipal budget* in Bickfaya (headquarters of a political party opposed to the March plan), *budget of the union* of municipality, *international donations* and *private person (politicians) donations*, for Mokhtara, *private sector investment* (in exchange of operation contract), in Beit Mery. *Online crowdfunding* has even been used in Antoura (with municipal budget and Mercy Corp support) to build the composting centre. Despite the fact that investments have not been disclosed to allow proper analysis, one can say that the most equipped centres are not necessarily the best performing ones. An order of magnitude which can be disclosed: smallest centres started with around 20 000 USD (~1 TPD), mid-sized projects costs around 200 000 USD (~15 TPD) and the largest ones may benefit from economy of scale.

It should also be mentioned that the government incentive for promoting decentralisation is still not in place. That is why, NGOs are building their financing models. Notably, Arcenciel NGO's logic is to provide free consulting services, and if the project proceeds, to build and operate the plant during the first years, before transferring it to the municipality with teaching/capacity building. Arcenciel's investment capacity comes from self-revenues and international aid. Fondation Diane has been willing to co-finance projects with low interest loans, depending on the profitability of the activity.

The OPEX is split between collection, treatment, disposal, depreciation and maintenance and (to a lower extent) awareness costs. These costs include manpower. According to various project managers, waste collection is the main source of expense. This is consistent with the global experience of waste management (UN-Habitat, 2010). Then come treatment costs, estimated by various NGOs at about 40 USD/ton for sorting, processing of recyclables and composting.

On the other hand, costs are recovered from three sources:

First, are the revenue generated by the selling of recyclables. It is estimated by the two main NGOs that the value of recyclables in one ton of MSW is around 40 USD. The revenues related to compost are usually not taken into account because uncertainty still exists about market demand and prices. From one manager to another, compost prices can vary from a few dollars per ton to several hundred per ton.

Second, a direct fee is collected by the municipalities. All investigated cases consider the service fee as a necessity to cover part of the costs. The price is either 5 000 LL – 3,3 USD (in Brih) or 10 000 LL – 6,7 USD (other cases) per month and per household. Such a new fee raises the question of affordability, and acceptability by the service users. The fee annually amounts

to 40 – 80 USD per household, representing 0,3 – 0,6% of the median annual household income (13 000 USD, in 2014). The cities analysed in the UN-Habitat report (2010) has a share varying between 0,11% and 3,60% of the annual household income. The fee is seen as tool to involve citizens and a way to alleviate irregular *payment of the municipal budgets by the central government*. Pay-as-you-throw fee were discussed but not implemented. Since municipalities also collect directly other taxes such as the property tax, the system for collecting taxes is already in place. However, no data about effectiveness of tax collection was found.

Third, the independent municipal fund (IMF) is a source of revenue for municipalities, based on a dozen indirect taxes collected by the central government. However, the payment is subject to several-year delays, and erratic rules and management by the central government. Finally, it should not be omitted that the cost recovery for the formal central system is taken from the IMF. Thus, in theory, municipalities stopping or diminishing their waste sent to the central system should see their IMF-revenues increase.

*About private sector participation*

Private sector participation (PSP) is often seen as a driver for improvements of public utilities (UN-Habitat, 2010). In these case studies, only Beit Mery has contracted an established private company for its waste services, namely Cedar Environmental, led by the charismatic 'garbage man' Ziad Abi Chaker advocator of zero waste to landfill plants. Other municipalities are leading the projects alongside with the civil society. Bickfaya has named its project BiClean, but is not formally a company. Mokhtara's Union is subcontracting the collection service, but the trucks are still owned by the Union. Brih's project is led by the village's youth and the municipality. Arcenciel NGO might as well be subcontracted for consultancy, construction, operation and transfer in future projects.

Overall, private sector participation in these initiatives seems limited, to the benefit of municipal and community-based projects, backed up by NGO support. Established corporates are not involved in such small scale projects or not interested. It can be mentioned that Public Private Partnerships[12] (PPP) are rarely used in Lebanon; traditional procurements and contracts are the preferred option by the Government.

*Resilience keys*

Table 7 shows the resilience grading of the projects made according to the criteria presented in section 3.5. Resilience seems high for all projects except Mokhtara's Union. Compared to the other projects, despite being one of the oldest projects, it does not have a high inclusivity of users, it does not have a solution for the residual waste (except dumping) and residual waste still represents a large share as composting is not yet available. Large amounts of money have already been invested in this plant, and some as been lost in a fire (criminal or accidental) in October 2016.

[12] PPPs differs from tradition contracting due to clauses of shared risks and responsibilities.

*Table 7 - Resilience grading of initiatives, based on five criteria assessed with 0 if absent, 0,5 if present and 1 if present and efficient. Maximum grade is 5.*

| *Municipality* | Brih | Antoura | Beit Mery | Moukhtara | Bickfaya |
|---|---|---|---|---|---|
| *Population (thousand)* | *1* | *4* | *10 -- 15* | *10 -- 15* | *20* |
| *Resilience grade* | **4** | **3,5** | **3,5** | **2,5** | **3,5** |
| 1. Residual waste | 0 | 1 | 0,5 | 0 | 1 |
| 2. Diversion rate | 1 | 0,5 | 1 | 0,5 | 0,5 |
| 3. Cost recovery | 1 | 0 | 1 | 1 | 1 |
| 4. User inclusivity | 1 | 1 | 0 | 0 | 0 |
| 5. Dynamic for future | 1 | 1 | 1 | 1 | 1 |

The other cases score better for different reasons. The smaller villages can count on a strong inclusivity of users as the project has often been initiated by civil society itself. In larger municipalities, such as Beit Mery and Bickfaya, this lower inclusivity can be seen as a result of the political fight that waste is: the project managers seek to prove their concept. All projects have however in common their willingness to continue what has been started.

*About compliance with national law*

Despite the limited legal framework regulating such initiatives, the law requiring environmental impact assessments (EIA) to be performed prior to decision-making was passed in 2002 and the decree in 2012. Alongside with the March plan in 2016, a technical committee was formed to assess and authorise projects of municipalities willing to recover their independence in waste management.

No project has respected these two requirements. Some submitted EIAs to the MoE after beginning of construction or operation. Most did not bother with getting the approval of the technical committee. It should be mentioned that even the central facilities (i.e. the new coastal seafills) were decided without proper EIAs, which is now causing serious problems at the Costa Brava seafill located a few hundred meters away from the airport's runways. Both parties can claim that their actions were decided in an emergency state, and thus by-passed the normal procedure. However, such behaviour can be criticised, referring to the Naples' waste crisis and "permanent emergency state" (D'Alisa and Armiero, 2013), as it hinders democratic and transparent procedures, as well as aware and sound decision-making.

Finally, it should be noted that the government's *laissez-faire* with material recovery projects contrasts with the *firmness* shown with small-scale incineration attempts.

## 4.3. Potential sinks of materials for *organics* and *residual waste*

The previous section has shown that most decentralised initiatives place material recovery first. MSW is thus split in four streams of materials:

(i) a stream of *recyclable* materials;
(ii) a stream of *organic* matter, most often composted,
(iii) a stream of *residual* waste, and finally
(iv) a stream of *occasional, bulky or toxic* waste.

These four streams have been recognised and explained in the awareness campaign *Min el Masdar* (*At the source*, by Terre Liban NGO) and supported by the MoE though not implemented nationwide. As highlighted before, the resilience of the case studies partly relies on organising a supply chain to direct these streams to the appropriate sinks. It also raises the topic of resource management, going beyond waste management.

The main concern of municipal actors and *a fortiori* ministries is the existence, in Lebanon, of recycling channels and their readiness to absorb all materials generated by sorting centres. This is an essential question which has already led to many reports, funded by the UN or the EU (StREG, 2016; UN Green jobs) and more recently to documentaries about the existing *recycling industry* in Lebanon.

Less light has been shed on the fate of organic matter, residual waste or even occasional, bulky and toxic waste. The connections established with Fondation Diane and its decentralised composting activities, and with the Ministry of Environment interested in solutions for residual waste, has led to the preparation of short studies for *compost products* and *residual* waste. The work on energy recovery from residual waste was presented at the Ministry of Environment during a lunch seminar. Even though these results are *not of academic interest*, but more of economic interest, the paragraphs below simply intend to present the main conclusions, for the sake of coherence and completeness with the questions raised during the thesis. More details can be found the separate documents listed in appendix F.

***Residual waste and energy recovery***

Residual waste is defined here as all materials left from the daily waste which could not be valorised. It includes rejects from recycling industries but excludes occasional, bulky and toxic waste. Around half of the residual waste is still combustible and could be used for energy recovery. In a waste management model with recycling and sorting at source, it was estimated that around 400 000 tons/year could be produced nationwide, with a calorific value of around 16 MJ/kg and acceptable humidity as a result of proper sorting. This represents 16% of the total waste stream.

Three potential sinks have been identified: incineration in dedicated units, co-incineration in thermal power plants, and co-incineration units for industrial purposes. The readiest sink in Lebanon is the latter one: several industries requiring heat and power exist across the country. In particular, the cement industries' ability to absorb residual waste was estimated to be around 350 000 tons/year (constituting 30% of their current energy mix). Other industries have developed waste-to-energy systems and already process around 40 000 tons/year of rejects mainly in the paper recycling industry. If produced properly, fuel derived from residual waste can be an alternative to fossil fuels and to the heavily polluting petroleum coke used in the cement industry.

The figures do not say that residual waste should exclusively be sent for energy recovery in industries even if they seem to have the capacity to absorb it. Instead, it should raise concerns about the risk of overcapacity that the country is facing if it implements a strategy based on large scale incinerators. Still, many questions are left to be answered especially regarding

quality control of the waste, monitoring of emissions, organisation of the sector and acceptance by local communities.

### *Organic waste* and the compost market

For a developing country whose waste is mainly organic, composting seems straightforward. However, decades of mechanical-biological treatment process have contributed to today's bad reputation of compost products. Authorities usually claim that there is no potential for compost use and farmers may be suspicious about using a waste-derived product.

Despite these statements, an agricultural demand for compost exists in Lebanon. The CEO of Cedar Environmental even estimates a current consumption of around 10 000 tons/year. The prices are rather high (200 to 700 $/ton, when packaged in small bags). Other occasional uses have been reported for quarries rehabilitation or alternative landfill cover, which can accept lower grade compost.

The potential for compost production from MSW, nationwide, does not exceed 600 000 tons/year (1600 tons/day). Considering the agricultural land *in use*, this equals to 2,4 ton/year/ha (i.e. applying a layer of 0,5 mm/year). Extending to the total agricultural land, the figure is divided by two.

The main issue regarding compost is ensuring quality, which highly depends on waste collection. Smaller communities have proven to be able to change their collection and sorting system. It seems a greater challenge for the Greater Beirut Area, but is not impossible as has been proven by larger cities across the world. For now, only a few private companies have been interested by the production of compost from MSW. They start implementing composting platform in rural areas and consider exporting source-sorted organics from specific emitters in larger hubs to these platforms.

# 5. Discussion

In this chapter, the results are confronted with the goals initially set and some propositions are made regarding the priorities for the solid waste issue.

## 5.1. Describing the Lebanese SWM system

The system description aimed at presenting all aspects of waste management in the study area, not limiting it to the Sukleen centralised system, as has been the case in many other studies. The timing for this was favourable as alternatives to the central system were growing in number and quantity of waste handled, in addition to the high media coverage they received. Some challenges have been to quantify the waste flows for each sub-system and to identify the group of actors behind each sub-system.

***A SWM system subdivided in three non-cooperating systems***

All this led to the main conclusion that the waste system is organised around three centres. Each one is now well established, in the sense that they deal with a significant number of users and tons of waste, and are not likely to get off the stage. It also appeared that the (i) formal central system (FCS), the informal central system (ICS) living at the margin of the former, and (iii) the recent *semi*-formal decentralised system (FDS) have their own legitimacy, supporters, area of expertise, dynamics and challenges. These features are reformulated in Table 8 below.

*Table 8 - Summary of features for each component of the Lebanese SWM system.*

| | **Formal Central System** | **Informal Central System** | **Formal Decentralised System** |
|---|---|---|---|
| *Legitimacy or merit* | ***Basic*** collection and disposal ***services***, ***for all***. | Social and environmental impact via ***quality resource recovery***. | Better collection and ***treatment*** services, locally. |
| *Main support from …* | Central government. | Social businesses, NGOs. | Local powers, NGOs, CBOs. |
| *Area of expertise* | GBA and dense areas. | GBA and dense areas. | Mountain & rural areas. |
| *Dynamic* | Shrinking catchment area. Internal reform. | Expanding number of clients and services. | Expanding number of projects and services. |
| *Challenges* | Higher diversion rates. ***Improved collection.*** ***Lower corruption***. | Formalisation. ***Recognition*** by central government. | ***Residual waste.*** Cooperation internally and with government. |
| *Waste Flow (tons/day)* | **2500-2700** (decreasing) | **150-550** (increasing) | ***100 – 200*** (increasing) |

Most means and large investments benefit the FCS, under the logic that it is responsible for public health of most users. It is still today, and since the 2016 March plan, the priority of the central government, which is facing many problems of implementation. In addition to

corruption presumption by the other actors, this situation entails limited cooperation with the two other systems.

The ICS still lacks recognition from officials and the FCS. It can be explained by the competing economic interest they face, since informal actors divert a fraction of recyclables which would otherwise directly benefit the monopolistic formal companies in charge of the waste services, even though it is a fact that they have lower recycling rates due to the compacting collection. This opposition is however counter-productive: according to Velis *et al.*'s review (2012) there is "an increasing consensus among all stakeholders and experts that the informal sector in general should not and, in fact, cannot be ignored while attempting to improve waste and resource management systems in developing countries."

The FDS are paving their own way with very limited support from the central government, but also with limited willingness to cooperate and comply with the institutional processes, again often accused of corruption. The main support to the FDS comes from civil society, local powers and NGOs. The latter thus connects decentralisation with the informal sector where NGOs have gained experience over the last decades. The FDS would also gain from more integration, internally and externally, as will be further discussed.

The classification of actors has shown that all levels of governance are now involved in the waste issue but within different and non-cooperating working groups. At first, the classification (Figure 12) included the names of all identified actors. This however appeared not useful for the understanding of the process, even if it was a necessary step to meet actors and collect data.

***Quantitative figures: a challenge in waste management and in Lebanon***

The description also aimed at providing quantitative figures. If figures in waste management are always subject to high uncertainties and definition issues, in Lebanon it is worsened by the lack of data itself and multiplicity of divergent sources of information.

The choice has been made to present the weight of the three systems by comparing the quantities of waste handled, i.e. collected by the system, whether or not they end in the same system or another. The reason behind this choice is that most actors communicate about the waste they have processed, not being very clear with the outputs. In cases where figures are not available, population estimates are also used in combination with an average generation rate per capita. Thus, the figures given are average values with a large uncertainty and which do not include seasonal variations (in some areas, population doubles in the summer months).

If more data had been available, both demographic and waste collection data, it would have been interesting to describe each system by two figures: the number of tons handled and the number of persons served. This could have brought more insights on the variations of waste generation per capita across the region, to be linked with adaptive cost recovery fees.

***Usefulness of the descriptions***

The process-flow diagram (Figure 11), more technical oriented, and the classification of actors (Figure 12), more governance oriented, can be useful to foreigners willing to dig into the Lebanese waste sector and get the whole picture. The question was raised of the value of such

a work for local people, whether or not solid waste experts. For citizens showing some interest, e.g. those who attend conferences or participate in waste-related events, simplified versions of the description could be meaningful. It can give a general description of the situation, with more pragmatism than the usual discourse which tends to accuse others of corruption.

For decision-makers, it also gives a neutral perspective of the issue and tends to shed light on the role of new initiatives in the overall system. This appears important since Marshall and Farahbakhsh (2013) suggest that it is a common mistake when trying to implement ISWM to focus on individual components and not consider all existing actors.

## 5.2. The changes in the aftermath of the crisis highlighted in this study

First of all, the scope of the study did not include all the impacts of the recent waste crisis. For instance, the impacts the crisis had on illegal waste dumping, environmental contamination, air and water pollution and the related health impacts were not investigated. Other entities published reports regarding those. Worth mentioning are reports from the American University of Beirut regarding dioxins contents in Beirut's air (2016), the Ministry of Environment's study on illegal MSW and C&D (construction and demolition) dumps across the country (2016-2017) and the presentation about pathologies linked to the waste crisis made by hospitals.

In this section, two changes will be discussed: (i) the end of Sukleen's monopoly and its consequences, and (ii) the assessment of decentralisation initiatives and their challenges.

### 5.2.1. The end of a monopoly and less corruption?

The main shift in the central system is the end of a 20-year-long monopoly whose history has been recalled in chapter 2. This had two organisational consequences: creating a new oligopoly of operators and opening the door for small-scale actors.

The details about the distribution of operators, taking over the former operator's facilities, is presented in appendix C. Disposal, treatment and collection services are now split between four main operators, which have often built joint ventures with foreign partners to meet the public tenders' requirements. However, critiques have been made regarding this oligopoly: the contractors are accused to be close to officials, some companies might actually belong to the same group. The bidding process event went through some irregularities (when for instance one tender was redone and the same contractor was awarded the bid for a few million dollars less than its first call). In other words, there is a fear of *business-as-usual* behind these large contracts *(exceeding 250 million dollars for only 4 years)*, in a plan already similar in many aspects (solutions designed, persons in charge, management) to the 1997 emergency plan. With respect to corruption in the formal centralised system, appendix F presents of example of how public money can be diverted from its original purpose.

Besides, some criticise the repeated use of "trash in the streets" as an instrument of pressure to pass the plans by force. Such plans will inevitably lack of acceptance, inclusivity and transparency. Decision-making in a state of emergency, as D'Alisa and Armiero (2013) recall

about the Italian crisis, is a threat to democratic and transparent processes, and impedes acceptance.

On the other hand, the eviction of Sukleen from the waste scene has opened the door to multiple small actors, starting businesses or extending their activities, and municipalities taking back part of their responsibilities. They benefit from civil society support and financial support of various institutions. Many actors met during this study believe that such initiatives, as they include civil society and manage to establish good communication with their users, can help to diminish corruption in the waste sector as well as improve its efficiency. As corruption is often linked to the size of the project, it is suggested that administrative decentralisation could diminish the lure of money. This is however not a guarantee.

Another element for fighting corruption is the digitalisation of state and municipal services. As seen in the waste actor classification, several teams are working on apps for municipal waste services and connection with recycling industries and intermediaries. This goes jointly with efforts of modernisation of the State.

### 5.2.2. Assessment of decentralisation initiatives and challenges

During the thesis, the effort has been made to describe several initiatives and underline their similarities and differences, both in their physical and governance dimensions. These initiatives have positive impacts, but they face various challenges and need to cooperate with the central government to achieve more in the long run.

*Limitations*

Before dwelling on the impacts and challenges, one should reckon that the analysis has some limits. First, the number of project analysed (six) compared to the fifty projects in development set the question of representative sample. This can be mitigated by the fact that all decentralised projects pinned on Figure 13 do promote material recovery and sorting, and thus may have similar strategies. Besides, even though projects are increasing in numbers, the sources of consultancy are often the same, i.e. the main NGOs operating in waste management. Focus has essentially been put on existing decentralisation projects in remote areas. But decentralisation is also happening in larger municipalities, including Beirut. There, the political stakes and technical challenges are rather different and the options considered as well.

Then, the depth of the analysis can be criticised for having been mainly descriptive and subjective, especially for the resilience grade attributed to each case according to comparisons between projects and personal judgement. Despite adapting the framework developed in UN-Habitat's assessment of 20 cities (2010), comparisons can hardly be made between these cities and the Lebanese villages.

Nevertheless, the framework developed for describing the projects could be reused to record changes in the current projects but also new ones. In this sense, it joins the work already started by the MoE who sent a questionnaire to all municipalities during the crisis, whose results have not been published. If more features are added to the description canvas (*such as indicators of efficiency, quantitative figures, quality controls*) it could serve as a basis for a centralised

monitoring of municipal waste practices. This could be the task of hypothetical national agency for solid waste.

*Positive impacts*

Despite the old myth, often relayed within institutions, that Lebanese will never sort their waste, all projects have demonstrated that the contrary is possible. This has allowed, alongside with collection without compaction, higher rates of recycling but also higher quality in recycling and composting than the central system. This actually directly benefits to the government's plan as less waste is landfilled, lowering the pressure on the volatile March plan.

Another success of decentralisation is the involvement of users and the cooperation with municipalities. Inhabitants have been reached by awareness campaigns often led by other inhabitants. From a social perspective, each new facility creates several technical green jobs and a few managing positions.

Even if monitoring is not yet perfect, municipalities are building capacities after more than twenty years of monopoly. This is a slow process which should also be regarded as a driver of change for waste management in the country. Indeed, the projects contribute to developing local knowledge, a local experience or proof of concept. They answer many questions regarding how people react to sorting awareness, how composting is accepted, how it can be locally used or marketed. The impacts also go beyond the area of the municipality in at least two ways: first, similar municipalities and decision-makers can have a look at such project's and replicate it. Then, due to the fact that Lebanese have a strong link with their village of origin, even if they live in cities, such projects convey the core ideas towards larger cities.

*Securing access to landfill for residual waste*

Under the current contracts with the centralised operators, municipalities which decide to start their own waste management project can no longer benefit from the access to the central sanitary landfills. Thus, they end-up either storing or dumping the residual waste locally, or exporting it to other landfills or dumps outside the region by paying private haulers. Burning can also occur. As it has been seen in many facilities across the country, including state facilities, overflow of residual waste is the main cause of project failures.

Even if the residual fraction from the municipal projects has less economic value (recyclables and compostable extracted), it still represents a lower volume (up to 90%) to be transported and landfilled than if nothing had been done locally. If decentralisation is truly to be supported by the government, it then seems logical that an option should be made available for decentralised initiatives to have access to the central landfills, eventually at preferential prices (e.g. monthly pickup at specific price). It should be noted that residual waste could can still be valorised either in material recovery facilities or as refused derived fuel before landfilling (Morris *et al*, 2015).

*Monitoring and networking*

The municipal projects are led by different types of persons often with little to no experience in waste management, but with willingness to learn. In most projects, monitoring is not systematic, either because of lack of means or knowledge. When data is recorded, it does not

follow a standardised procedure. Emanating from the state or from a network of municipalities, a common framework for collecting data and monitoring local waste management practices could help to measure progress over time and enable comparisons between projects. Monitoring the composition of residual waste is a key parameter, as it helps to identify recycling needs, products to be redesigned or prevention campaigns.

The idea of a network of municipalities could also be a formal way to agree on pursuing the same principles, aim for the same targets (e.g. of prevention and recycling), share experiences and even equipment, and gain in visibility and legitimacy with respect to the central government. Such networks exist in Europe but have also been recognised as useful for developing countries in West Africa (OEKO, 2011). A proposal of organisation of the network and shared principles has been prepared and discussed with several municipalities and Terre Liban NGO.

*Risks of uncontrolled decentralisation*

Some actors are defining decentralisation as the freedom given to municipalities to deal with their own waste, in their own way, within a certain scope of possibilities set by the law. In this vision, decentralisation can be seen as the creation of multiple small autonomous areas of service.

This can raise concerns in several ways. First, sensitive technologies such as incineration (requiring strict controls and high skills) may have impacts on surrounding areas, creating conflicts especially if neighbours are committed to different treatment options. In addition, too much freedom can entail proliferation of facilities without coordination, risking overcapacity or dissonance with national targets. One should not exclude the fact that multiplying facilities make it harder for the responsible authorities to control them (hundreds of small scale landfills, incinerators or composting platforms). The underlying question raised here is about the optimal scale of decentralisation with respect to efficiency in achieving high recycling rates and benefiting from economy of scale. Several local stakeholders mention the scale of facilities treating between 100 and 300 tons/day as an optimum outside of Beirut (Arcenciel, 2015; AUB, 2017).

So, decentralisation must not be synonymous with anarchy and complete independence, as it is currently being practised in the pilot projects. If it seems more efficient to empower municipalities because they achieve, among others, higher recycling rates and public participation, it should follow an *organised national plan*. Like for dams, it is very unlikely that all regions or sub-regions need or should build all kind of treatment and disposal facilities. Due to various reasons ranging from geological factors to socio-economic synergies, it may be more adapted to implement, for instance, waste-to-energy[13] in some regions and landfill in others. This, however, raises the polemical subject of having larger facilities receiving waste from other regions. It is basically the *not-in-my-backyard* syndrome coupled with strong politico-confessional divisions, which already contributed to the crisis in 2015. Acceptance of such

[13] Since January 2017, some municipalities have started to consider waste-to-energy plants (120 tons/day) to get rid of their residual waste, but also accept commingled waste from other municipalities, to co-produce heat and power for valorisation in industrial areas.

‘transboundary’ flows of waste can be built around a national plan making it clear that the flows are controlled and not harmful.

Another dimension which should be monitored under the decentralisation schemes is the widening of service inequalities between users. Municipalities and unions do not have the same means, in particular financial means. For instance, the revenues from the IMF do not necessarily reflect the actual number of inhabitants.

To answer the initial objective regarding the new actors, it can’t be denied that they are contributing to a better WMS, more sustainable, more in accordance with ISWM principles. However, they still face resilience and organisational issues which the government can mitigate by taking some immediate measures and by formalising the actors. In the end, there is a complementarity between the centralised and decentralised systems which has to be promoted in the future plans.

## 5.3. Setting priorities for the country

The last objective of the thesis, was to identify priorities for the country’s strategy in waste management based on the overall work.

***Exit management of emergency***

Since 1997, all waste plans which have been implemented were designed in emergency situations, and led to today’s state. The current four-year plan is under constant threat of failures and no future plan has been decided nor publicly discussed. Exiting emergency management is possible only if short-term needs and long-term goals are addressed, or at least defined, at the same time. Otherwise, the country will continue to go through repeated waste crises as landfills open and close down.

In our case, the short-term needs are to guarantee a basic service for more than the four years to come and for all citizens. The long-term goal would have set the country on the path ISWM, with a lower dependency on landfills, acknowledging that there is no ‘one-size-fits-all’ solution nor ‘quick technological fix’ without participation of all stakeholders.

In addition, the decision-making process could benefit from more transparency and public participation, leading to increased legitimacy and acceptance. This is however a challenge for a country where the political habits often lead to discreet negotiations, to satisfy all political clans, before a decision is taken.

***Legislative, strategic and operational priorities***

At the *legislative level*, it seems urgent to adopt a waste law. It might be time for the ISWM draft law (prepared in 2004 by the MoE and never adopted by the Parliament since then) to be updated and voted. This would once and for all set by law the distinction between different sources of solid waste (municipal, industrial, agricultural, hospital…). It would also set the priorities of treatment readjusting the weights between prevention, reuse, recycling, energy recovery and landfilling. Only then can economic incentives be justified to promote for instance the recycling industry, support informal actors or implement extended producer responsibility (EPR) policies. Even if international standards are recognised in Lebanon, through the

environmental code of 2002, national standards could be adopted for compost products or incineration emissions limits.

The laws could be accompanied by the creation of a national agency for waste, responsible for the supervision of the sector, reuniting the concerned ministries, the municipalities, contractors, other businesses and industries, informal actors and civil society. Such an institution would also guarantee continuity of management, unlike the current ministerial management switching from one ministry to another.

At the *strategic level*, more specific goals should be set going beyond the traditional "no more waste in the streets" which supports the idea that waste is only a problem when collection stops. It could take the form of quantitative targets for treatment and waste generation, based on the waste composition. Some inspiration can be found in the Italian zero waste cities which have committed to overall reduction targets (less than 50 kg/year/person to landfill), or the Swedish and European ban on organic waste landfilling without treatment. As Hans Rosling used to say about the international poverty reduction targets, setting ambitious targets is the best way to achieve goals faster.

At the *operational level*, if in 1994, at the end of the war, the priority had been given to restoring waste collection and safe disposal, and then to increase composting and sorting capacities, it seems to me that today's priority should be given to improve the collection system. Indeed, if treatment capacities (composting and sorting) of the central system do not perform efficiently, it is to a large extent due to the compaction of commingled waste. The quality of waste material is affected: compost is necessarily of low quality, recyclables are soiled and of lower economic value, and manual sorting becomes an even more difficult task. Mixing waste also increases the humidity of materials which could be used for waste-to-energy. In other words, whatever the treatment, its efficiency is positively affected by separate collection.

The Italian city of Parma (Folli, 2016) has for instance shown that by investing more in waste collection, the overall cost could be reduced due to lower treatment costs, higher revenues and less landfilling. The idea that time has come to change collection and implement sorting at source is reinforced by two factors: the 2015 crisis acted as a boost of awareness among many Lebanese, who are now readier than ever to segregate their waste, and the existing sorting facilities are still operational and would highly benefit from such a collection upgrade.

Looking at the *municipal scale* requires to distinguish between low density areas (rural and mountain areas) and dense areas (mainly GBA and the coastal strip). In low density areas, projects based on sorting at source and local treatment of organic waste seem easier to implement, providing that management of residual waste and financing are secured at a higher level. In rural areas, some synergies can also be found between MSW and agricultural waste through anaerobic digestion or composting. For larger cities, the pressure of waste generation is bigger. Due to the waste collection and the scarcity of land, quality composting may be restricted to large emitters of organic waste. Interesting synergies can also be found with sewage and abattoir waste.

***Political pragmatism in Lebanon and post-normal science***

The propositions made in the previous paragraphs must be put in perspective with some kind of political pragmatism. Politics in Lebanon do not follow the same rules as in European countries. As the State Minister of Planning explained in a meeting held in December 2016, even for waste, the proposed solution has to satisfy all political forces, who are usually in conflict, in order to be accepted. This old-fashioned way of doing politics is a reality. It reinforces the idea that waste management systems can be analysed under the lens of post-normal science (D'Alisa *et al.*, 2010; Marshall and Farahbakhsh, 2013). In addition to the uncertainty of facts, the time constraints for decision-making, the health risks, and the multiplicity of legitimate stakeholders, this political gameplay hinders rational change. Therefore, strategies of change management must be heavily reliant on compromises and a fine understanding of each party's interests.

## 5.4. Recent developments and future works

At the time of concluding the thesis, the solid waste topic is making the headlines again. Nearly one year after the implementation of the emergency plan, the government is about to announce its long-term solution plan. Whatever its contents, the plan will be decisive in determining the desired balance between centralisation and decentralisation. The efforts made by the small-scale actors to reduce the county's dependence on landfills will either be encouraged or remain neglected.

It has been clear from the very beginning that Lebanon's waste problem is not only a matter of technical means but also an issue of governance and mismanagement led by private interests. Today, the case is still managed as an emergency in the highest spheres of the government (top-down approach). Only some empowered civil societies, social entrepreneurs and municipalities have managed to propose local alternatives (bottom-up approaches), often achieving better than the central system. Despite their small size, local proofs of concepts can be tremendous drivers of change for decision-makers.

The responsibility of the national authorities is to recognise the multiplicity of waste actors, the shared responsibility of municipalities *and* central government, and foster cooperation between all actors within a renewed legal framework and targets. Such a wave of formalisation would improve the outcome of all projects and give a clear direction to the people and the waste-actors.

Being a country of diversity in a region of high instability, Lebanon's priorities are not only limited to solid waste issues. Not mentioning environmental threats, energy failures, water supply and sanitation, the country is facing security issues as well as the humanitarian refugee crisis, impacting the overall society. In other words, one should remind that the time, budget and efforts allocated to solid waste are necessarily limited to reflect this order of priorities. In a way, setting once and for all a clear waste decentralisation framework could help alleviating the current pressure on the government and count on its emerging local authorities to deal with the waste issue. In addition, the general fight against corruption which has been started by the new government is expected to have positive spill overs on the waste management. Finally, by

respecting its international commitment (e.g. international conventions), Lebanon would justify the financial aid it continues to receive from international donors.

From a personal perspective, analysing the Lebanese waste sector has nourished the envy of diving into action which sometimes conflicted with the research goals. Despite the similarities with the 1997-crisis, the maturity of the civil society and the positive political context, have brought back dynamism in the sector.

Further operational research could be directed at organising the decentralisation movement in its relation with a national solid waste authority, developing tools for accountability and monitoring of waste flows. More academic research could focus on the optimisation of the waste collection routes and transfer stations in the Lebanese geographical and contextual setting. This would contribute to better defining the fair balance that is to be sought between centralised and decentralised waste management.

# 6. Conclusion

Studying the waste management system in the Beirut Mount-Lebanon region in the post-crisis context led to system and project scale conclusions.

In the region, the waste management system is organised around three non-cooperating sub-systems: the formal centralised and historic system, the informal centralised system and the newly semi-formal decentralised system. Each system has been characterised by the quantity and types of waste it handles, the type of actors and supporters involved and the area of operation. The current dynamics of reform and expansion result from the history of each system and the recent crisis: the formal system restructures itself to ensure a basic service, informal actors fill the gaps left by the central system in terms of resource recovery, and the decentralised system tries to provide an alternative to the centralised one. However, the lack of cooperation between the actors appears as a limiting factor to the overall efficiency.

The new municipal projects analysed tend to perform better than the centralised system with respect to most ISWM features. The physical system achieves higher diversion rates, ranging from 20% to 90%, thanks to attempts of producing quality compost and an improved collection system. Landfill space is thus saved but the options available to municipalities for proper handling of residual waste are limited. The decentralised governance achieves better user inclusivity and has seen the first attempts of financial sustainability through user fees. The future resilience of the projects is mainly linked to the handling of residual waste and financial sustainability, both of which can be addressed by the central government. The physical and governance innovation made through decentralised projects can be a driver of change for the overall Lebanese waste management system.

The Lebanese case exemplifies that waste management is more than a technical problem and requires systemic and post-normal sciences approaches. The overall context, the history and the interests of all actors are key factors to understand the hidden stakes and guess the future of waste in the country. For the physical part, suggested priorities are to improve sorting and collection, and for the governance part, to resume normal institutional process, through law, strategy and recognition of all actors.

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# Appendixes

# A. Waste-related legislation in Lebanon

Laws and regulation concerning waste is mostly outdated. International reports (ref) highlight that enforcement of existing law is non-existent. The most striking example is the Decree 9735, dated 1974, which bans the use of non-closed road containers. Such containers were at the basis of the 1994 solution to resume collection services in Beirut.

***National regulation: laws, decrees and drafts***

| Legislation | Date of issue | Main subject |
|---|---|---|
| ***Under the French Mandate (1920 – 1943)*** | | |
| Decision 188 | April 1920 | Prevention of risks to public health. This decision forbids open dumping of solid waste and assigns to the Ministry of Public Health (MoPH) the responsibility of supervising open dumping. |
| Decree 7975 | May 1931 | Prohibition of discarding all types of solid wastes and manure around houses and burying or delivering them to the Municipal Cleanliness Department.<br><br>This decree was followed by Law 16/L which prohibited all actions which are likely to cause disease or facilitate the spread of epidemics, and thus implicitly improper waste disposal. |
| Law 16/L | June 1932 | General health rules and regulations. |
| Decree 2761 | December 1933 | Directions related to discharge of wastewater and dirty substances. |
| Penal Code | March 1943 | Sanctions for dumping wastes, manure or any other polluting substances in springs and waterways. Sanctions vary between 1 to 3 years in prison and fines from 50k to 600k LP. |
| ***After the country's independence (1943 – 1990)*** | | |
| Decree 10276 | October 1962 | Protection of surface and groundwater resources. |
| Decision 425/1 | September 1971 | Garbage must be placed in plastic bags for disposal. Municipalities are responsible for waste collection and waste must not be dumped on the streets or any other public place. |
| Decree 8735 | August 1974 | Description of domestic waste.<br>Municipalities are responsible for collection and disposal of waste.<br>Ban on throwing waste on roads, public places, rivers, under private properties of the state or the municipalities, and in maritime areas.<br>Ban on gathering by municipalities of garbage on roadsides and in public places in non-closed containers prior to transport and the use of transport means that are open and non-hermetically sealed.<br>Disposal sites must have the approval of the Health Council of the Mohafaza. |
| Law 118 | 30 June 1977 | Description of waste in general, role and functional responsibilities of municipalities, the institutional functions of the municipal council, the financing and cost recovery provisions through direct and indirect taxes.<br>Known as the municipal law which gives the municipalities the power to organise solid waste collection and disposal.<br>*Still in application today outside BML region* |

| | | |
|---|---|---|
| Law 64/88 | August 1988 | Protection of the environment from toxic and dangerous substances by defining dangerous waste and groups of activities concerned.<br>Responsibility of the producer to ensure a proper management of waste and sanctions applied on failure.<br>It is the duty of every person to preserve the safety of the environment from pollution. |
| ***Post-war era (1990 – 2016)*** | | |
| Law 216 | April 1993 | Creation of the Ministry of Environment (MoE). It is responsible for developing a management strategy for solid waste. |
| Law 359 | July 1994 | Ratification of the CC convention by Lebanon |
| Decree 5591 | August 1994 | Organisation of the MoE. *More details* |
| Law 501 | June 1996 | Establishes an agreement to accept a loan from the World Bank to implement a solid waste environmental management project in the country. |
| Decree 5243 | 05/04/2001 | Classification of industrial establishments according to the International Standard Industrial Classification (ISIC) code. Scale from 1 (most dangerous) to 5 (safest).<br>SWM facilities ISIC number: 3720 Class 2. |
| Decree 8018 | June 2002 | Determining the basics and permitting conditions for establishment of industrial institutions.<br>Includes permitting requirements for solid waste disposal. |
| Law 444 | July 2002 | Environmental Act |
| Decree 9093 (amendment to Decree 1917/1979) | November 2002 | Encouragement of municipalities to host waste management facilities and disposal sites within their territories. The municipality shall receive 5 times its allocation from the IMF, and 10 times its allocation if it accepts to treat or dispose of waste from neighbouring areas.<br>*Never implemented* |
| Decision 6/1 | 04/08/2003 | New guidelines for the SWM sector.<br>Private establishments will be responsible for collection, transport, treatment and disposal of SW generated by their institutions. |
| Ministerial Decision 16 | November 2003 | Recommendation of the ministerial committee assigned to study the CDR's proposal for treatment of municipal, industrial, hospital and slaughterhouse waste and rejects from wastewater treatment plants in Lebanon:<br>Collection and transfer of MSW to treatment facilities and landfills should be the responsibility of municipalities and ought to be funded by them. These services can be performed by each municipality solely, by several ones working together, or can be contracted privately.<br>The treatment and landfilling of waste are a central responsibility to be funded by the state budget or through the provision of proper funding. |
| Law 34 | 16/10/2008 | Amendment to Barcelona Convention. |
| Decree 8003 | January 2012 | Integrated Solid Waste Management for Lebanon. Not adopted by Parliament. |
| Circular 8/1 | 16/11/2015 | Guidelines on ISWM addressed to all municipalities, unions, kaemmakams and governors, during the waste crisis. |

| | | |
|---|---|---|
| MoE draft policy | Not legally adopted | Environmental guidelines for the establishment and operation of solid domestic waste sorting plants.<br>Environmental guidelines for the establishment and operation of solid domestic waste composting plants. |
| MoE draft SEA 2015 | Not legally adopted | SEA for the National Solid Waste Management Plan |

***Main national plans***

| | |
|---|---|
| 1994 | Emergency plan for Beirut city |
| 1997 | Emergency plan for Beirut Mount-Lebanon region |
| 2006 | Master plan for SWM, requested by Decision 1/4952, dated 18/08/2005, from CoM |
| 2010 | Plan for W2E, requested by Decision 55, dated 01/09/2010, from CoM |
| 2014 | Plan for waste decentralisation and waste-to-energy |
| 2016 | Emergency plan for Beirut Mount-Lebanon region |

***International conventions***

| | |
|---|---|
| 1973 | London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter |
| 1976 | Barcelona Convention, on the protection of the Mediterranean Sea, ratification in June 1977 (Decree 126) |
| 1980 | Athens Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources |
| 1994 | Basel Convention, on the control of transboundary movements of hazardous waste and their disposal. Adopted 22/12/1994, through law 387. |
| 2001 | Stockholm Convention, on persistent organic pollutants, (entry in force, 17/05/2004) |

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# B. List of persons met

*Name, Position and organisation, Nature of meetings.*

Abi Chaker Ziad, CEO of Cedar Environmental, multiple meetings

Abi Khalil Elsa, Community Developer at Make Sense Lebanon, meeting for composting activities.

Abi Rached Paul, president of Terre Liban and Lebanon Eco Movement, multiple meetings.

Abou Moussa Antoine, CEO and Founder of Compost Baladi, multiple meetings.

Antoun Gergi, member of the Municipal Council of Araya, meeting for consultancy.

Aoun Marc, Co-founder of Compost Baladi, Junior Consultant at Elard, single meeting.

Baghdadi Alexis, SOILS permaculture association, visit at sorting centre in Saïdoun.

Bejjani Pierre G, President of the Municipal Council of Araya, multiple meetings.

Caillat Théo, Institut Francais, meetings related to compost activities

Cartier Stéphane, researcher at IFPO, interview on general situation and political research.

Chakhtoura Antoine, President of the Municipal Council of Dekwaneh, single meeting.

Chamieh Naji, Managing Director at SES – Environmental Engineering & Consulting, single meeting on general situation.

El Haj Fadi (Dr), Chairman at Université Saint-Joseph, CEECDD, discussion on sorting campaign on university campus.

Gédéon Alia, teacher and AFDC member, meetings for composting activities

Gemayel Nicole, President of the Municipal Council of Bickfaya, discussion on decentralisation.

Goraeib Mario, Manager of Environmental Program, Arcenciel, meeting on decentralisation.

Gustafsson Kare, Fortrum Sweden, interview on waste-to-energy.

Haddad Karim, Waste-to-energy engineer at Sicomo – Energeco, discussion on small-scale units.

Hajj Sara & Serge, Landscaper and compost producer and user

Hoayek Angela, Intern at SOILS, working in Syrian refugee camps for waste and composting, discussion.

Kallas Lara, USEK teacher and freelance consultant, single meeting on general situation.

Keszi Franck, consultant at Lebanon Eco Movement, multiple meetings.

Khawand Rita, founder of SOILS permaculture association, field visit sorting centre in Saidoun

Kehdy Jocelyn, Artist and leader of Recycle Lebanon group, multiple encounters

Lévi Alvarès Delphine, Zero Waste Europe, meeting for zero-waste network in Lebanon.

Mc Hugues Alexander, Cofounder of Recycle Beirut, multiple meetings.

Meouchy Antoine, CEO of Liban Consult, single meeting on general situation.

Moussallem Manal, Senior Environmental Advisor at the Ministry of Environment and UNDP, multiple meetings.

Pharaon Michel, Ministry of State for Planning, single meeting on general situation and emergency

Rosa Ferran, Zero Waste Europe, meeting for zero-waste network in Lebanon.

Salamé Ralph, Ministry of Environment, supervision Costa Brava's operations, single meeting.

Saliba Najat (Dr), Chair of the AUB Waste Management Task Force, Director of NCC, presentation.

Samen Nadim & Andrea, founder of Samen Eco Gardens, single meeting for composting activities.

Semrany Antoine (Dr), Lebanese University, Faculty of Sciences, interview on soil quality.

Tabcharani Rana, Head of Environment Department at ALI, single meeting on general situation.

Tannoury Abdo, Engineer Agronomy at Arcenciel NGO, discussion on composting activator.

Zantout Nabil, General Manager of IBC S.A.L, field visit to Saïda's solid waste facility.

# C. Formal Central System – Distribution of new contracts under the March plan

There are 12 new contracts to be signed under the March plan's measures, half for operation and half for supervision. Additional contracts such as the landfill gas recovery project at Naameh landfill. Not all contracts have been attributed, in some cases the tendering process is not over.

| *Operation Contracts* | *Supervision Contracts* |
|---|---|
| ***Final disposal (4)*** | |
| Construction and Operation of Bourj Hammoud and Jdeideh seafills and Rehabilitation of former Bourj Hammoud dump.<br>To: Khoury Contracting Co. (KCC)<br>Duration: 4 years<br>Amount: 110 million USD | *No information** |
| Construction and Operation of Costa Brava seafill.<br>To: Jihad Commerce and Contracting (JCC) jointly with Soriko (Bulgaria)<br>Duration: 4 years<br>Amount: 60 million USD | *No information** |
| ***Treatment (2)*** | |
| Operation of sites formerly operated by Sukleen, including Qarantina, Amrousieh, Coral, Bourj Hammoud Warehouse and Bsalim bulky landfill.<br>To: Jihad Commerce and Contracting (JCC) jointly with Soriko (Bulgaria)<br>Duration: 4 years<br>Amount: 81 million USD | Supervision of Treatment of MSW in BML except Jbeil.<br><br>*Deadline for application: 24/02/2017*<br>*Currently: Laceco (since 1997)* |
| ***Collection & Sweeping (6)*** | |
| Lot 1" – Beirut Municipality alone *??* tons/day<br>*Tendering under preparation by Municipality of Beirut. Independent from CDR. Is expected to include segregated bins.* | *No information** |
| Lot 2 – North BML 1050 tons/day<br>To: Joint Venture Ramco with Turkish partner<br>Duration: 7 years<br>Amount: 86 million USD | *No information** |
| Lot 3" – South BML<br>To: Mouawad – Eddé Contracting, jointly with Soriko (Bulgaria).<br>Duration: 7 years<br>Amount: 129 million USD | *No information** |
| *Additional contracts (2)* | |
| Construction, operation and maintenance of Landfill Gas Recovery at Naameh.<br>To: Sukleen/Sukomi<br>Duration 1 year, ending 31/12/2017<br>Amount: 10 310 318 USD | Supervision of Landfil Gas Recovery at Naameh<br><br>To: Mott-Macdonald<br>Duration: 07/01/2016 to 31/12/2017<br>Amount: 499 630 USD |

**'No information'* means that no information was found on the official website of the CDR.

# D. Mapping of main recycling industries

The large recycling industries, both in BML and the hinterlands, are shown on the map. They buy recyclable materials either directly from municipalities or through intermediaries. Intermediaries are numerous but also difficult to map as they are small companies or individual haulers owning a truck moving from town to town. Digital services (such as LimmApp) might be a way to better understand the way those actors proceed. Future works with Recycle Lebanon NGO may lead to online version of such maps.

It appears that the highest diversity of recycling industries is in the BML region.

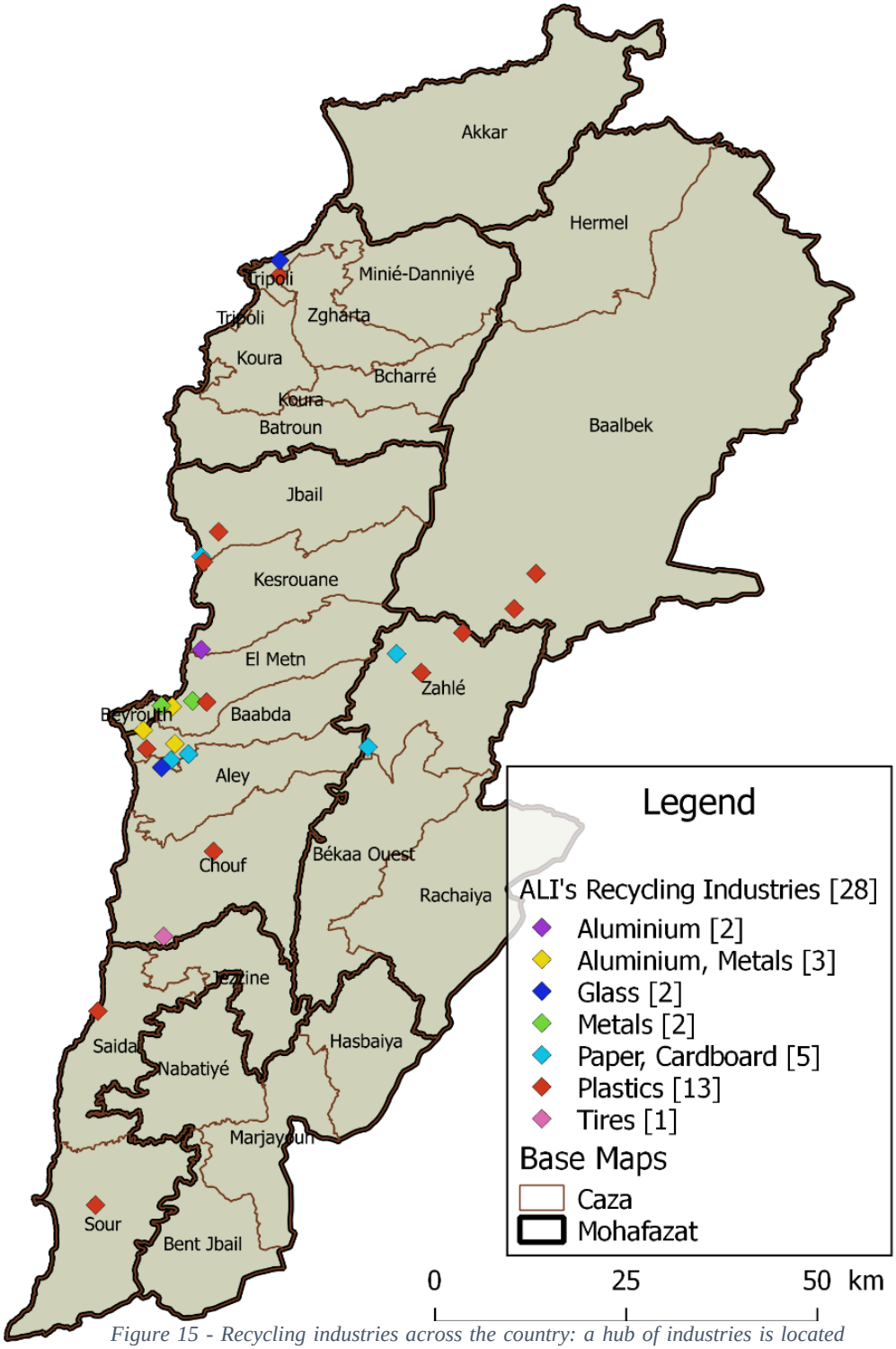


*Figure 15 - Recycling industries across the country: a hub of industries is located around the capital. Data from ALI (2016).*

# E. Benchmarking of FX solutions – Raw data


| Table (i) - General Information | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| **Brih** | Chouf (mountain) | 1 000 | 0,6 to 0,8 ton/day | oct-16 | (35,658; 33,718) |

| Table (ii) - Physical system | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br>3-bag system + occasional and toxic waste pickup<br><br>*Shops/Restaurants:* follow same system. | *Vehicles:*<br>1 municipal pick-up, no compaction. No scale.<br><br>*Frequency*:<br>Every day door-to-door collection of all waste. | Single facility. Land rented. Concrete and roof, without walls.<br>*Recyclables*: secondary sorting, separation by products (cans, batteries, bulbs…). No compaction yet.<br><br>*Compost*: table for bag removal and sorting, shredder available, addition of saw dust for moisture, daily or every other day rotation, 21 days composting, followed by maturation. Temperature monitoring on a daily basis for each pile.<br><br>*Residual*: diapers in 'sanitary hole' adjacent to facility. | *Recyclables*: to intermediary collectors, including plastic bags.<br><br>*Compost*: given or sold locally.<br><br>*Residual & Occasional*: stored on site or occasionally sent to landfill (gate fee)?. |

| Table (iii) - Governance system | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*: around 20 k$, public/private/municipal?<br><br>*Opex*: paid by municipality, eventually monthly fee of 5 000 LL per household.<br><br>*Revenues*: recyclables, and small share of compost to local farmers (just beginning). | *Operator*: by municipality and village youth (CBO).<br><br>*Human Resources*:<br>4 employees and supervision by 1 municipal employee.<br><br>*Consultancy:*<br>Terre Liban NGO | High public participation.<br>Knowledgeable citizens and workers.<br>High satisfaction. | *Min el masdar* campaign.<br><br>Door-to-door awareness by village's youth. | Improve composting process.<br>Continue awareness.<br>Find solution for residual waste. | No EIA performed. |

| Table (i) - General Information | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| **Antoura** | Keserouane | 4 000 | 3 to 4 ton/day | 23-apr-16 | (33,961; 35,637) |

| Table (ii) - Physical system | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br>initially 2-bag system, upgrading to 3-bag system for composting<br><br>*Shops/Restaurants:*<br>follow same system. | *Vehicles:*<br>Municipal trucks, no compaction.<br><br>*Frequency*:<br>Blue bag: 2pw, starting 7am<br>Other bags: every day but Sunday, starting 7am<br><br>*pw: per week* | Two facilities, under greenhouses. Municipal land. Recycling plant operational since april 2016; compost plant under construction.<br><br>*Recyclables*: secondary manual sorting and processing (compactor, baling).<br><br>[currently] Organics: open-air mixing with topsoil and left on ground for decomposition.<br>*[once operational] Compost*: under greenhouse, very likely to be windrow composting, low-tech and labour intensive.<br><br>*Residual*: storage of small quantities according to project member | *Recyclables*: to intermediary collectors.<br><br>*Organics: local burying*.<br>*Compost:* aim to market a high quality product.<br><br>*Residual & Occasional*: stored on site. |

| Table (iii) - Governance system | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*: around 50 kUSD (Mercy Corps, Municipality). Composting centre with crowdfunding.<br><br>*Opex*: paid by municipality.<br><br>*Revenues*: recyclables. | *Operator*: municipality, initiated by village youth through Mercy Corps.<br><br>*Human Resources*:<br>Several workers, municipal employees and team from Mercy Corps.<br><br>*Consultancy:*<br>Mercy Corps, Independent experts. | N/A | Social media and flyers, meetings.<br><br>Door-to-door awareness. | Upgrade of sorting at source (2 to 3 bags)<br><br>Produce compost and market it. | N/A<br><br>No third-party contract for monitoring and surveillance |

| Table (i) - General Information | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| **Beit Mery** | Metn (mountain) | 13 000 to 17 000 | 16 ton/day | sept-16 | (33,869; 35,608) |

| Table (ii) - Physical system | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br>2-colored-bag system (since oct-2016), disposing of in road containers<br><br>*Shops/Restaurants:*<br>follow same system. | *Vehicles:*<br>Trucks without compaction collecting all waste.<br><br>*Frequency*:<br>Every day collection of all waste. | Single facility, 5000m², 20 workers daily. Scale at entrance.<br><br>*Recyclables*: manual separation on conveyor, separation in 7 fractions, including electronic waste, textiles… Compactor available.<br><br>*Compost*: in rotating drum for 3 days, followed by open air maturation phase, including paper and diapers. Continuous temperature monitoring in drum. Screening and bagging after maturation.<br><br>*Residual*: soft plastics and packaging used as 'eco-board' | *Recyclables*: to recycling industries and intermediaries for export<br><br>*Compost*: sold to farmers in Bekaa region and given to sister company in Hermel (organic wheat production). Quality tests: B to A.<br><br>*Residual:* 'eco-boards' used in other projects of the company.<br><br>*Claim to be landfill free!* |


| Table (iii) - Governance system | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*: private (contractor invested 500 000 USD, expected to be recovered after 3 years)<br><br>*Opex*: municipality's budget and monthly fee of 10 000 LL per household (30 000 USD per month). By contract, municipality pays 62 USD/ton sent to facility.<br><br>*Revenues*: recyclables and compost sold | *Operator*: Contract between municipality and private operator (Cedar Environmental)<br><br>*Human Resources*:<br>20 workers + 1 manager + 1 municipal employee for supervision of weighting | According to visits and newspaper articles: public not yet very much involved in sorting. | Flyers and social media. | *First month*: one bag system<br>*Second month*: two bag system<br>*Further plans?*<br>Increase sorting awareness.<br>Increase in fee over time to recover investment. | No EIA performed (at first).<br><br>No third-party contract for monitoring and surveillance. |

| Table (i) - General Information | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| **Bickfaya** | Metn | ~20 000 | 15 to 20 ton/day | apr-16 | (33,925; 35,693) |

| Table (ii) - Physical system | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br>3-bag system<br><br>*Shops/Restaurants:*<br>follow same system. | *Vehicles:*<br>Trucks collecting waste with calendar.<br><br>*Frequency*:<br>Recyclables: wed = 1pw<br>Organic: mon, fri = 2pw<br>Residual: mon, fri = 2pw<br><br>*(pw: per week)* | Single facility, *closed metal hangar* for storage and secondary sorting and processing.<br><br>*Recyclables*: secondary manual sorting and processing (compactor, baling).<br><br>*Organics*: sorted for animal feeding, partly.<br><br>*Residual*: no specific treatment. | *Recyclables*: to intermediary collectors.<br><br>*Organics*: local pig farm.<br><br>*Residual*: sent to other landfill under contract with gate fee (Hbaline, Jbeil). |

| Table (iii) - Governance system | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*: private source and municipal budget<br><br>*Opex*: paid by municipality<br><br>*Revenues*: recyclables. | *Operator*: municipality, under the name of BiClean.<br><br>*Human Resources*:<br>Several workers.<br><br>*Consultancy:*<br>Various NGOs. | N/A | Flyers, social media and website.<br><br>*Door-to-door campaigns.* | Find solution for residual waste based on waste-to-energy plant for industrial zone.<br><br>No plans of composting or biogas. | No EIA performed (at first).<br><br>No third-party contract for monitoring and surveillance. |

| Table (i) - General Information | | | | | |
|---|---|---|---|---|---|
| Municipality | Caza | Population | Generation | Project started | Coordinates |
| **Mokhtara's Union** (12 villages, 10 km radius) | Chouf | 10 000 to 15 000 | 12 – 16 (up to 20) ton/day | end-15 | (33,638; 35,621) |

| Table (ii) - Physical system | | | |
|---|---|---|---|
| Sources | Collection | Treatment | Sinks |
| *Households:*<br>Not sorting at source, at first.<br><br>Since, December 2016, sorting in 2-bag system in 7 out of 12 villages. | *Vehicles:*<br>Municipal trucks, no compaction. No scale.<br><br>*Frequency*:<br>Every day door-to-door collection of all waste. | Two facilities, 5000m² area. Closed metallic hangars, connected by a conveyor initially to transfer organics after mechanical sorting.<br><br>*Recyclables*: manual debagging, secondary manual sorting, separation of valuable product and processing (compactor).<br><br>*Compost*: hangar used for storage of all commingled residual waste.<br><br>*Residual*: no treatment. | *Recyclables*: to intermediary collectors.<br><br>*Compost*: no production.<br><br>*Residual*: stored on site in hangar, probably occasional dumped. |

| Table (iii) - Governance system | | | | | |
|---|---|---|---|---|---|
| Financing | Organisation | Inclusivity | Awareness | Plans | Law |
| *Capex*: higher than 500 000 USD, various donors (Mercy Corps, UKaid, INTAJ, LHEE, Chouf Reserve), Union's budget and private donation (political leaders, 2x75 kUSD). (land acquisition <250 kUSD, composting hangar for 260 kUSD).<br><br>Opex: Union's budget + eventually direct fee to inhabitants (expected around 10 kLL per hh per month) + whole operation estimated around 220 kUSD/year, ie 40 USD/ton (18% of previous budget allocated to Sukleen's service).<br><br>*Revenues*: sales of recyclables. | *Operator*: Union.<br>Collection subcontracted to independent drivers, but trucks owned by Union.<br><br>*Human Resources*:<br>10 employees and 2 supervisors<br><br>*Consultancy:*<br>Many actors: NGOs, Donors, Private Consulting Company. | Little public participation. | Though information campaign about sorting at source is being implemented, there is no clear framework. | Many plans led by Union's President:<br>Upgrade of road leading to facility.<br>Implementation of sorting at source.<br>Start composting.<br>Acquisition of more equipment (already a lot is not used).<br>Search for more financing. | Draft EIA performed. But construction not as planned in the EIA. |

# F. An example of public money diversion in the waste sector

The example below was prepared at the margin of the thesis work. It is based on two consistent sources of information and illustrates three corruption drivers which apply to waste management in Lebanon.

Under the new treatment contract, the new waste operators *are assumed to be* paid 154,5 USD/ton of MSW handled. The breakdown of costs, from the same sources, is as follow:

| **DETAILED COSTS OF OPERATIONS** | |
|---|---|
| *in USD per ton of MSW* | |
| Collection and Transport | **$ 27,50** |
| Sorting and Composting | ***$ 39,00*** |
| Landfilling operations | **$ 88,00** |
| Total | **$ 154,50** |

However, from the amounts of waste landfilled which have been reported for the last few months, and from investigations at the sorting and composting plants, it is a fact that: (i) sorting is not performed though plants are operational, (ii) composting is not performed and the upgrading works at the plant have not started, (iii) waste is simply wrapped before transfer to the landfills (a cost which is assumed to be included in the landfilling operations).

So, as long as sorting and composting is not performed, one can say that 39 $/ton of MSW are paid for non-performed operations. Assuming that 2500 tons are handled daily, it equals to an overpayment of nearly 100 000 $/day and about 35 million $/year.

However, (i) ***payment of non-performed operations*** is only one element of corruption. The other ones are (ii) ***overpricing of operations*** and (iii) ***speculation on reclaimed land***.

Indeed, financial analysis of the bids, prepared by international consultants for the Ministry of Environment, have suggested that *some* operations were slightly overpriced compared to international standards.

Finally, hindering sorting and composting operations is of high interest for those benefiting from corruption since it has the direct impact of reducing the lifetime of the coastal landfills. The land reclaimed on the sea with waste is made available for further commercial projects sooner than expected and new landfills, marine works and contracts will be necessary.

# G. List of deliverables

- RDF: a potential sink for residual waste? [Presentation]
- Compost: a potential sink for organic waste? [Synthesis]
- Facts about the Swedish waste-to-energy industry [Presentation]
- Executive Summary of the thesis [Report]

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