The Lebanon municipal solid waste crisis and pathways forward

Insights into long-term solutions for the municipal solid waste crisis

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Content

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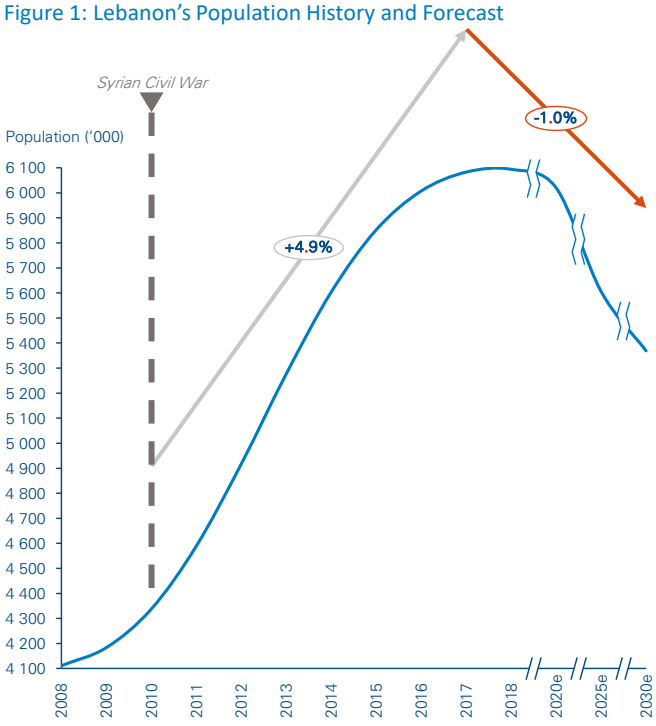
Executive summary

Most developed countries have established solid waste management practices to deal with different types of waste in economical and environmentally friendly ways, including industrial and hazardous waste, medical waste, construction and demolition waste, agricultural waste, waste-water sludge and special waste types such as tires, end-of-life vehicles, and electronic waste. However, Lebanon underwent a crisis in 2015 due to its difficulties in dealing with its municipal solid waste, which culminated in uncollected waste piling up in the streets and illegal open dumping and burning. While an emergency plan has been enacted and the visible effects of the crisis have been managed, many challenges are still preventing the development of long-term solutions. From previous experience in setting up national waste strategies, we believe any long-term plan should strive to answer crucial governance questions while developing a strategic focus on treatment methods, financial instruments and other technology and process enablers.

1. Waste crisis drivers and barriers to long term solutions

The primary drivers of the waste crisis in 2015 were weak governmental planning and a sharp increase in population due to the inflow of refugees fleeing the Syrian Civil War.

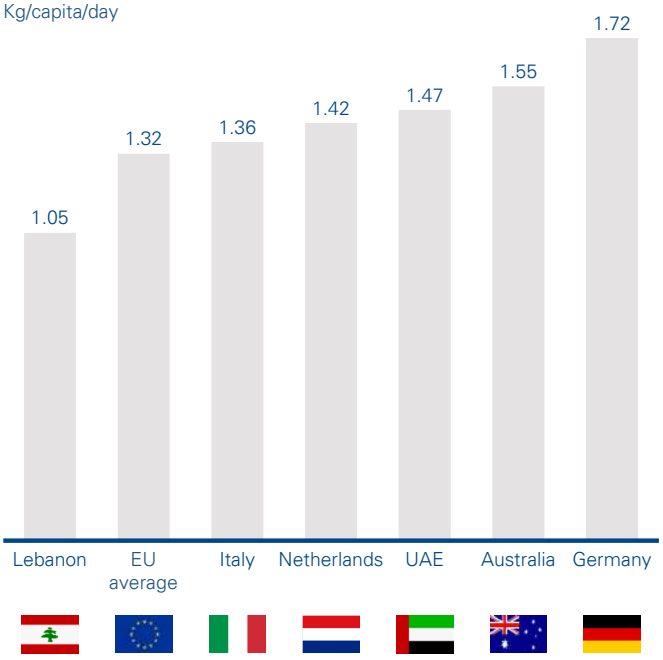
Figure 1: Lebanon's Population History and Forecast



Source: United Nations DESA/ Population Division World Population Division 2017

The latter put a strain on the already-burdened infrastructure, and eventually led to the Naameh landfill closing and the subsequent crisis. While the impact of the population surge had serious consequences in the short term, the long-term implications might be less severe, considering the country's total population is expected to decrease with a CAGR of negative 1 percent starting in 2018. Nevertheless, municipal solid waste (MSW) generated in Lebanon is still expected to increase from 2,040 thousand tons in 2014 [1] to around 2,653 thousand tons in 2025 due to an increase in the daily production rate of MSW per capita (the current level is 1.05 kg per capita per day [1] which is well below EU average).

Figure 2: Benchmark of Daily Waste Production Rates Per Capita



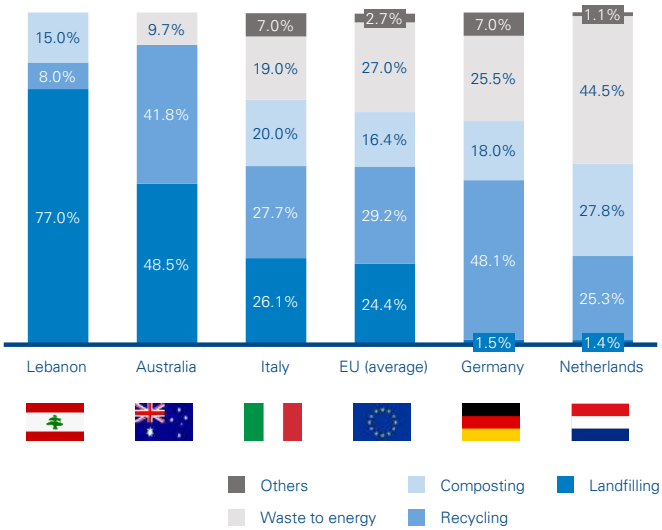
Source: German Cooperation Report on SWM Lebanon, Eurostat, UAE Statistics Center

Lebanon's current emergency plan still relies on landfills as the preferred treatment method

Since the waste collection crisis in 2015, Lebanon has established an emergency plan entailing the construction of two coastal landfills in Bourj Hammoud and Costa Brava, respectively. Environmental controversies have followed, including possible dumping of waste in the Mediterranean Sea, in violation of the Barcelona convention, as well as open burning by some municipalities.

Estimates report that the country currently only treats 23 percent of total MSW weight (8 percent material recovery and 15 percent composting), while 77 percent is directed to landfills or open dumpsites [1]. In comparison, Germany and the Netherlands landfill less than 2 percent of the total MSW they generate, while diverting the rest through various techniques including recycling, composting and waste to energy (WTE).

Figure 3: MSW Treatment and Disposal Methods Benchmark



Source: German Cooperation Report on SWM Lebanon, Eurostat

Current barriers to long-term solutions

While the temporary emergency plan has cleaned up the streets and removed the visible effects of waste mismanagement, long-term solutions are still impeded by four key barriers.

Figure 4: Current barriers

1. Lack of regulations and enforcement

2. Improper planning and unsynchronized efforts

3. Lack of proper infrastructure

4. Social barriers and compliance issues

Source: Arthur D. Little Analysis

1. Weak regulations and enforcement

Lebanon still lacks the integrated legal framework necessary to govern the waste sector. Typically, waste regulations fall within two categories. The first being environmental regulations aimed at limiting the impact of waste on the environment (including emissions control, proper site localization and soil/water preservation). The second includes operational regulations aimed at determining cost-recovery mechanisms and rules that waste operators and polluters should follow during daily operations. While some of these regulations are already in place, they are still not properly enforced on the ground.

2. Improper planning and unsynchronized efforts

Waste treatment and disposal facilities are capital intensive, and certain treatment facilities, such as WTE plants, require investments of hundreds of millions of dollars (depending on the treatment capacity). Without proper long-term planning and pooling of resources, these investments could prove challenging for individual municipalities. Proper planning is also necessary to ensure that adequate capacities for each treatment type are installed in order to avoid service outages and overcapacity. The recently approved policy from the council of ministers (January 2018) calls for decentralization of planning to the municipalities, which could potentially complicate the realization of economies of scale. Over the last two years, some municipalities have made initiatives, such as investments in building waste treatment facilities. However, some of these initiatives have already encountered difficulties, and consequently been discontinued.

3. Lack of proper infrastructure

Apart from the sporadic treatment centers set up by municipalities, the current infrastructure has been mainly developed for final disposal, and relies on open dumping rather than sanitary landfilling. Based on data from the Ministry of Environment and UNDP, as of 2017, there were 617 MSW dump sites in the country [2]. Without proper supporting infrastructure, these dumpsites could lead to health and environmental issues related to leachate and emissions.

While the emergency infrastructure has temporarily solved the crisis, these landfills and dumpsites will soon reach capacity; this emphasizes the need for initiatives to increase the landfill diversion rate and find alternative disposal sites.

4. Social barriers and compliance issues

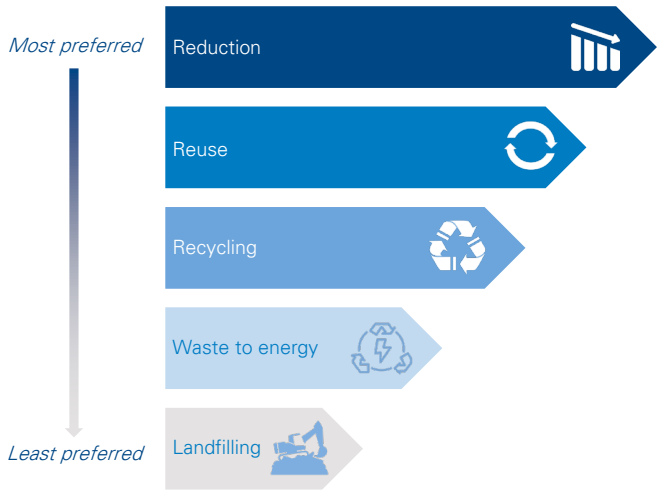
The social barriers preventing the implementation of long-term waste solutions in Lebanon can be categorized into two types: issues around awareness and compliance, as well as social pressure.

The awareness and compliance issues in Lebanon affect not only the general population, but also the municipalities, which are supposedly the front line in charge of enforcing the rules. As an example, many municipalities employed open burning and illegal dumping during the crisis, despite public and governmental disapproval.

On the other hand, social pressure caused by the multitude of civil society movements and the "not in my backyard" phenomenon are hindering decision-making power and thus long-term planning. Several misconceptions are guiding the narrative and limiting the options. It is our view that:

1. Waste is not a goldmine of potential profit: Waste management activities can be profitable for waste operators and some specific applications, but benchmarks show that the waste ecosystem as a whole still requires funding from the residents and companies and/or the government.

Fight 5: The Waste Hierarchy



Source: Arthur D. Little Analysis

2. Recycling and composting alone are not viable alternatives to landfilling: While recycling and composting are top priorities in terms of waste treatment according to the waste hierarchy (see figure above), in practice it is not possible to recover the entirety of "recyclable" and "compostable" waste. The actual recovery rates vary depending on the waste stream composition and the available collection, sorting (at source or post-collection) and treatment systems. For example, some of the waste types are not easily recoverable in most materials recovery facility (MRF) designs, such as plastic film and colored glass. Residual waste from recycling and composting processes, along with mixed non-recyclable/compostable waste (diapers, tissues, etc.), can represent around 20 percent of the total waste stream; this will then have to go through secondary treatment or directly to final disposal.
3. Incineration is not catastrophic to the environment and public health: While the open burning of waste unquestionably leads to serious environmental and health consequences, such as the release of toxic dioxins and other chemicals, modern waste-to-energy (WTE) plants are typically equipped with strict forms of environmental control systems. The incineration process itself can result in three potential sources of environmental exposure: (1) air emissions, (2) solid ash residue (including bottom ash and fly ash) and (3) contaminated cooling water. Provided that the solid ash residue and cooling water are tested, handled and disposed of properly as per strict environmental standards, air emissions remain the biggest concern for the public. However, as all modern WTE plants are equipped with flue gas treatment systems, they typically comply with stringent environmental restrictions and reduce toxic emissions to well below the levels acceptable to the EU. A study conducted by the UK Health Protection Agency concluded that the contribution of incinerator emissions to residents' intake of dioxins was small and well below the tolerable daily intake of two picograms WHO-TEQ per kilogram of body weight per day. The report also concluded that the contribution made by waste incineration to national particle emissions (PM10) was low, constituting 0.03 percent of total emissions, compared to 27 and 25 percent for traffic and industry, respectively [3]. All in all, recycling and composting remain more environmentally friendly than WTE. However, for residual waste that would have been otherwise landfilled, properly managed WTE can be a viable alternative that does not lead to drastic consequences for the environment and public health. This is assuming that all conditions have been fulfilled and capacity is carefully managed to avoid hindering future recycling initiatives.

2. The way forward

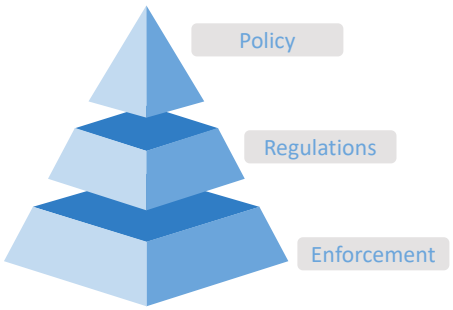
While the visible effects of the waste crisis have been dealt with, Lebanon will still need to develop long-term solutions encompassing governance and strategic direction in order to avoid a repeat of the situation.

Governance, a delicate balance of decentralization and central planning

Proper governance of the sector is crucial to enabling long-term solutions that consider the basic pillars of waste management: environmental protection, governmental cost management, socio-economic impact optimization and ease of implementation. In our view, several layers of governance have to be implemented:

1. Policy making: This role is typically awarded to environmental regulators across the world. It entails setting the broad policies related to waste, as well as the KPIs and targets necessary to achieve the objectives.
2. Regulation setting: This role entails detailing the waste policies into specific regulations that aim to fulfill the targets. These regulations should describe the various operational restrictions for waste operators, the general population and other stakeholders to follow.

Figure 6: Layers of governance



Source: Arthur D. Little Analysis

Enforcement: This role ensures the implementation of all regulations through various enforcement mechanisms aimed at raising compliance.

The role of operating all steps of the value chain, from collection to final disposal, can be performed by either the public sector or the private sector through various public-private partnerships (PPPs) or contractual arrangements. Individual initiatives by private investors and NGOs should also abide by all relevant regulations and policies.

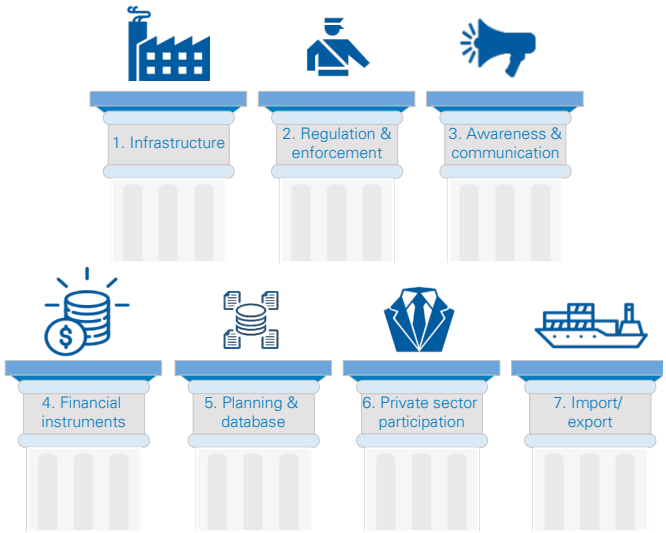
The appropriate allocation of these roles, as well as the establishment of proper checks and balances, are vital to ensure the successful implementation of any waste management strategy. To that effect, we believe the role of waste operators should be separated from other roles to avoid conflicts of interest and giving excessive weight to operational ease of implementation versus other considerations.

A second consideration remains: should these roles be centralized under one authority, or should a decentralization strategy be adopted to delegate them to multiple regional authorities or municipalities? This decision implies a compromise in two dimensions: prioritization of either economies of scale or ease of implementation. A careful balance should be achieved. Over-reliance on central governance can overburden the individual municipalities by forcing them down certain paths that are either too difficult or too costly to implement. On the other hand, too much decentralization can lead to duplication of efforts and unnecessary spending, or ad hoc solutions not aligned with the integrated strategy. As of the latest Solid Waste Policy approved by cabinet in January 2018, Lebanon is opting for decentralizing waste management whenever possible, while still allowing municipalities to opt in to certain central government solutions. While this approach can theoretically strike the right balance of decentralization and central planning, we believe extensive coordination and portfolio optimization should be continuously conducted in order to achieve the full benefits of the plan and a harmonious, integrated solid waste management framework.

Aiming for and achieving the right targets

The general direction followed by global leaders in waste management, such as Germany and the Netherlands, adheres to the waste hierarchy. Accordingly, the largest portion of waste is handled by recycling (including the composting of organics), followed by thermal treatment at WTE plants. Landfilling of remaining waste is the least-preferred option. For the Lebanese government, the pathway forward should be to develop an integrated waste management plan that achieves the best combination of the aforementioned pillars (overall cost, environmental impact, socio-economic impact and ease of implementation). Once defined, the national plan will require the support of seven key enablers to ensure its success.

Figure 7: Key enablers for a national waste plan



Source: Arthur D. Little Analysis

1. Infrastructure

Lebanon's integrated waste management framework should aim to increase landfill diversion rates. To that effect, a combination of recycling/composting and WTE is necessary before landfilling. In order to support the economic viability of each treatment option, the following requirements are needed along the waste value chain:

a. Sorting waste at household level to maximize recyclable recovery rates

At the production and collection stage, best-practice countries such as Switzerland, Germany and the Netherlands impose sorting at household level in order to maximize recyclable recovery rates. These collecting & sorting systems differ across locations, with some German cities utilizing up to seven bins at household level in their systems. For countries such as Lebanon, with less mature waste management systems, a three-bin system could be a more suitable solution. In this system, waste would be split into recyclable waste, organic waste and residual waste.

b. Development of a master plan that sets the right mix of techniques and balances economies of scale and transportation costs

A master plan is essential to enabling smart infrastructure investment. The first step would be to set the right mix for treatment by choosing the targets for each treatment type. The available waste subcategories would undergo three treatment types:

1. The bulk of recyclable waste would be sent to material recovery facilities (MRFs) in order to separate and treat the co-mingled components (plastic, paper, metals, etc.) so they can be sold as raw materials for other industries. These facilities are also useful in correcting mistakes citizens make during initial separation, especially in early phases.
2. The bulk of organic waste would be sent to composting stations to produce natural fertilizers in commercially viable quantities. Alternatively, depending on the plants' locations and budgets, anaerobic digesters could also be used to treat organic waste and recover biogas in addition to the fertilizer.
3. The remaining waste would be sent to WTE plants to be converted into useable electricity. Post-treatment waste then undergoes final disposal by landfilling.

A balance should then be struck regarding the sizing and locations of the treatment and disposal facilities in order to, among other factors, maximize economies of scale and minimize transportation costs. For example, sorting facilities might be located in each of the regions defined by the government plan, while WTE plants could be shared by multiple regions to ensure the proper scale for economic viability. Supporting infrastructure must then be integrated into the master plan, including the use of transfer stations to minimize transportation costs.

c. Waste-to-energy as part of the integrated solution

As part of the treatment mix, waste to energy is usually used as a penultimate step for residual waste, in order to reduce the quantities destined for landfilling and extract some value in the form of energy.

It is important to bear in mind that WTE plants can only contribute modestly to solving Lebanon's electricity crisis, which is caused by a staggering ~30 percent deficit in generation capacity [4]. In the Netherlands, for example, WTE plants only constitute 2 percent of the total electricity generation capacity, even though the country incinerates around 45 percent of its total waste [5].

Moreover, should the Lebanese government decide to proceed with its plans to build WTE plants, extra considerations should be put in place to account for the by-products. While the WTE (incineration) process reduces MSW volume by 90 percent, it still leaves approximately 8 percent of bottom ash and 2 percent of fly ash (including other air pollution-control residues) [6].

Bottom ash, depending on its composition, is generally non-hazardous and can be disposed of in sanitary landfills similar to those for MSW. Fly ash, on the other hand, requires proper treatment and disposal infrastructure suitable for its hazardous nature.

Multiple alternatives could be adopted to handle these by-products. Japan, for instance, recycles fly ash and bottom ash in cement, concrete and road construction activities [7]. Another possible solution is to follow Denmark's example and export the

hazardous fly ash to countries that already have the necessary infrastructure to deal with it, such as Norway.

Regardless of the method used, adequate testing infrastructure is necessary because these by-products need to be examined regularly for dioxins and other harmful substances.

Another point to consider is that careful WTE capacity planning must be done to avoid damaging the future recycling potential that may arise from new technologies and better sorting compliance. Lebanon should learn from other countries' mistakes in capacity planning, such as those of the Netherlands, which has built an overcapacity of WTE plants in the past. As a consequence, it has to rely on importing waste from neighboring countries to satisfy contract requirements with the operators.

d. Setting up sanitary landfills and banning open dumping and burning

Up-to-standard sanitary landfills are required for the final and safe disposal of MSW. These must include leachate collection and treatment, as well as methane gas collection and flaring/utilization systems. Existing improper disposal techniques, such as open dumping and burning, need to be remediated as soon as possible in order to alleviate their negative environmental impact.

2. Regulation and enforcement

Stricter regulations and proper enforcement of waste activities

While the responsibility for drafting and enforcing regulations is a governance consideration, the content of these regulations and the methodology of their enforcement can be tools to further facilitate the implementation of any waste strategy. On the regulations side, restrictions on certain types of waste activities, such as landfill bans, can incentivize other treatment types. Penalties for violations of environmental standards and sorting requirements are particularly useful for increasing compliance.

Though in an ideal setting, issuing regulations is technically sufficient to influence behavior, in the real world (especially in Lebanon, where lack of compliance with established regulations is common), enforcement is crucial to their success. The responsible authority can leverage various systems and tools to facilitate enforcement. Examples are track & control systems, which can be installed on transport vehicles to track the real-time location of each truck, with collected data used to flag illegal dumping or unwarranted deviations. While these issues might not be widespread currently, systems such as these might become necessary with the introduction of new treatment infrastructure and its corresponding gate fees and taxes.

3. Awareness and communication

Guidance on and awareness of proper waste management activities for residents and institutions

Awareness and communication activities are imperative to the success of the Lebanon's waste management plan. They guide residents and institutions on proper waste management and sorting, as well as increase the level of transparency and communication between policy makers and stakeholders. A communication approach should be developed to engage the different sectors: commercial, governmental, educational and residential.

In the Netherlands, for example, sustainability education is already embedded in school curricula. As part of the new plan entitled "A Circular Economy in the Netherlands by 2050", the concept of a circular economy, which is aimed at the efficient and environmentally friendly use and reuse of raw materials, will be reinforced in school programs. [8]

4. Financial instruments

The objectives of financial instruments can be split into two main categories. **Financial incentives** that promote proper waste management practices, and **cost-recovery mechanisms** that help with the financial burden of waste management efforts.

Financial incentives such as deposit-refund systems, financial grants, tax cuts and discounts

Deposit-refund systems, such as the German "Pfand" system, are types of financial incentives used across Europe. When purchasing plastic- or glass-bottle products, consumers pay an extra deposit, which is later refunded upon the return of the bottles. These types of systems can support the Lebanese government to increase the volume of recyclable products captured, as well as decrease littering.

Other incentives, such as financial grants, tax cuts and discounts, can be aimed at the private sector. Given the current economic issues in Lebanon, these instruments can be used to support the set-up and operation of waste management companies. They can also promote private sector participation in waste management activities (e.g., sorting, recycling, utilization of recycled material instead of virgin material in production).

Cost-recovery mechanisms including "polluter pays" systems and extended producer responsibility

Currently, the Lebanese government pays around USD 420 million annually for MSW management. However, to support its long-term goals, it needs an effective cost-recovery system. Cost-recovery systems can typically be split into two

main types: "polluter pays" systems and extended producer responsibility (EPR) systems.

"Polluter pays" states that the generator of the waste should bear the costs of managing it. This is usually accomplished by implementing collection fees and gate fees to use treatment/disposal infrastructure. Currently in Lebanon, residents and businesses pay municipal fees based on the rental value, and part of those fees finances waste collection and treatment. However, in many European countries, more advanced systems, known as "pay-as-you-throw", are in place. The collection fees in these systems are variable and based on the quantities of waste thrown. These systems are usually geared towards incentivizing recycling by imposing heavier charges on mixed waste, versus low or no charges for properly sorted recyclables. (Thus, in those systems, generating more waste incurs a higher fee and more efficient sorting incurs a lower fee). In the Swiss Canton de Vaud, for example, residents are required to purchase special municipality-approved waste bags before putting non-sorted waste in street containers or curb-side. The price of these waste bags already includes the waste treatment fee. Properly sorted recyclables have to be delivered to collection centers, and they incur no charges. Any deviations are fined, thus ensuring a high level of compliance and fee collection. Lebanon should consider transitioning to similar systems in the long term, because correlating the fee with the quantity generated and sorted will incentivize the population to produce less waste and recycle more.

Another type of mechanism targeted at operators would be the introduction of gate fees which are charges levied upon the delivery of waste to treatment and final disposal facilities. Lebanon can utilize such fees to support the economic viability of treatment facilities (e.g., recycling and WTE), and promote certain treatment types over others by imposing higher fees for landfilling compared to those for WTE, for example.

Extended producer responsibility, on the other hand, is aimed at recovering waste management costs from producers and importers. Through regulations, these players are expected to form "producer responsibility organizations" tasked with supporting the collection, treatment and final disposal of their products. In the EU, for example, 27 countries impose EPR systems on producers and importers of packaging materials. A similar system applied in Lebanon would decrease some of the financial burden on the government and encourage the producers and importers to utilize more eco-friendly products.

5. Planning and database

Set-up of a national database for more effective decision-making

A national database containing key information should be set up to support all involved stakeholders in achieving success. Through regular analysis of data collected, the Lebanese government can make more effective policy decisions and track the progress of its initiatives.

6. Private sector participation

Updated contract types, accessible database, ease of doing business and enforcement to support the private sector

Private sector participation plays a vital role in waste management across the entire length of the value chain. Its involvement can support technical and economic efficiency, and mobilization of private investment can expand the amount of financial resources available for infrastructure. In order for the private sector to succeed, however, it is imperative for it to have the support of the Lebanese government.

In that regard, more advanced and technically up-to-date **contract types** should be utilized (e.g., BOT, BOOT, DBFOT) to provide more attractive opportunities for investors.

Investors could use the aforementioned **database**, which would contain important data on Lebanon (such as quantity, composition and waste drivers), to make better-informed decisions.

Governmental support can also come in the form of **financial incentives,** such as tax cuts, grants and subsidized loans for waste management companies to make private sector investments more financially feasible.

Other actions could be aimed at increasing the demand for recycled products and compost through increasing tariffs on imported products and enforcing the use of these products in public sector activities.

Last, but definitely not least, the laws and regulations should be **properly enforced** to stop illegal scavenging of valuable waste components from containers before they reach licensed operators, as well as to ensure materials are properly sorted and hazardous waste (e.g., medical and industrial) is not mixed with MSW.

7. Import/export

Import and export of MSW is not a feasible solution, but export of hazardous waste should be considered

Several countries engage in the import and export of waste. For example, in 2014 Italy imported 5.9 million tons (77 percent scrap metal) and exported 3.8 million tons (60 percent hazardous waste and 24 percent paper and plastic) [9].This is usually driven by multiple factors, such as treatment costs,

transportation costs, availability of treatment facilities and expertise, and local and international regulations and treaties.

In the case of Lebanon, importing of waste is out of the picture in both the short term and the long term. Exporting of MSW is not a recommended solution either, mainly due to the high costs. On the other hand, exporting hazardous waste resulting from incineration should be considered because Lebanon currently does not possess the necessary infrastructure or expertise to manage it.

This can also support in decreasing some of the negative public sentiment against incinerators. Export of fly ash is currently being practiced by Sweden, Denmark and the Netherlands, mainly to Norway, Germany and Finland.

In order for Lebanon to leverage this solution however, several factors need to be considered. These include certain restrictions set by international treaties such as the Basel Convention, as well as EU and local-level regulations and standards.

Other considerations

MSW management can be a quick win to help achieve the CO_2 reduction pledges of the Paris Agreement

Lebanon is one of the signatory nations of the 2015 Paris climate change agreement, and must therefore act to reduce its national CO_2 (and equivalent gases) footprint. Municipal solid waste is a large contributor of greenhouse gas emissions. (They can constitute up to 8 percent of total emissions in developed countries. [10]) As such, waste management techniques can contribute in multiple ways to reducing emissions, mainly by limiting the impact of unmanaged landfills where greenhouse gases (GHG) escape, recycling plastics and other materials to avoid using virgin resources (that release GHGs during production), and recovering energy.

Some treatment options for other waste types can be integrated with those for MSW, but others require specialized facilities

While municipal solid waste is the most visible issue in Lebanon, it only constitutes part of the total waste produced. The remaining streams include construction and demolition waste, agricultural waste, industrial waste, sludge, medical waste, and special wastes (electronics, tires, end-of-life vehicles, batteries). Improper management of the aforementioned streams has led to frequent illegal dumping and pollution across Lebanon, and special consideration should be enacted, especially for hazardous materials that have the largest potential negative impact on the environment.

The treatment options for some waste streams can be integrated with those for MSW (e.g., agricultural waste can be composted with organic MSW, and post-treatment electronics, end-of-life vehicles and sludge can be added to WTE plants). However, other streams, such as industrial hazardous waste, require specialized treatment and disposal facilities

Arthur D. Little waste management project

Arthur D. Little recently completed an engagement with a leading ministry of a large country. We supported the ministry in defining its integrated national waste management strategy, which included a review of its institutional framework. Based on our experience with this project, we believe the key success factors for a country wishing to revamp its waste sector are:

- Engaging and ensuring alignment across all relevant stakeholders in order to form recommendations that consider all aspects
- Selecting relevant case studies and leveraging best practices and lessons learned
- Developing practical and implementable recommendations
- Utilizing deep technical expertise from ADL's experts network to select strategic options that optimize environmental impact, cost, socio-economic impact and ease of implementation

Key outcomes from this assignment were:

- Waste sector strategy definition and detailing, including basic outlines of key enablers, as well as waste-stream policies and targets
- Recommendations for central governance structure and mechanisms
- Impact assessment of selected strategic options based on economic, social and environmental indicators
- Definition of implementation roadmaps

3. Conclusion

Municipal solid waste in Lebanon still requires long-term solutions, as the current emergency solution is temporary. While the government has already set in motion longer-term plans, it is still facing many challenges. Strategic initiatives should be launched to enable the integrated national waste strategy through development of a robust governance system and leveraging the seven key enablers. This can allow Lebanon to preserve its ecological wealth.

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The Lebanon municipal solid waste crisis and pathways forward – Insights into long-term solutions for the municipal solid waste crisis

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