ENABLING ENVIRONMENT
FOR INNOVATION IN CLEANTECH

SOLID WASTE

RESEARCH REPORT

AMERICAN UNIVERSITY OF BEIRUT
ISSAM FARES INSTITUTE FOR PUBLIC POLICY & INTERNATIONAL AFFAIRS
معهد عصام فارس للسياسات العامة والشؤون الدولية

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Introduction

Despite their undeniable contribution to the progress of society, technologies have long been associated with negative environmental impacts, extensive exploitation of natural resources, inefficient uses of energy, etc.

"Greentech could be the largest economic opportunity of the 21st century."

A growing number of innovative businesses identifies viable opportunities for adopting sustainable practices, based on Cleantech solutions. This new forefront in corporate social responsibility is a circular business model, which, unlike the linear business model, focuses on strategies in recycling and product life-extension.

Global clean technology activity is expected to exceed $2.5 trillion by 2022 (Smart Prosperity Institute, 2018), and to contribute to a worldwide transition in the circular economy through:

- competitive performance at lower costs
- encouraging the productive and responsible use of natural resources
- reducing or eliminating negative ecological impacts
- promoting innovation
- creating an environment that favors job creation
- fostering an environment for entrepreneurs to take advantage of the sector's growth

These technologies are developed by a broad array of firms, and their adoption spans across many sectors of the economy including:

Figure 1: Main Cleantech Sectors

The backbone of clean technologies is the small- and medium-sized enterprises (SME). The latter are important engines of innovation, growth, job creation, and social cohesion in high-income/emerging economies as well as in low-income developing countries. Indeed, SMEs undertake the majority of private economic activity and account for a significant percentage of employment and GDP.

Solid Waste

In the local context, Lebanon is subject to serious environmental pressures due to climate change, population growth, and urbanization, which require more optimal resource management plans and water and waste management systems. Based on a World Bank study (UNDP, 2020), the annual cost of environmental degradation is of the order of 4.4 percent of GDP of which the solid waste management sector contributes by a factor of 0.4 percent to GDP, i.e.,10 percent of the overall cost of environmental degradation **Figure 2**.

Figure 2: Cost of Environmental Damage (UNDP, 2020)

Accordingly, SMEs provide a great opportunity for innovations in the Cleantech sector in Lebanon, preserving its natural resources and resolving its environmental problems.

The ACT SMART (Agri-food and Cleantech) Innovation Hub represents a new out-of-the-box approach for strengthening business advancement and job creation in the Agri-food and Cleantech sectors in Lebanon. It applies a sector-wide approach for economic growth by stimulating innovators and entrepreneurs to put their creativity and energy at the service of these two sectors and encouraging them to develop local solutions to environmental and food security challenges faced by the Lebanese and refugee communities.

As part of ACT SMART, the Issam Fares Institute for Public Policy and International Affairs at the American University of Beirut has established working groups on water, waste, and energy based on a mapping of stakeholders. The working groups aim to discuss industry needs and priorities for improving entrepreneurship and business landscape in their respective sectors. The output from the working groups will contribute to three Cleantech white papers on innovation and entrepreneurship integration in creating a conducive business environment in water, energy, and waste, and a white paper on integrating the Water, Food, and Energy nexus in Lebanon's current business landscape.

This paper provides a comprehensive overview and assessment of clean technologies and innovation in the solid waste management sector in Lebanon (quantities, types, institutional framework, challenges, needs, etc.).

Overview of the Waste Management Sector

Since the end of the civil war, solid waste management (SWM) was one of the major challenges facing successive Lebanese governments. At the national level, several attempts had been planned and implemented to integrate SWM schemes. To date, none could be implemented; they were always hindered by the government's failure to impose new sanitary landfill sites. The **not in my backyard** (NIMBY) syndrome coupled with the administrative, religious, and ethnic composition of the country had always been the main obstacles to overcome (Yacoubian, 2018; Holtmeier, 2019).

Additional obstructions comprise: land scarcity, especially along the coastal line where the population density is significantly high and where the bulk of the waste quantities is produced; the country's topographic nature, which makes it hard and expensive to transport the waste generated along the coastal line, all the way to the mountains where more space could be made available; the nation's dependence on abundant underground water resources, the quality of which should not be compromised; and the major fault lines and the tectonic activity in the area, which poses a great risk of pollution from landfills, in the case of seismic activity, etc. Indeed, a study conducted in 2001 uses GIS to identify sites that meet the USEPA landfill selection criteria, which confirms the scarcity of such sites (El-Fadel, 2001).

As a result, implemented solutions were always temporary and contingent in nature, forced in response to emergency situations. The city of Beirut and its suburbs, where almost 50 percent of the country's waste is generated, have and still take the lion's share of all government emergency plans (Yacoubian, 2018; Holtmeier, 2019; European Union & OMSAR, 2017; SWEEPNET, 2014; Abbas et al., 2017; Farah et al., 2019).

Figure 3 below summarizes the evolution of waste management practices in Lebanon.

Figure 3: Evolution of Waste Management Practices in Lebanon

This section of the paper overviews the waste management sector in Lebanon while highlighting the volumes and types of waste generated, current adopted practices, and the current regulatory framework.

Waste Quantities and Types

Lebanon generates different types of solid waste. The database availability in relation to the quantities and types of waste varies depending on the geography and type of waste.

As far as the municipal solid waste is concerned, a detailed database is found for instances of the city of Beirut and the bulk of Mount Lebanon. The same cannot be said about other areas. The database associated with the healthcare sector is somehow associated with some degree of certainty. Industrial waste-related data, on the other hand, is less accurate in nature.

According to the Ministry of Environment, the amount of waste currently generated from the various country governorates is outlined in **Figure 4**.

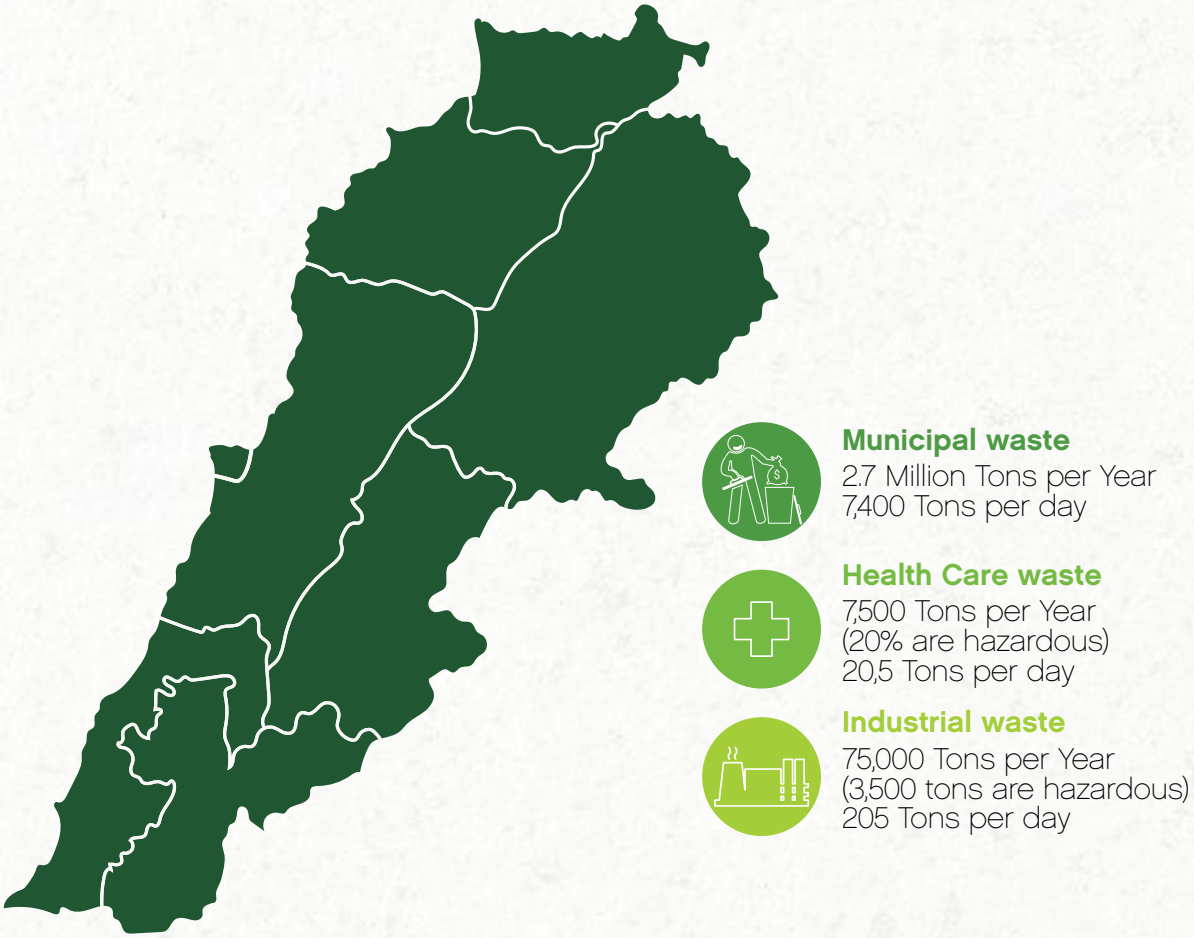

Figure 4: Waste Generated Quantities in Lebanon (European Union & OMSAR, 2017; Human Rights Watch, 2018a)

Obviously, the bulk of the waste quantities generated is municipal in nature, mostly composed of organic materials and a mix of recyclables (plastic, glass, metals, etc.) and other inert and non-biodegradable waste components. The most recent study characterizing the municipal solid waste composition was by the CDR as part of a feasibility study for integrating waste to energy in the existing waste management scheme **Figure 5**. In this context, it is worth mentioning that these percentages reflect the analysis performed by the waste composition reaching the sorting facilities. This means the recyclables amounts in the original waste stream are higher, which is due to the informal recycling activities occurring before the waste stream collects.

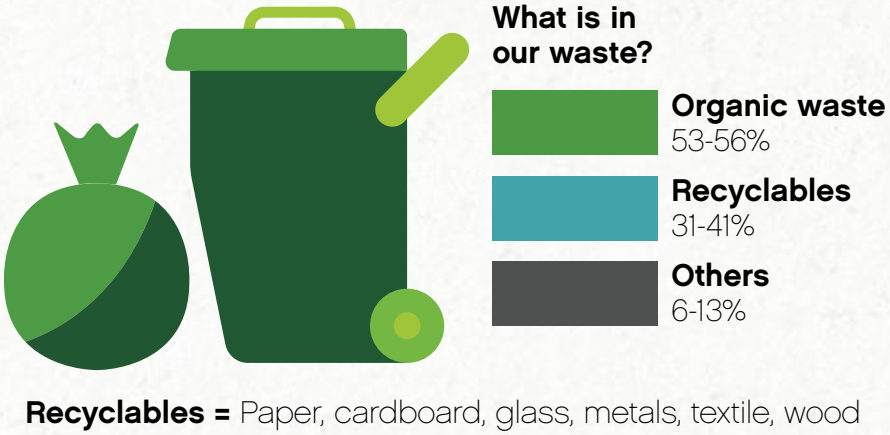

Figure 5: Municipal Waste Composition in Lebanon (European Union & OMSAR, 2017; Human Rights Watch, 2018a)

Current Practices

Waste management practices refer to the set of activities that take place from the moment of generation until disposal. This means the full lifecycle, which covers:

- waste handling at the source of generation
- waste collection
- waste treatment
- final disposal

All source separation activities take place at the source. Otherwise, the recyclables become contaminated thus compromising the efficiency of any recycling recovery attempts during waste treatment. For example, paper contaminated with organic waste loses its potentials as a valuable recycled material. The plastic bags cleaning process is such an expensive process, thus compromising the whole financial feasibility of the recycling process. The same applies to organic waste. Once organic waste is contaminated with diapers, batteries, cleaning products, etc. there is no way one can achieve high-grade compost product for agricultural activities. Therefore, source separation causes bottlenecks for an efficient waste management system.

Solid Waste

Many waste sorting and compositing facilities are distributed over the Lebanese territory. The scale of these facilities varies with large-scale plants, mostly centralized in Beirut and Mount Lebanon, with smaller-scale facilities in the rest of the country.

According to data published by the Ministry of Environment (European Union & OMSAR, 2017; Human Rights Watch, 2018a), currently, waste is handled as follows:

- fifty percent in uncontrolled dumpsites (about 940 dumpsites across Lebanon)
- thirty-five percent in sanitary landfills (Bourj Hammoud, Costa Brava, and Zahle)
- fifteen percent is sorted in material recovery facilities where recyclable and reusable materials are recovered (paper and cardboard, plastic, metal, glass, etc.), or converted into organic soil enhancer/fertilizers in approximately 80 facilities across the Lebanese territories

Despite its importance in reducing landfilling, energy recovery is not practically carried out in existing facilities, with the exception of two or three facilities.

In addition to MSW, Lebanon produces a significant amount of hazardous solid waste each year, including hazardous industrial chemical waste, electronic waste, expired solid drugs and materials, healthcare waste (hazardous non-infectious waste, waste requiring special management, hazardous infectious waste, etc.), used oil, used tires, used batteries, persistent organic pollutants from the energy sector or other sectors, and various types of sludge, etc. (European Union & OMSAR, 2017; Human Rights Watch, 2018a).

Furthermore, there are other wastes, such as solid waste from the olive oil industry, slaughterhouse waste, construction and demolition waste, bulky refuse/waste, etc.

Environmentally sound treatment of hazardous solid waste and other waste is also non-existent, as most are disposed haphazardly, with the exception of a portion of healthcare hazardous infectious waste that is treated in accordance with Decree provisions 13389/2004, and some exported types of hazardous waste, in accordance with the provisions of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Law 389/1994).

Current Technologies

Many technologies are adopted in Lebanon for the management and/or the treatment of municipal solid waste. Most of them are based on a combination of manual, mechanical, and biological processes. A brief description of the major ones is outlined below **Table 1**.

Table 1: Major Waste Management Technologies in Lebanon (European Union & OMSAR, 2017; SWEEPNET, 2014; Abbas et al., 2017; Human Rights Watch, 2018a)

No	Categorization	Technology /Equipment	Usage	Existing drawbacks
1.	Mechanical sorting for the segregation of waste ingredients and the recovery of some recyclables	Bag opener	Opening the bags of collected municipal solid waste.	✔ Not very efficient, especially that, due to poor planning, most facilities are forced to operate at a higher capacity than planned or designed. ✔ Continuously damaged by bulky items because of waste non-segregation at source. ✔ Physically damaged by the sharp items detected in the waste stream. ✔ Efficiency affected by the significant quantity of plastic bags present in the waste stream.
		Trommel	Separating the organic material from the remaining waste stream.	
		Magnetic separator	Separating the ferrous metals from the waste stream.	
		Eddy current separator	Separating the non ferrous metals from the waste stream.	
		Ballistic separator	Separating 3D materials (Al, Ferrous, PET, mixed bottles, and other plastics, such as PE / PP) and the light 2D materials (such as plastic films and paper).	✔ More efficient for the source separated waste stream. ✔ Efficiency hindered by significantly high quantities of plastic bags.
2.	Manual recovery of recyclables	Moving conveyors	Conveyors belts where recyclables are recovered manually.	✔ Conveyors are damaged very frequently because of the sharp items within the waste stream.
3.	Biological	Windrow composting Tunnel composting	Aerobic decomposition of the organic waste fraction to produce compost.	✔ Organic materials are contaminated because of the non-segregation of the waste stream at source and, as a result, the produced materials contain more stabilized organics than compost.
		Anaerobic digestion	Anaerobic decomposition of the organic fraction to produce energy as a byproduct.	✔ Published information is limited to highlighting the drawbacks in the system.

Most of the available technologies do not achieve the efficiency rates anticipated from them, as a direct implication of the absence of a source separation scheme, as highlighted in **Table 1**. The latter affects the whole process, most importantly:

- The recovery of the good quality recyclables, which most of the time is highly contaminated by the time it reaches the sorting facilities. This mainly applies to waste components, such as plastic bags, papers, and cardboard.
- The production of grades A and B compost is by no means feasible when attempting to compost organic materials that are recovered from commingled solid waste. In Europe, the resulting product from such a process is called stabilized bio-waste instead of compost.

As a result of the above, the bulk of the waste stream is diverted to landfills, compromising the overall system efficiency.

Legal Framework

The existing legislation related to solid waste management consists of fragmented regulations not specifically dealing with solid waste (SWEEPNET, 2014) and could be described as follows:

- Is outdated and lacks short-term as well as long-term vision. In this respect, the legislation does not set any target limits for waste generation, treatment, and disposal levels.
- Does not differentiate between the various waste categories and/or hazard levels associated with each (with the exception of medical waste, where the decree differentiates between the various types of generated waste within a health care facility).
- Does not cover all components of an integrated waste management system, and is mainly limited to banning open-dumping and specifying storage conditions.
- Misses environmental considerations in the planning process, which results in non-sustainable decisions related to waste management.
- Lacks a law framework that specifies standards, responsibilities, environmental requirements, and the conditions for an integrated waste management network, financing and cost recovery, financial incentives, minimum specifications for waste management technologies, permitting requirements, etc. The Ministry of Environment (MoE) has issued some guidance booklets but they are not legally enforced.
- Does not assign a specific responsible authority for supervising waste management facilities thus creates confusion among the concerned authorities.
- Does not specify the monitoring mechanisms to ensure minimum environmental compliance..

The MoE drafted a solid waste management law, which brings together all locally involved stakeholders into one independent Solid Waste Management Board responsible for planning and decision-making at the national level. According to the proposed law, the municipalities and the municipality unions will be responsible for the collection of the waste generated within their territories. The proposed board will be responsible for waste management (treatment, landfilling, etc.) and headed by the MoE, including members from relevant public authorities as well as the private sector (academics and consultants) and NGOs. The Council of Ministers endorsed the draft law on January 4, 2012. It took until October 2018 for parliament to approve the law (Human Rights Watch. 2018b).

On the basis of that law, the MoE was supposed to prepare a National Waste Management strategy. A brief overview of both the law and the strategy is presented below.

Solid Waste

Law 80. The MoE prepared and drafted the Integrated Solid Waste Management law in 2005, which was submitted to the Council of Ministers in October 2012 and approved in January 2012. Currently, the law awaits approval and ratification by parliament. The law is structured in chapters and divided into clauses, then further divided into articles. The figure below summarizes the contents of the draft law.

The draft law aims to regulate the solid waste management in Lebanon, hazardous and non-hazardous. It calls for:

- reducing wastes quantities in general, and, specifically, those to be disposed of
- promoting source separation as well as recycling at specially dedicated treatment facilities
- promoting waste minimization, energy recovery, and effective waste treatment facilities
- setting up a general policy for cost-recovery
- specifying the institutional framework for SWM (Human Rights Watch. 2018b)

The law in itself is not sufficient for the implementation of an integrated SWM system, which necessitates drafting and issuing the necessary applicable decrees, strategies, and plans while ensuring system sustainability, in terms of cost-recovery mechanisms, well-defined institutional frameworks, and consensus, both at the national and local levels, on an agreed-upon strategy.

Figure 6 summarizes the key aspects of Law 80.

BRIEF OF LAW 80 (10/10/2018)

CHAPTER 1
General provisions and principles for ISWM

This chapter introduces the solid waste sector related terminology and defines the concepts and principles on the basis of which the LAW is structured.

CHAPTER 2
Institutional Framework for ISWM

This chapter proposes an institutional framework whereby planning, implementation, Monitoring, and data management responsibilities are defined.

CHAPTER 3
Non-hazardous solid waste management

This Chapter describes the main components of an integrated solid waste management system for non-hazardous solid waste.

CHAPTER 4
Hazardous Solid Waste Management

This chapter describes the main component of an integrated solid waste management system for hazardous solid wastes.

CHAPTER 5
Financing, fees and incentives

This Chapter proposes financing mechanisms, fees and incentives for waste management practices.

CHAPTER 6
Responsibilities / Violations Control / Penalties

This chapter defines the general responsibilities starting from the individual citizen to the level of the governmental authorities who should be involved. It describes general tools for controlling violations as well as penalties to be imposed.

END

CHAPTER 7
Concluding Provisions

This chapter:

- Cancels all legal texts that are in contradiction with this law
- Indicates that the Law is applicable once published in the offical gazette

Figure 6: Summary of Law 80 (Human Rights Watch. 2018b)

Solid Waste

MoE Solid Waste National Policy. On the basis of Law 80 in 2018, the Ministry of Environment prepared a national waste management policy that defines a road map for governing the waste management sector for the coming ten years. The strategy was subject to public consultation sessions involving stakeholders from the public and private sectors as well as local communities. The strategy was approved by August 2019 (Human Rights Watch. 2018a).

After witnessing the 2015 waste management crisis in Lebanon, environmental awareness increased and most experts in the field consider that the time is ripe to implement a sustainable, long-term plan whereby public and private actors work in tandem to properly manage the country's waste.

The Ministry of Environment proposed a roadmap and strategy that seems like a solid step in the right direction. However, concerns were raised about its feasibility in terms of achieving the very optimistic objectives set.

The major concerns are highlighted below:

- Lack of a funding and financial recovery mechanism in support of planned decentralization. The law and strategy, in general, encourage the decentralization of waste management practices, and places these on the shoulder of local municipalities without providing a clear financial recovery mechanism to reduce the debt incurred by the sector. This is expected to compromise the efficient plan implementation.
- Very optimistic and ambitious targets in terms of setting percentages for recyclable recovery rates and landfill divergence. The targets set may not be attainable without incineration. Therefore, the policy indirectly endorses WtE as a key component of any plan.
- The number of sanitary landfills will be hard to achieve given all the social, political, and technical constraints associated with siting sanitary landfills in Lebanon.
- The policy does not encourage or foster innovation in the SWM sector.
- The policy does integrate any incentive strategy.
- The policy requires a lot of supporting laws, legislations, and circulars before it can be implemented. Knowing the case of Lebanon, it is anticipated that the feasibility of the policy might be questioned by the time such laws are endorsed.
- The policy does not take into consideration the economy of scale in the definition of the limited, accepted capacity for each type of technology.
- The policy allows having small-scale incinerators, which is quite risky for Lebanon's size and scale.

Accordingly, any tangible progress is a long way off, even allowing for the minimum time needed to start implementing the new policy, measures which, at the time of writing, had not been agreed on in full.

Solid Waste Business Landscape

Like other Cleantech[1] sectors, the solid waste management sector in Lebanon is mostly governed by SMEs involved in various operational activities associated with the management of solid waste.

This part of the paper provides a snapshot of small- and medium-sized enterprises (SME) operating in the solid waste management Cleantech sector in Lebanon. It highlights the major characteristics of these SMEs in terms of types of business, size of operations, financial capacities, reported and innovation types in the field, etc.

The results presented below are based on information provided through surveys and informal consultations with a number of SMEs, including two workshops held in August and December 2020 with a number of stakeholders representing public, semi-public, private, and active organizations in the waste management field in Lebanon.

The existing innovation capacity is explored, based on the outcome of the survey and workshop, the authors' experience in the field, and previously published data and studies.

General SME Business Landscape

The constraints challenging all SMEs within the Lebanese business ecosystem, limiting their growth, could be classified under three main levels: enterprise, sector or industry, and national (Berytech, 2020).

At the **enterprise** level, local SMEs face different types of challenges hindering their technical and financial capabilities. Indeed, the technical capabilities and growth of SMEs are limited by:

- the high rate of emigration and resulting poor talent retention
- the lack of technical specialists and highly skilled workforce
- the shortage of vocational programs and technical specializations

From a financial point of view and until just before the beginning of the current economic crisis, SMEs benefited from debt financing instruments through government subsidized loans, microfinancing, and loan guarantees. This limited the Lebanese business owners' appetite for outside investors, which could have played an active role in supporting their growth.

1 Cleantech encompasses any process, technology, product, or service that reduces the negative environmental impacts through efficient energy usage, sustainable exploitation of resources, or environmental protection activities.

At the **industry** level, SMEs are facing a series of challenges related to market structure, unfairness between large-scale companies and SMEs, lack of reliable and recent market information and statistics in support of business intelligence, bureaucratic inefficiencies, costly regulatory and setup processes, restrictive taxation policies, etc. All these place SMEs at a disadvantage compared to larger, more established competitors.

Additional constraints hindering the growth of the SME business landscape relate to existing infrastructure and governing legal frameworks at the **national** level. These are briefly outlined below:

- The existing poor infrastructure (road quality, costly communications, electricity supply challenges, etc.) increases transaction costs to SMEs and their ability to operate across the Lebanese territory.
- The current labor law restricts foreign workers to types of jobs and industries in which they can seek employment. As a result, there are no special provisions for highly skilled professionals, with limited encouragement for knowledge transfer.

SME Mapping

A total of 700 SMEs were contacted. A questionnaire was addressed to each of these enterprises to establish baseline data about their structure, business type and size of operations, in terms of establishment year, type of business, annual turnover, number of employees, innovation, etc. The questionnaire **Table 2** summarizes its basic structure.

Table 2: Survey Structure

SURVEY STRUCTURE

BASIC INFORMATION

- Name of SME
- Address
- Caza/District
- Year of establishment
- Service market geography
- Contact details
- Name & position of the entity filling the questionnaire
- Number of employees
- Annual Turnover

SERVICE LINE

- Type of activity the stakeholder is involved in
- Business line sector
- Type of Business (Consultant, contractor, operator, designer, etc.)

INNOVATION CHALLENGES

- Limited financial resources for R&D
- Lack of human resources
- Lack of technical knowledge
- Resistance to change
- Lack of knowledge of legal/adminstrative
- regulations and processes
- process effectively and efficiently
- Bureaucratic hurdles (long adminstrative procedures,
- restrictive laws and regulations)
- Conceptualization of innovative products
- Lack of supportive institutions
- Weak/absence of supportive policy framework
- Market outlet

INNOVATION OPPORTUNITIES

- Ability to adapt quickly to new products, platforms and markets
- Ability to adapt to innovation in technologies, products, processes
- or service provision
- R&D collaboration and joint ventures
- Speed and flexibility in decision-making
- Access to private funding
- High value of personal networks
- Flexibility and adaptability in development of strategies

Of the total 700 SMEs contacted, 160 SMEs responded to this study, 33 percent of which are active in the solid waste management sector, which provides a snapshot of Lebanese SMEs operating in the field: understanding their capacity for innovation, the challenges hindering this capacity and the foreseen opportunities.

Stakeholder Working Groups

Around 22 SMEs were contacted to participate in the first workshop for the purpose of characterizing the business environment governing their operations and contribution to innovation. In the selection process, the team exerted a special effort to ensure that the pool of SMEs is sufficiently diverse and all types and sizes of business are represented. The same SMEs were invited to attend the second working group as well.

A brief analysis of the SMEs attending the two workshops is summarized below to show their diversity thus rendering the workshops a representative sample of waste management SMEs in Lebanon.

Type of Business and Size. All types of businesses **Figure 7** were represented in the sample invited to the first workshop. The SMEs number of employees varied in size.

The bulk of Cleantech solid waste SMEs were well-established businesses with most in operation for more than 15 years. SMEs were much more likely to be small-sized, with 40 percent having less than ten employees and 23 percent having between 50 and 100 employees, compared to only 13 percent having more than 100 employees.

Indeed, this relates to the situation at the national level whereby micro enterprises with less than ten employees constitute the largest proportion of SMEs in Lebanon (73%) (Ministry of Economy & Trade, 2020).

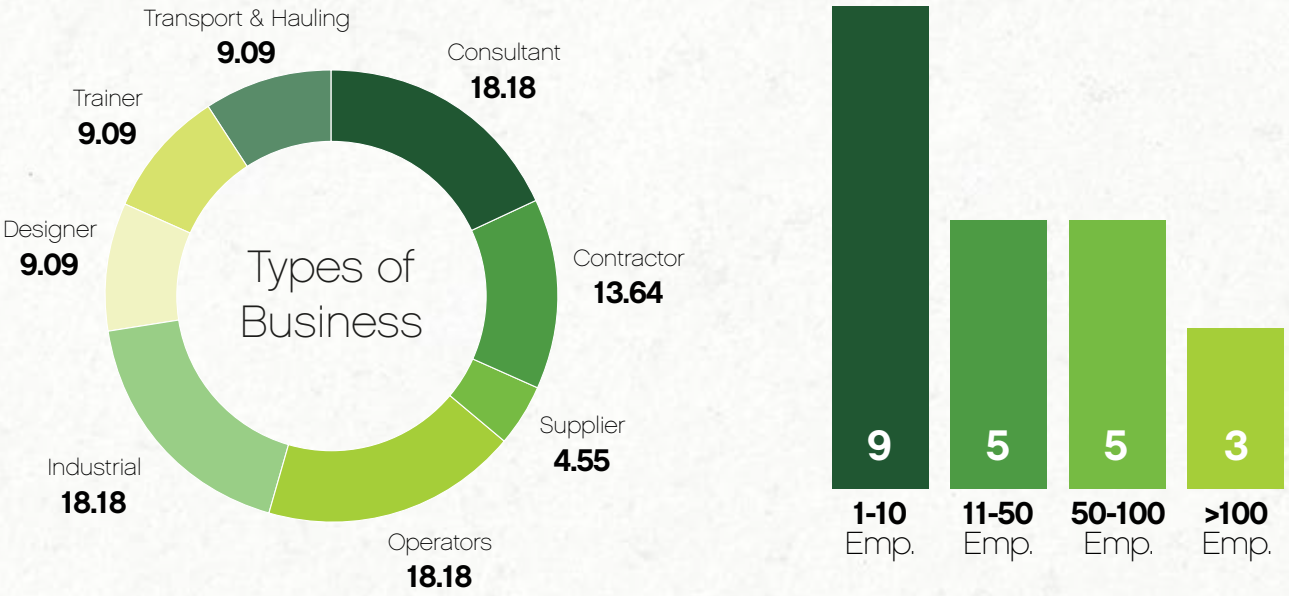

Figure 7: Characteristics of the SMEs Attending the Workshop

Solid Waste

SME Age. Almost 50 percent **Figure 8** of the Cleantech solid waste SMEs had been in operation for less than 15 years, and 14 percent more than 50 years.

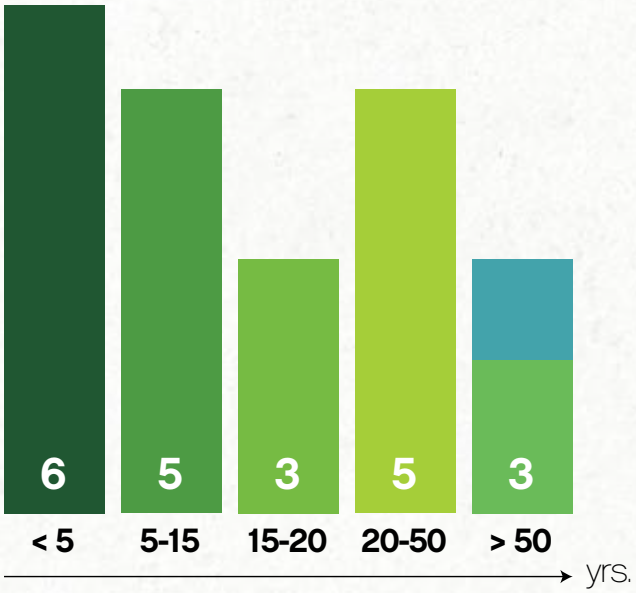

Figure 8: SMEs Ages

Annual Turnover. Illustrated is the company annual turnover distribution **Figure 9**.

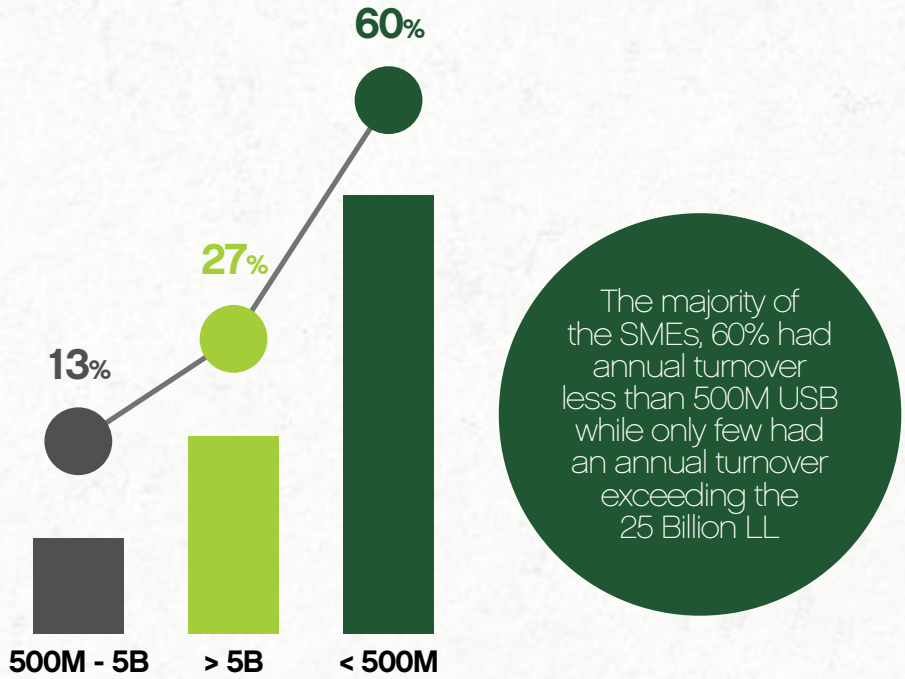

Figure 9: Annual Turnover of SMEs

SWOT Analysis of the Current System

As mentioned earlier, during both workshops, challenges were identified, strengths were recognized, threats and risks were pinpointed. **Figure 10**.

SWOT Analysis

Strengths

- Waste Quantity & composition
- Active private sector & existing SMEs
- Increased Environmental awareness after 2015 crisis
- Existing infrastructure facilities
- Successful initiatives
- Existing Decree that encourage green initiatives

Weaknesses

- Lack of planning & clear waste management strategy
- Inadequate legislative & regulatory framework
- No enforcement of laws/ decisions
- Absence of a cost recovery mechanism
- Lack of a source separation scheme & policy which is:
  - Affecting recycling of innovative technologies
  - Affecting recycling recovery rates
  - Leading to the failure of such initiatives as RDF
  - Challenging operations & higher O&M costs
- Lack of financial resources
- No cleantech incentives
- Lack of economy of scale
- Politically driven solutions & decisions
- Existing model is not sustainable

Opportunities

- Increased Employment rates
- Recycling of special waste streams like tires and electronics
- Use of RDF as an alternative to incineration
- Energy recovery from specific types of waste (Biomass fuels, landfill biogas, pyrolysis from tires or words, etc.)
- Public private partnership (private sectors/ municipalities)
- Optimize composting efficiency
- Investing in glass recycling
- Build up on existing initiatives by encouraging the use of smart tech (ECO ATM, plastic bottles stations, elc.)

Threat

- NIMBY Syndrome
- Invisibility of how the current economic conditions would evolve which, at the moment, is freezing any attempts for new projects in Lebanon

Figure 10: SWOT Analysis of Current Waste Management Sector

Challenges Prioritization

As shown in the SWOT analysis, the bulk of the challenges focus on the lack of a well-defined policy for the management of waste, which leads to the failure of internationally proven technologies, the deficiency in financial means and resources deployed in the sector, the absence of a cost-recovery mechanism, the non-sustainable approach in dealing with the sector, etc.

Challenges were prioritized on the basis of:

- Their importance to improve the enabling environment for innovation.
- The urgency of action.
- The impact on SME businesses.
- The potential in creating a ripple effect on the overall business landscape.
- The outcome is summarized below **Table 3**:

Table 3: Challenges Prioritization by Working Groups' Attendees

No	Challenge	Prioritization results						
		1st	2nd	3rd	4th	5th	6th	7th
1	Lack of financial resources	✓		✓				
2	Scarcity of technical capabilities and facilities for research and development				✓			✓
3	Absence of stringent standards and lack of policies stimulating and encouraging innovation and Cleantech incentives		✓	✓				
4	Lengthy bureaucratic procedures for approvals of new technologies				✓			
5	Lack of networking				✓			
6	Absence of a clear and sustainable waste management strategy (source separation, resources recovery, etc.)					✓		
7	Failure of state-of-the-art technologies in existing waste management facilities				✓		✓	✓

Additional identified challenges include:

- A lack of community engagement in implementing in-house solid waste management practices.
- Payment process for SWM services in the GBA and mount Lebanon service zones.
- Lack of trust in the public sector.
- Slow decision-making.
- Lack of collaboration between SMEs that can indeed create value for each other.

During the working groups, it was very hard to focus the discussion on the innovation perspective or aspect of the sector. The challenges and problems of the sector as a whole were always the focus of the SMEs and non-SMEs. This is quite normal given the dramatic conditions governing the performance of all attempts for managing the sector in a sustainable and integrated manner.

Innovation in the Solid Waste Management Sector

Innovative Capacity in Lebanon's Waste Cleantech Economy

Cleantech researchers, entrepreneurs, investors, corporate executives, and policymakers across the world drive economic growth, stimulating the creation of new jobs and businesses and protecting the environment by developing new and innovative clean technologies (Berytech, 2020; Potdar et al., 2016).

This is specifically important in the case of solid waste management where the volume of solid waste continues to grow and is expected to double over the next decade (World Bank). This is a driving force for engineers and officials to look increasingly towards smarter management.

The adoption of innovative technologies will result in more integrated waste management offerings that move beyond the traditional and conventional waste management systems. At the heart of the smart waste evolution is a focus on reducing operational costs, using SWM as a strategic renewable resource for material and energy recovery (Berytech, 2020; Potdar et al., 2016).

Major questions to be addressed include:

- Where does Lebanon stand in terms of innovation in the solid waste management sector?
- How does Lebanon compare to regional and international innovational achievements in the sector?
- What characteristics of the business and enabling environment support such innovation capacity?

These questions are answered below on the basis of the outcome of the survey, the author's experience in the field, and published data and studies.

Survey Outcome. When asked if the SMEs are involved in innovation, 60 percent responded positively. The surveyed Cleantech solid waste SMEs actually export and engage in adopting new technologies. With the exception of a few cases, most types of innovation that were reported in the questionnaires were mainly addressing the use of technologies and/or practices that are already under implementation in the international market.

Lists of the types of innovation reported by SMEs **Figure 11**.

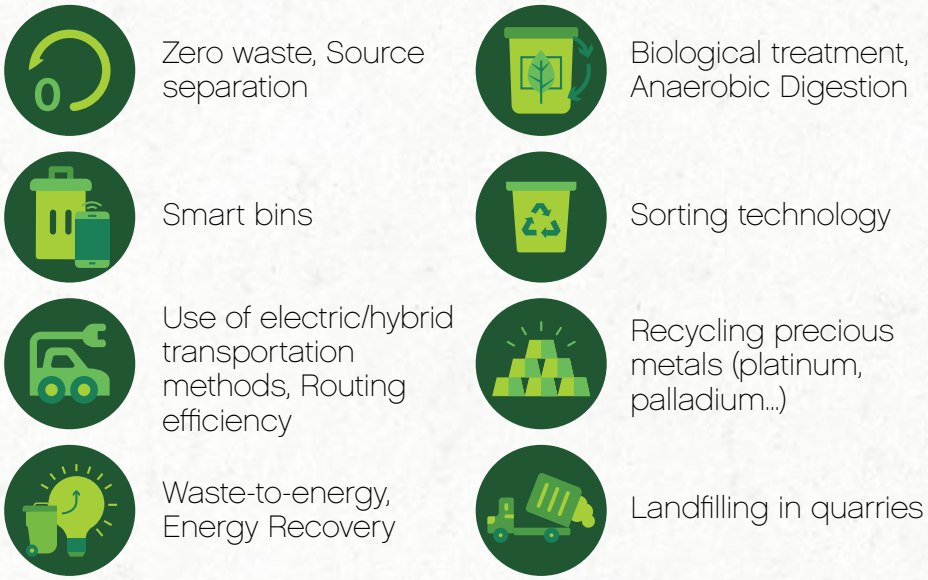

Figure 11: Innovation Types as Reported by SMEs

Reported Pilot Initiatives in Lebanon. Many innovation case studies have been reported in the literature about startups that initiated innovative approaches for more sustainable waste management practices. They range from innovative social applications of internationally adopted technologies to mobile application platforms or just ideas whose implementation does not require any sophistication. The end result adds up to an environmental performance in the sector.

Some of these innovations have been ranked amongst the Top 20 projects that highlight UN Habitat's **Innovative solutions to transform Waste to Wealth** in 2019.

Of these pilot initiatives, some turned into real projects and/or SMEs that are still on-going and operational, like Compost Baladi, Reverse Vending Machines, Fabric Aid, Live Love Recycle, and many others.

Challenges to Innovation

Innovation infrastructure is generally defined as the resources and assets that support Cleantech innovation, such as:

- Scientific resources, knowledge, and talent at universities and other major research institutions, which can be deployed to support technology Research and Development (R&D).
- A robust local value chain, including companies providing R&D, manufacturing, marketing and distribution, and other services that support Cleantech innovation.
- Business and investment resources that support the creation of new companies and commercialization of technologies in new or emerging fields.
- A policy and regulatory framework that encourages, supports, and fosters innovation, especially in the Cleantech sector.

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Typically, any innovative Cleantech solution undergoes the stages outlined below, before market deployment. Two stages are considered particularly critical:

- The very early stage when "innovative bold ideas" need to acquire and secure the initial funding in order to become noteworthy R&D collaborations.
- The second major challenge is the stage before "mass-market commercialization" when there is a need to convince investors and partners to join the project.

The above is illustrated in **Figure 12**.

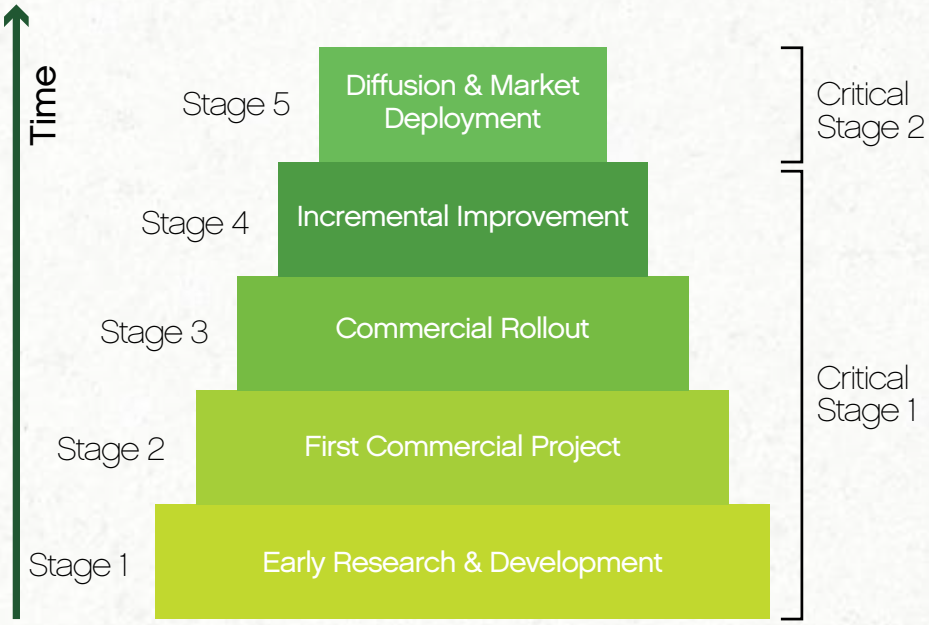

Figure 12: Stages of an Innovative Cleantech Solution

Few are those ideas that bring with them an innovative effect that is fundamental enough - that carries a significant added value in terms of technology or process.

Most innovations in Lebanon, especially in the solid waste management sector, are still at the startup stage and have not reached commercialized solutions, mainly due to the lack of support and enabling environment that encourages innovation.

The bulk of the discussions held during the first workshop mainly focused on the challenges facing the sector as a whole, especially that this sector has been and still is one of the most debatable sectors. As for the challenges hindering innovation, attendees raised the following.

Category 1: Lack of Financial Resources

Most of the attendees concurred on the financial burden being the factor hindering innovation. The lack of funding for the management of this sector, in general, and for innovative startups in particular, was the key challenge SMEs and non-SMEs raised during the workshop.

Indeed, improving the availability of early-stage capital for Cleantech innovative startups pose challenges in Lebanon as well as in many other countries. Attracting early-stage capital is always one of the major challenges for innovative startups and for programs that support startup growth and success.

The initial capital funding is not the only financial burden. Additional challenges include reducing investment risks (for instance, having shared pilot-facilities) and creating a well-aligned funding and investment process and network.

Category 2: Research & Development

R&D is the backbone of innovation. The existing landscape environment and infrastructure does not allocate the necessary services for promoting and advocating R&D activities in Lebanon.

One of the challenges for Cleantech startups is the need for dedicated R&D lab facilities and prototyping and demonstrator facilities. Realizing such facilities individually for startups is a key challenge from financial and feasibility perspectives. That is why the common practice is to have shared facilities through creating innovation clusters that usually include universities, research institutes, industries in the waste management sector, investors, etc. Examples on such clusters are the National Energy Research Laboratory, DTU, Risø in Denmark, or the EnviPark in Turin, Italy.

Category 3: Scarcity of Technical Capabilities/Knowledge Transfer

Scarcity of talents is a significant challenge faced at the national level as a result of the significantly high rates of emigration. In addition, the existing environment has limited tools and/or platforms that encourage the transfer of knowledge and the exchange of expertise.

Category 4: Lack of Policies Stimulating and Encouraging Innovation

In Lebanon there are no governmental or sector-specific policies that stimulate and/or advocate innovation in the solid waste management sector. In addition, the absence of stringent domestic environmental regulations, and/or the non-enforcement of such regulations when they do exist, hinders the adoption of new technologies, and does not encourage innovation to improve the performance of exiting systems.

The only governmental move towards encouraging Cleantech in general is a law that was drafted to minimize the taxation on clean technologies. However, the law has yet to be put in place (Ministry of Environment, 2017; [25]).

Category 5: Lengthy and Stringent Bureaucratic Procedures

The time needed for governmental decisions and laws to be approved is unusually long; the same applies to any new technology permitting processes. In addition, the existing regulatory framework is not flexible enough to allow the assessment of innovative solutions in the field.

Category 6: Lack of Networking

Networking startups is as important as the initial financial capital. Indeed, this is the tool that will help and support the growth of innovative startups throughout their whole lifecycle, i.e., from initial inception until the product is mature and commercialized.

Fundamental to any startup is the access to strategic networks (NGOs, regional government, incubators, universities, science parks, banks, pension funds, companies, research institutes, consultancy companies, and VCs) to get in contact with professionals and alumni associations, to establish long-term and professional relationships with higher education institutions in the region, to enter a strong and strategic network of companies and institutions, and to start nurturing links with strategic partners, attracting investors or investment funds who have access to (non) commercial loans.

Category 7: Failure of Successful International Technologies in Lebanon

Many advanced and sophisticated technologies have been imported for use in Lebanon (ballistic separators, trommels, RDF production, tunnel composting, etc.). Unfortunately, most of these have failed to achieve the targets and objectives anticipated from their implementation. This mostly results from a lack of source separation policy in the country, which in turn affects all system efficiencies.

These failures are seen as threats to new innovative technologies in the field; they direct efforts towards social innovation rather than technical solutions.

Category 8: Existing Business Model Does not Encourage Innovation

The existing business model governing the current operations in the sector does not encourage innovation and competition to optimize the efficiency of existing systems. Public-private partnerships (PPP) could be a great business model to be encouraged as it allows the private sector to support public infrastructure provisions. Four main factors of PPP implementation include:

- value-for-money projects
- identification of risks (description and allocations) between public and private sectors
- effective performance monitoring strategies via quantitative performance indicators
- user affordability

Opportunities for Innovation

An overwhelming demand is to call for immediate action to drastically reduce the negative impacts of municipal solid waste in Lebanon. However, progress is way too slow, considering the short time left to avoid catastrophic consequences of current practices. Cleantech development efforts in the sector are falling behind schedule in nearly all the stages of solid waste management.

What is of crucial significance in Lebanon now is the implementation of a policy that ensures source separation of waste, this being the bottleneck that hinders the efficiency and performance of existing systems and proven technologies.

From that perspective, **social innovations** are what the Lebanese Municipal Solid Waste Sector is in need of if we are to think of the overall performance of the sector.

According to the European Commission: "the concept of social innovation is the development and implementation of new ideas (products, services, and models) to meet social needs and create new social relationships or collaborations. It represents new responses to pressing social demands, which affect the process of social interactions. It is aimed at improving human well-being. Social innovations are innovations that are social in both their ends and their means. They are innovations that are not only good for society but also enhance the individuals' capacity to act" (European Commission, 2013a, p. 6)

Social innovations are needed to promote and foster source separation schemes and recyclables recovery in an efficient way by involving and integrating the local community. Integrating smart technology in support of these social innovations would be of great added value. For instance, existing recycling stations in supermarkets, smartphone applications for collecting source separated materials, individual garden composting units for rural areas, etc.

Other potential areas of technological innovations include glass recycling, electronic waste, tires, RDF, and other special wastes.

International Case Studies

Robust innovation requires an enabling ecosystem for hosting and supporting innovative Cleantech solutions throughout the whole lifecycle of a startup. Such an ecosystem includes:

- A network of relevant influencers and/or stakeholders, such as governmental entities, universities, research institutes, government, private investors, public investors, industry, business service providers, knowledge institutes, local authorities, and other companies.
- The supporting tools, such as education, network, business, services, funding, infrastructure, organization, and strategy.

The best practices for each tool supporting innovation ecosystems during different stages of solution development, as per research done in many countries **summarized in Table 4**.

Table 4: Best Practices Supporting Innovation Ecosystems

STAKEHOLDERS		Universities Research Institutes Government Municipalities	Universities Research Institutes Private Investors Industry Business Service Provider	Universities Research Institutes public Investor Private Investors Industry Business Service Providers Government	Private Investors Business Service Providers Government
	PROCESS	**Generation of IDEA & Early R&D**	**1st Comercial Project**	**Commercial Rollout & Improvement**	**Diffusion & Market Deployement**
BEST PRACTICE	EDUCATION	Technology and knowledge Transfer	Pre-incubation	Training & Coaching	
	NETWORK	Innovative Environment		Mediation & network	Mediation
	BUSINESS SERVICES		Intellectual Property Rights support	Business support	Growth infrastructure & support
	FUNDING	Funding of basic research Funding of technology creation	Idea & business Plan Competition	Funding during idea & technology creation Funding during market-focused business product development	Funding during commercialization and growth
	INFRASTRUCTURE			Office Space Test & Demonstration facilities	Growth infrastructure & support
	ORGANIZATION	Technology Transfer Offices	Idea & Business Plan Completion	Incubator & Cluster management team	
	STRATEGY	Innovative environment	Winning Strategy	Business Model	Exit Process Steps

Strategies to accelerate growth in Cleantech businesses in all sectors, including solid waste management and traditional industry renewal through innovations in clean technology, are set at the level of government in many countries.

Solid Waste

Indeed, nowadays, Cleantech business is at the core of many countries' business policies. International case studies of how the Lebanese challenges can be successfully dealt with **Table 5**.

Table 5: International Case Studies (Meister Consultants Group & NECEC Institute, 2020; Agamuthu, 2010; WASTECOSMART, 2015; European Commission, 2014; Canada's Economic Strategy Tables, 2018; Huang, 2020)

No	Challenge	International Case studies
1.	Lack of financial resources	Allocation of governmental yearly budgets to finance innovative Cleantech startups. Examples: ✔ In 2019, Canada invested $1.4 million in Waste Robotics. ✔ Each year, four percent of Finland's gross domestic product (GDP) is dedicated to public investments in R&D.
2.	Scarcity of technical capabilities and R&D infrastructure	Designing expert platforms for technical support, advising Cleantech startups, and/or putting university technical expertise and R&D infrastructure at the service of Cleantech startups. Examples: ✔ **Clean growth hub** platform in Canada. ✔ Technology Transfer Offices (TTO) or Knowledge Transfer Offices (KTO) on many university campuses across countries like Denmark, Austria, Finland, and others.
3.	Lack of policies encouraging innovation	Cleantech innovation in the international market is based strongly on stimuli and commitment of officially established public bodies, which act as the initial trigger for innovative startups. Examples: ✔ Ministry of Innovation, Science, and Economic Development in Canada ✔ Cleantech Finland Board in Finland
4.	Lengthy and stringent bureaucratic procedures	Granting special exemptions to licensing Cleantech procedures or allocating special governmental licensing bodies. Examples: ✔ Innovation and Regulation Charter in Canada ✔ Exemptions in Finland
5.	Lack of networking	Innovation clusters, incubators, governmental platforms, etc. Examples: ✔ **Team Finland network**, a governmental network created to market Finnish country brand Cleantech in international market. ✔ Lobbying regular international forums and network events (Canada, Finland, and Netherlands)

Solutions to national challenges were proposed to the working groups based on the above international best practices, and were evaluated in terms of:

- ease of implementation (Easy, Medium, Hard)
- relevance to the local context (not relevant, medium relevance, very relevant)
- cost implication (no cost, low cost, high cost)
- timeframe (short-term, medium-term, long-term)
- governance and party in charge

Table 6 Summarizes the outcome of this exercise.

Solid Waste

Table 6: Evaluation of Proposed Solutions

Challenge	Examples of Solutions	Implementation			Relevance		Cost			Time			Gov.
		Easy	Med	Hard	Med	High	Low	Med	High	Short	Med	Long	
Absence of a clear, integrated, and sustainable waste management strategy (source separation, resources recovery, etc.) and dependence on emergency plans based on political decisions rather than technical decisions	Endorse and implement the national policy set by the Ministry of Environment after filling in the gaps related to integrating a sustainable cost-recovery mechanism, considering the economy of scale when sizing up facilities, more realistic target amendments, and integrating incentives for innovation in Cleantech in the sector.	25	50	25	0	100	37.5	25	37.5	57	43		MoE, MoF, MoI, MoET, KAFALAT, IDAL
Lack of a source separation scheme, considered a bottleneck affecting the efficiency of all processes and all technological innovations in the sector	Enforce, as soon as possible, a source separation policy with short-term, medium-term, and long-term targets.	12.5	50	37.5	12.5	87.5	12.5	62.5	25	14	71	14	MoE, MoF, MoI, MoET, KAFALAT, IDAL
Absence of stringent standards, which usually stimulate innovation and Cleantech incentives to improve the performance of existing systems	Enforce sectoral MoE or SMES existing standards. Establish clear classification criteria for SMEs in the waste sector to enhance credibility and ensure good quality services that are in compliance with local codes and standards	12.5	87.5	0	25	75	62.5	25	12.5	29	71		MoE, MoF, MoI, MoET, KAFALAT, IDAL, LIBNOR
Lack of policies that usually stimulate and encourage innovation and Cleantech incentives	Create a governmental entity that would foster and promote Cleantech as a priority at the level of government. Such an entity would be specifically dedicated to the creation of an enabling environment that fosters and encourages innovation in the Cleantech sector. Examples: ✔ Ministry of Innovation in Canada ✔ Cleantech Finland Board headed by the prime minister of Finland	50	12.5	37.5	37.5	62.5	50	50		29	43	29	MoE, MoF, MoI, MoET, KAFALAT, IDAL, LIBNOR

Solid Waste

Challenge	Examples of Solutions	Implementation			Relevance		Cost			Time			Gov.
		Easy	Med	Hard	Med	High	Low	Med	High	Short	Med	Long	
Scarcity of technical capabilities and facilities for R&D	Create a scientific platform where SMEs working in Cleantech can get advice from a team of experts from across government. This could be created and managed by the governmental entity (proposed under point 4 above) and in collaboration with academic institutions, technology providers, researchers, etc. This platform would provide a single, easy point of contact for connecting with clean technology programs and services. Examples: ✔ technology transfer offices in most universities in Europe ✔ The Clean growth hub in Canada ✔ Knowledge Transfer Offices in Europe	37.5	50	12.5	12.5	87.5	50	37.5	12.5	29	57	14	MoE, MoF, MoI, MoET, KAFALAT, IDAL
	Solicit the local universities to design, study, and test innovative material and solutions in the Cleantech industry. Laboratories used in testing must be qualified and certified.	37.5	62.5	0				50	50				MoE, MoF, MoI, MoET, LCEC, IDAL, KAFALAT, LIBNOR, IRI
Lengthy bureaucratic procedures for approvals of new technologies	Find alternative solutions and shortcuts to avoid governmental/institutional bureaucratic delays that hinder the implementation of any decision/decree. The target is to considerably accelerate and reduce the number of the licensing procedures needed for investment decisions. Example: Canadian Innovation and Regulation Charter.	0	62.5	37.5	0	100	75	25		14	71	14	MoE, MoF, MoI, MoET, MoA, LCEC
Lack of networking between startups and relevant parties (e.g. investors, research institutes, industries, business partners, launch customers, consultants/experts, and fellow entrepreneurs)	Encourage innovation clusters and incubators and organize regular events to put startups in contact with investors, research institutes, industries, business partners, launch customers, consultants/experts, etc.	62.5	37.5	0	25	75	62.5	37.5		43	43	14	MoE, MoF, MoI, MoET, KAFALAT, IDAL, LCEC
Lack of financial resources	At sector level, endorse a cost-recovery scheme that would ensure the financial sustainability of proposed systems and pave the way for waste management decentralization services.	12.5	12.5	75	12.5	87.5	25	25	50	14	57	29	MoE, MoF, MoI, KAFALAT, IDAL,
	At the innovation level, identify and implement alternative financial schemes to fund innovation for SMEs in the Cleantech sectors.	0	75	25	12.5	87.5	12.5	50	37.5	14	57	29	MoE, MoF, MoI

As shown, all responses concurred on the relevance of the proposed solutions to the local context. In terms of ease of implementation, the majority of the attendees considered the options considerably easy to implement.

Similarly, the results of the survey indicate that the proposed solutions could be implemented at a significantly low cost and in the short- to medium-term.

As for the governance system, in terms of the authorities or parties in charge implementing the proposed solutions, the major stakeholders identified to initiate actions, included the Ministry of Environment (MoE), the Ministry of Finance (MoF), the Ministry of Interior and Municipalities (MoIM), the Ministry of Economy and Trade (MoET), KAFALAT, the Investment Development Authority of Lebanon (IDAL), the Lebanese Center for Energy Conservation (LCEC), and LIBNOR.

Recommendations

Obviously the business environment encouraging investment in waste management clean technologies is affected by more or less the same constraints and challenges that are hindering other sectors. However, a key challenge that could be looked at as the obstacle behind sector development is, without doubt, "the absence of an implemented integrated and sustainable strategy for waste management." All adopted and implemented strategies have so far been temporary in nature and forced, in the context of an emergency situation, driven and fostered by political interventions and interests. Politicians have always taken technical decisions rather than the technical experts.

For decades, Lebanon failed to put in place an integrated and sustainable strategy. Decision makers use such terms in Lebanon to refer to waste management plans extremely far from the principles endorsed, of which we mention:

- Waste management hierarchy which places waste prevention on top, followed by recycling, energy recovery and sanitary landfilling. For such a hierarchy, resources recovery through the promotion of source separation and segregation schemes is essential;
- The governance system, including laws and regulations, the inclusivity principle, and the cost recovery, are crucial. Despite the passage of Law 80 (2018) after six years of stagnation, nothing has been done about the inclusivity of stakeholders nor the efficient cost-recovery mechanism, which to date has not been seriously addressed.

Although the Ministry of Environment proposed a National Solid Waste Management Strategy, such a strategy is still theoretical. In the absence of an approved national strategy, the risk factor associated with any investment in clean technologies in the solid waste management sector is high. Indeed, the inefficiency of the currently implemented waste management plans and the failure to divert waste from landfilling is proof of this risk. Money has been invested by the government to build modern waste management facilities with up-to-date technologies. Yet, the results are not encouraging.

Therefore, this paper has two main sets of recommendations:

- General recommendations that address the overall waste management sector, which are crucial to encouraging and promoting investment in innovative clean technologies in the field.
- Focused or specific recommendations that highlight the type of innovations that would optimize performance of this sector without being negatively affected by the absence or the delay in the implementation of a national solid waste management plan.

General Recommendations

In general, the strategic decisions related to waste management in Lebanon cannot follow the same pace and trend followed over the past three decades. The bulk of our waste stream ends up either in open dumpsites or sanitary landfills. Setting and implementing an integrated and sustainable waste management strategy including all the components and ingredients illustrated below is an emergency.

Figure 13: Ingredients of an integrated & sustainable waste management strategy

This, in principle, could be the combination of those recommendations listed earlier under **International Case Studies**. However, the recommendations focus on those that should be immediately addressed, given the urgency of the current situation:

- Amend, endorse, and implement the National Strategy set by the Ministry of Environment. The amendments should address all the gaps highlighted over the course of this paper, specifically those related to the integration of a sustainable cost-recovery mechanism, consideration of an economy of scale when sizing up facilities, more realistic target amendments, and integrating incentives for innovation in Cleantech in the sector. The policy should be amended in coordination with the stakeholders involved, specifically the municipalities and the Ministry of Interior.
- Develop and implement a national waste management masterplan on the basis of the National Strategy that includes all the components of an integrated and sustainable waste management framework, as outlined above. The plan should be developed by the Solid Waste Committee to be established by Law 80. Such a committee should include members from all relevant stakeholders. Political interference in committee decisions should not be allowed.

The implementation of the above would set the governing framework for the safe/secure investment and guaranteed performance (technical and financial) of modern clean technologies, such as waste to energy, RDF, optical sorting, and others.

Focused Recommendations

Until the above general recommendations are achieved, SMEs promoting social innovations should be encouraged to:

- promote waste recycling activities, specifically at the source of generation
- raise public awareness through the involvement of local communities
- focus on the organic fraction of municipal solid waste management, which constitutes more than 50 percent of the waste stream

Examples of existing social innovations include many existing pilot projects in Lebanon, such as Reverse Vending Machines, Live Love Recycle, Fabric AID, Compost Baladi, and Eco-Boards.

Such innovations are not associated with significant capital investment and they depend highly on social contributions. They promote a culture of source separation of specific waste streams, which, in the long run, would converge towards meeting the objectives of any waste management strategy.

References

Abbas, I., Chaaban, J. K., Al-Rabaa, A.-R., & Shaar, A. A. (2017). Solid waste management in Lebanon: Challenges and recommendations. **Journal of Environment and Waste Management, 4(2), 53-63.** https://www.researchgate.net/publication/320190830_Solid_Waste_Management_in_Lebanon_Challenges_and_Recommendations

Agamuthu P. (2010). **Best practices and innovative approaches for sustainable waste management** [Powerpoint presentation]. United Nations Department for Economic and Social Affairs (UNDESA), Division for Sustainable Development Goals (DSDG). https://sustainabledevelopment.un.org/content/dsd/susdevtopics/sdt_pdfs/meetings2010/icm0310/2a_Agamuthu.pdf

Berytech. (2020). **Clean technology: A focus On water, waste and energy in Lebanon.** https://berytech.org/clean-technology-a-focus-on-water-waste-and-energy-in-lebanon/

Canada's Economic Strategy Tables. (2018). **The innovation and competitiveness imperative: Seizing opportunities for growth.** Innovation, Science and Economic Development Canada (ISEDC). https://www.ic.gc.ca/eic/site/098.nsf/vwapj/ISEDC_SeizingOpportunites.pdf/$file/ISEDC_SeizingOpportunites.pdf

El-Fadel, M. (2001, October 21-24). **Optimizing landfill siting through GIS application** [Conference speaker]. Seventeenth International Conference on Solid Waste Technology and Management, Philadelphia, PA. https://eprints.soton.ac.uk/52857/

European Commission. (2014). **Government strategy to promote Cleantech business in Finland.** https://ec.europa.eu/environment/ecoap/sites/default/files/documents/government_strategy_to_promote_cleantech_business_in_finland.pdf

European Union & OMSAR. (2017). **Technical support to upgrading the solid waste management capacities in Lebanon: Add hoc report screening tool for waste treatment technologies.** European Union (EU) and Lebanese Office of Minister of State for Administrative Reform (OMSAR). https://wmclebanon.org/wp-content/uploads/2019/06/EU-OMSAR-SCREENING-TOOL-FOR-WASTE-TECHNOLOGIES_v1.pdf

Farah, J., Ghaddar, R., Nasr, E., Nasr, R., Wehbe, H., & Verdeil, É .(2019). Solid waste management in Lebanon: Lessons for decentralization. **Democracy Reporting International.** https://transparency-lebanon.org/Uploads/Library/258/download/80942116-5fdc-41ac-b3fa-1fa2a9617d6a_258.pdf

Holtmeier, L. (2019, September 9). Lebanon's struggle to implement a coherent waste management strategy. **The Executive.** https://www.executive-magazine.com/economics-policy/lebanons-struggle-to-implement-a-coherent-waste-management-strategy

Huang, L. (2020). **SME profile: Clean technology in Canada.** Innovation, Science and Economic Development Canada (ISEDC). https://www.ic.gc.ca/eic/site/061.nsf/vwapj/SME-profile_Clean-technology-Canada_2-eng.pdf/$FILE/SME-profile_Clean-technology-Canada_2-eng.pdf

Human Rights Watch. (2018a). **Brief on the proposed integrated solid waste management.** https://www.hrw.org/sites/default/files/supporting_resources/brief_proposed_policy_isw_managementenglish.pdf

Human Rights Watch. (2018b). **Law number 80: Integrated solid waste management.** https://www.hrw.org/sites/default/files/supporting_resources/iswm_law_80_october2018_english.pdf

Meister Consultants Group & NECEC Institute. (2020). **New England's Cleantech innovation landscape: A snapshot of a growing cluster.** http://www.revermont.org/wp-content/uploads/2.20.14NE-Cleantech-Innovation-Landscape_Final.pdf

Ministry of Environment. (2017). **Decision No 1281-1 26.12.2017 in OG 60 of 28-12-2017.** (تحديد آلية الاستفادة من التخفيض الضريبي للأشخاص الذين يقومون بنشاطات تحافظ على البيئة)

Ministry of Finance. (2020). **Decision No 18-1 Jan 13.2020** (اعتماد نماذج تصاريح للمكلفين الذين يستفيدون من التخفيض الضريبي استنادا» إلى المرسوم رقم 167 تاريخ 17-2-2017)

Potdar, A., Singh, A., Unnikrishnan, S., Naik, N., Naik, M., Nimkar, I., & Patil, V. (2016). Innovation in solid waste management through clean development mechanism in developing countries. **Procedia Environmental Sciences 35,** 193-200. https://doi.org/10.1016/j.proenv.2016.07.078

Smart Prosperity Institute. (2018, March 15). **Smart Prosperity leaders call on government to help clean innovators get ideas to market, creating wealth and jobs** [Media release]. https://www.smartprosperity.ca/content/308

SWEEPNET. (2014). **Country report on the solid waste management in Lebanon.** GIZ. https://www.retech-germany.net/fileadmin/retech/05_mediathek/laenderinformationen/Libanon_RA_ANG_WEB_Laenderprofile_sweep_net.pdf

UNDP. (2020). **Rapid cost of environmental degradation: Note prepared for the Ministry of Environment, May 2019.** https://www.lb.undp.org/content/lebanon/en/home/library/environment_energy/rce.html

WASTECOSMART. (2015). **Joint action plan: A way forward for innovative waste management**. http://www.wastecosmart.eu/contents/deliverables/d64_wastecosmart_joint-action-plan.pdf

Yacoubian, P. (2018, December 17). Lebanon's waste sector at risk of the same mismanagement as electricity: Another crisis of our own making. **The Executive.** https://www.executive-magazine.com/economics-policy/lebanons-waste-sector-at-risk-of-the-same-mismanagement-as-electricity

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معهد عصام فارس للسياسات العامة والشؤون الدولية

About the Issam Fares Institute

The Issam Fares Institute for Public Policy and International Affairs (IFI) at the American University of Beirut AUB is an independent, research-based, policy-oriented institute. It aims to initiate and develop policy-relevant research in and about the Arab region. The Institute is committed to expanding and deepening knowledge production and to creating a space for the interdisciplinary exchange of ideas among researchers, civil society actors, and policy makers.

IFI goals:

- Enhancing and broadening public policy-related debate and knowledge production in the Arab world and beyond;
- Better understanding the Arab world within shifting international and global contexts;
- Providing a space to enrich the quality of interaction among scholars, officials and civil society actors in and about the Arab world;
- Disseminating knowledge that is accessible to policy-makers, media, research communities and the general public.

About Berytech

Berytech
The Ecosystem for Entrepreneurs

Berytech is an ecosystem for entrepreneurs, providing a dynamic environment for the creation and development of startups and SMEs, fostering innovation, technology and entrepreneurship in Lebanon. Since 2002, Berytech has assisted more than 4,200 entrepreneurs and helped create more than 3,400 job opportunities in Lebanon.

Berytech's support falls under capacity building/networking, policy reform, startup and SME development, startup and SME incubation, startup acceleration and incubation, student entrepreneurship development, technology transfer support, and women empowerment.

Berytech manages over 30 programs in agriculture and food, water, energy and food, clean technology, green entrepreneurship and circular economy, and social entrepreneurship, all involving ICT and innovation.

About Act Smart

ACT smart
AGRI-FOOD AND CLEAN TECHNOLOGIES
INNOVATION HUB

The objective of Berytech through its ACT Smart Innovation Hub project is to create opportunities for innovators through four pillars revolving around Acceleration - converting innovative ideas to growing businesses supporting job creation and economic growth; Clustering - strengthening the Agri-Food private sector, by increasing innovation practices, strengthening resilience and international competitiveness; Think Tank - supporting the creation of work groups to lobby for better enabling innovation and investment landscape; and finally IP Valorization - valorizing Lebanese research to commercialization and sectorial advancement.