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LEBANON

Cost of environmental degradation due to solid waste management practices in BEIRUT and MOUNT LEBANON

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SWEEPNET

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SWEEPNET

The Regional Solid Waste Exchange of Information and Expertise network in Mashreq and Maghreb countries

LEBANON

COST ASSESSMENT OF SOLID WASTE DEGRADATION IN BEIRUT AND MOUNT LEBANON

May 2014

Sherif Arif and Fadi Doumani

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ACRONYMS

BA	Benefit Assessment
B/C	Benefit/Cost
BCA	Benefit/Cost Analysis
BFT	Benefit Function Transfer
BML	Beirut and Mount Lebanon
CAS	Central Administration for Statistics
CASWD	Cost Assessment of Solid Waste Degradation
CDR	Council for Development and Reconstruction
CDW	Construction and Debris Waste
CH_4	Methane
CO_2	Carbon Dioxide
COED	Cost of Environmental Degradation
CV	Contingent valuation
EDL	Electricité du Liban
EPA	Environmental Protection Agency of the United States
EU	European Union
GDP	Gross Domestic Product
GIS	Geographical Information System
GiZ	Gesellschaft für Internationale Zusammenarbeit (previously GTZ)
Ha	Hectare
IMFU	Independent Municipal Fund
IRR	Internal Rate of Return
Kg	Kilogram
LP	Lebanese pound
m	meter
m^2	Square meter
m^3	Cubic meter
MOE	Ministry of Environment
MOF	Ministry of Finance
MOIM	Ministry of Interior and Municipalities
MOPH	Ministry of Public Health
MSW	Municipal Solid Waste
NOx	Nitrogen Oxides
NPV	Net Present Value
O&M	Operations and Maintenance

OMSAR	Office of the Ministry of State for Administrative Reform
PV	Present Value
SOx	Sulphur Oxides
SO_2	Sulphur Dioxide
SWM	Solid Waste Management
TEV	Total economic value
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WDI	World Development Indicators
WHO	World Health Organisation

EXECUTIVE SUMMARY

Solid Waste Management (SWM) was one of the priorities of the Government of Lebanon for removing the scars of the civil war which erupted in 1975 and lasted for 15 years during which all public services were deteriorated. To date with a population of 4.42 million in 2013 and a GDP per capita of US$ 9,190 in 2012, Lebanon generates an estimated 2.55 million tons/year of waste, and made the following valuable progress:

a) The collection services rate has reached 98-100% in urban areas and 90-95% in peri-urban and rural areas, ranking Lebanon first among the Middle East and North African countries;

b) About 53% of the waste generated is disposed in 4 sanitary landfills, the Naameh and Bsalim (rejects) landfill in Beirut and Mount Lebanon (BML), the Zahle landfill covering 18 municipalities of the 33 surrounding villages of this governorate and the coastal landfill in Tripoli;

c) The private sector is fully involved in the collection transport and disposal of MSW but at very high costs in BML;

d) The state of cleanliness in the major Lebanese cities is remarkable;

e) The solid waste sector ranks first in terms of the Government related spending with a total of US$ 647 million over the 1998-2008 periods;

f) The two largest dumpsites in Beirut, in Bourj Hammoud (a gas venting system was installed but the pile was not removed) was controlled and Normandy was rehabilitated respectively so was the dump site in Tripoli that was controlled. Moreover, the Zahle dumpsite was closed downed and a new landfill is being operated by the municipality, and Saida coastal dumpsite is currently being rehabilitated.

Despite such improvements, there has been very slow progress on the institutional, legal and financial front:

a) There has been a series of SWM policies, strategies and master plans since 1998 till now that have been approved by successive governments but remained inapplicable. These strategies called for an integrated SWM to be established either in governorates or group of municipalities using sanitary landfill where composting and recycling were encouraged. Recently in 2012, waste to energy was agreed by the Council of Ministers as a disposal method, but could not yet be implemented as it is perceived to be very costly;

b) A comprehensive SWM strategy was submitted to the Council of Ministers in 2006 and updated and approved in 2010. It is waiting to be ratified by the Parliament whose sessions are currently suspended;

c) The institutional framework comprising Council of Development and Reconstruction (CDR), the Ministry of Interior and Municipalities (MoIM), the Ministry of the Environment (MoE) and Municipalities is still unclear and confusing. The CDR contracts the private sector for the services of the collection, transport, treatment and disposal of the municipal waste for BML, as well as the rehabilitation of landfills. The municipalities of Tripoli and Zahle manage by default their landfills using their own resources and transfers through the Independent Municipal Fund for the former. Most other municipalities manage their waste chain on their own. The Council of Ministers gives financial incentives to host waste coming from other municipalities. The Office of the Minister of State for Administrative Reform (OMSAR), which is not supposed in its prerogatives to deal with the waste sector, is financing through grants from the European Union some solid waste composting and recycling plants. The Ministry of the Environment (MOE) has prepared legislation and contributes to the preparation of plans and strategies with CDR and MOIM;

d) Lebanon suffers from major budget deficits in the SWM sector and the system is not sustainable as cost recovery is minimal. Municipalities perceive a small fee for solid waste collection, sweeping and sewer network services (Arsifa wa Majarir) that were estimated at 10% of the cost of operation and maintenance of SWM;

e) Public participation in planning, policy and implementation is absent. There is persistent distrust vis-à-vis the provision of waste management services by the Government as well as resistance to pay for municipal waste services.

It is within this general context that the cost of environmental degradation due to municipal waste in the Mashrek and Maghreb Partner's countries is being supported by SWEEP-Net. SWEEP-Net is the Regional Solid Waste Exchange of Information and Expertise Network for strengthening the institutional and human capacities for integrated resource and SWM. SWEEP-Net's objective is to establish a common regional platform for exchange on best practices, expertise and experiences and technical assistance, and policy advice in the field of resource and SWM through:

- Stimulating and facilitating exchange and sharing of information, experiences, and knowledge using a combination of communication means;
- Allowing its members to share information and knowledge and support each other's work through its information and communication systems and tools;
- Providing advocacy and policy support for sustainable and integrated SWM;
- Facilitating and promoting the successful application of policies, planning tools, financing mechanisms, and technologies that are environmental sound, socially acceptable economically viable.

Table 1: BML Cost Assessment of Solid Waste Degradation and Opportunity Loss, 2012, US$ million

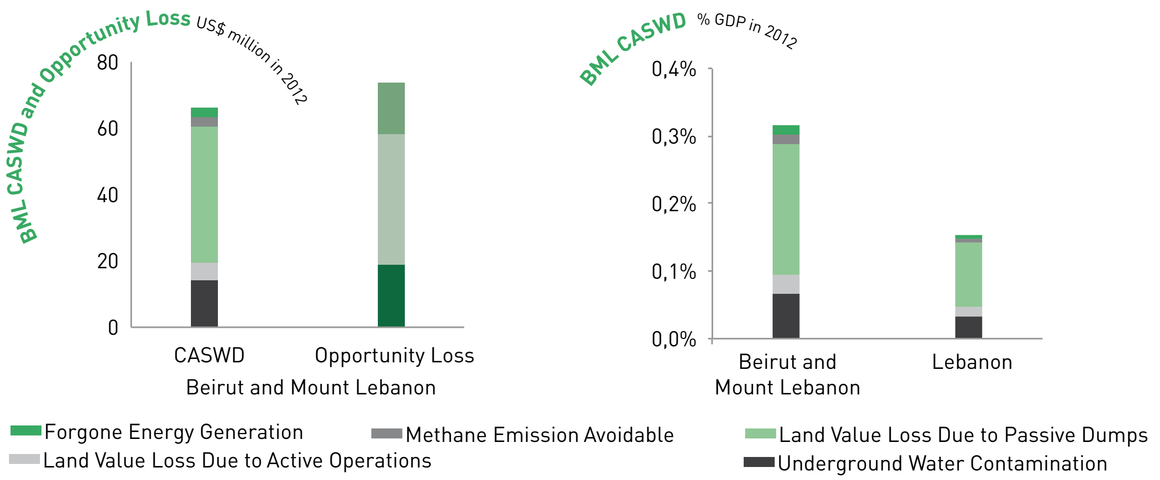
Typology of Degradation Costs	CASWD		Lower Bound	Upper Bound	Opportunity Loss	
	US$ million	%	US$ million	%	US$ million	%
Collection	0.0	0.0%	0.0	0.0	18.7	25.3%
Discharge	0.0	0.0%	0.0	0.0		
Recycling and composting	0.0	0.0%	0.0	0.0	39.7	53.7%
Landfill area avoidable	0.0	0.0%	0.0	0.0	15.5	21.0%
Underground water contamination from active landfills	14.3	21.6%	5.5	65.4		
Loss of land value around waste processing plants	2.5	3.8%	2.0	3.0		
Loss of land value around active landfills	2.8	4.2%	2.2	3.4		
Loss of land value around passive landfills	0.0	0.0%	0.0	0.0		
Loss of land value in active dumps	0.0	0.0%	0.0	0.0		
Loss of land value in high risk passive dumps	40.9	61.5%	32.7	49.1		
Health effects	NA	0.0%	NA	NA		
Methane emission avoidable	3.1	4.7%	2.9	3.3		
Forgone energy generation	2.8	4.2%	2.6	3.0		
Total	**66.5**	**100.0%**	**47.9**	**127.2**	**73.9**	**100.0%**
% GDP Beirut and Mount Lebanon	**0.3%**		**0.2%**	**0.6%**		**0.4%**
% GDP Lebanon	**0.2%**		**0.1%**	**0.3%**		**0.2%**

Note: NA stands for Not Available.

Source: Authors.

The results are divided into Two distinct categories: the CASWD and the opportunity loss from interventions that could reap some benefits and improve the management of the waste sector in the future. The BML CASWD and Opportunity Loss results are shown in Table 1 and Figure 1. The CASWD of BML reaches US$ 66.5 million (LP 100 billion) in 2012 with a variation between US$ 48 and 127 million equivalent on average to 0.3% of GDP in BML and 0.2% of the current national GDP of Lebanon in 2012. Conversely, the opportunity loss from interventions that could improve the waste sector management amounts to US$ 74 million (LP 112 billion) almost equivalent to the same GDP figures.

Figure 1: BML Cost Assessment of Solid Waste Degradation and Opportunity Loss, 2012, US$ million



Source : Authors.

Broken down by CASWD sub-category, the loss of land value around high risk passive dumps is the most significant in BML with a relative value with 61.5% of the total in 2012. The water contamination due to leachate (21.6%) ranks second followed by the land loss around active waste processing plants and landfills (8%), methane emission avoidable from Naameh (4.7%) and finally by the forgone energy generation (4.2%). Health effects were not valued because they need further investigations as they are perceived as an issue by the people living in the Naameh landfill area.

Broken down by opportunity loss sub-category, the forgone value associated with recyclables and composting (53.7%) ranks first and is followed by the opportunity cost of subsidizing the collection (25.3%) as municipal scarce funds are put to better use, and finally by the landfill area avoidable in Naameh and Hbaline landfills (21%) should all recyclables and composts mentioned above are processed.

The estimated cost assessment of solid waste degradation are shedding some new lights on the waste problem in Lebanon in general and BML in particular. The improvement of the valuation techniques and better data helped derived a significantly higher CASWD when compared to the national GDP: 0.2% for BML in terms of the national GDP as compared to barely 0.09% for the entire country in 2005. The largest sub-category (61.5%) remains the **liability inherited not only from past neglect** due to poor SWM but also from past and current CDW practices where the construction boom is not only taking its toll on quarries but also on spontaneous and possibly not inventoried CDW dumps. In the case of passive dumps, only the high risk passive dumps are considered in the CASWD. Yet, with its current practices, the landfill in Naameh, which is still being used beyond its full capacity, could already generate electricity through the capture of methane hence reducing GHG (9% of CASWD). The landfill seepage and contamination of soils and underground water is problem that requires further investigation and monitoring not only for active landfill downstream areas (21.6%) but also for passive dumps downstream areas. Land depreciation around processing waste plants and landfills (8%) is a **necessary bad** but remains a relatively small price to pay compared to the other problems valued in this exercise. Based on these findings, three priorities emerge in the short and medium term and merit further analysis:

- How viable is an increase in recycling and composting in BML and could these efficiencies drastically reduce the land needed for landfilling?
- How viable is the closure and rehabilitation of high risk MSW and CDW dumps?

- A third priority that will require further investigation in the future is as follows: are pollutants emanating from processing waste plants, dumps and landfills causing respiratory (through emission of pollutants) and water-related (through underground water contamination) diseases?

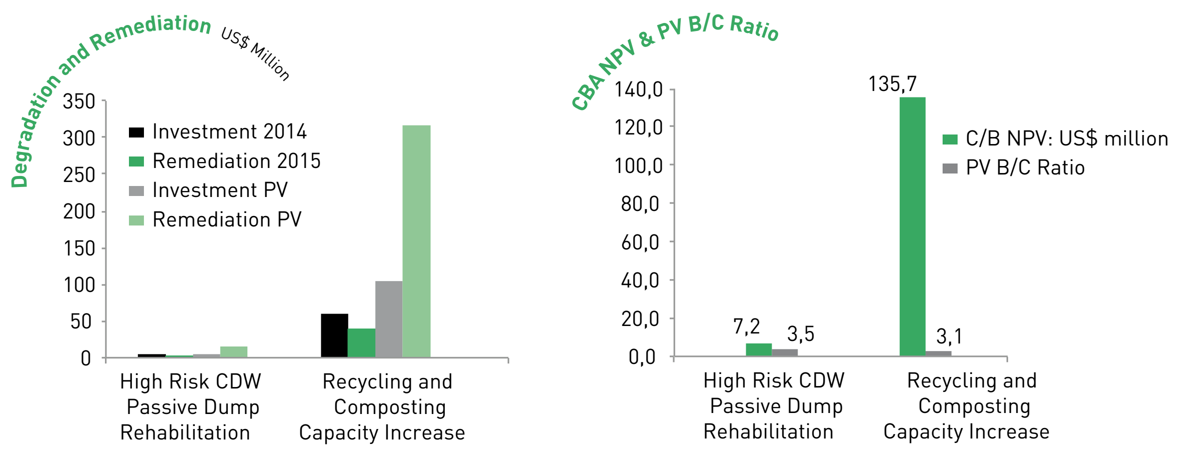
With regards to opportunity loss, recycling and composting has the potential of reducing wastage in terms of recyclables, compost and land for landfilling in BML as demonstrated by the waste processing plant in Hbaline that was unfortunately dismantled in 2011 and seemed profitable according to its first private operator until 2010: a mere 5% of the waste generated in Jbeil ended up in the landfill. Still, it remains to be seen if larger capacity could achieve economies of scale and improve efficiencies when it is compared to the new Government policies to install waste to energy (WTE) along the coast in Selaata and Jyeh to service BML. A serious aspect of opportunity loss is also the lack of cost recovery and considering the introduction of a household fee at least for collection will help put the sector on a sustainable footing.

Table 2: Cost/Benefit Analysis of BML Selected Interventions, 2012, US$ million

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 3 High Risk Passive MSW & CDW Dump Rehabilitation over 20 years	Scenario 1 Recycling and Composting 60% of the Constant Waste Volume Generated in BML in 2012 over 20 years
NPV (US$ million)	→0	8.5	135.7
IRR (±%)	↗10%	28%	36%
PV Benefit/Cost Ratio	→1	3.2	3.1
Project Viability		**Yes**	**Yes**

Source: Authors..

Figure 2: Cost/Benefit Analysis of BML Selected Interventions, 2012, US$ million



Source: Authors.

Based on priorities identified in the previous section, two selected remediation interventions were considered in BML by performing a BCA: rehabilitation of the BML passive dumps constituting a high risk; and recycling, composting and avoided landfilling in BML in case the Government adopts a zero waste strategy. The most relevant scenarios were selected and are shown in Table 2 and Figure 2. Three scenarios were considered for the rehabilitation of dumps where: (i) MSW passive dump rehabilitation; (ii) CDW passive dump rehabilitation; and (iii) MSW and CDW passive dump rehabilitation. For recycling and composting, one scenario was considered where the same amount of waste generated in 2012 was kept constant over

20 years and where treatment reduced 2012 generation by 60% in BML. This BCA analysis is meant to shows that recycling and composting pays when the volume recycled and composted is decentralized at the caza level (each caza is assumed to have a waste processing plant) and when the price of recyclables and certified compost is right. Additional analysis is however needed to do a volumetric analysis (waste generation increase overtime) and include the price of the landfill. The results are a very preliminary estimates that need to be refined should the Government decide to move ahead with these priorities. Both projects are viable with NPV reaching US$ 8.5 and 135.7 million respectively with an IRR of 28% and 36% and a PV Benefit/Cost Ratio greater than 1. Nevertheless, other weighted criteria (e.g., scarcity of land, people resistance and NIMBY syndrome, etc.) should be considered before any selection is made.

The High Risk MSW and CDW passive dump closure and rehabilitation are viable and could create occasional green jobs. However, the risk associated with soil and underground water pollution is probably considered in the Sensitivity Risk Indicator but merit further attention in selecting the priority dumps to be rehabilitated. Increasing the recycling and sorting capacity to reduce the actual waste by 60% is highly viable and needs further investigation and analysis before embarking upon more ambitious and costly investments such as the WTE that could increase the government deficits in the future. More efficient alternatives, such as zero waste, could prove very efficient and economically viable if waste processing is decentralized at the caza level and prices and quality of recyclables and compost are right.

The diagnosis and analysis helped reach the following conclusions:

- The municipal waste management sector especially in BML, is characterized "by many investments carrots and no institutional and regulatory sticks".
- The municipalities in BML do not have the tax base to be able to provide and sustain adequate MSW services.
- After 18 years since the emergency plan of SWM was approved, the Central Government continues to invest in the SWM services at very high cost.
- The lack of proper disposal of all types of wastes in the old dumps are adversely affecting the surface and groundwater resources of BML, given the high permeability of its soil.
- The cost assessment of solid waste degradation is high (US$ 66.5 million) and represents 0.2 percent of the national GDP in 2012. This degradation affects primarily the natural resources until further evidence is provided that pollution generated from MSW also can affect public health.
- The CASWD is almost equivalent to the opportunity loss (0.2% of GDP) in terms of collection fee subsidy and the forgone revenues that could be generated should recycling and composting is optimized.
- With the exception of three large dump sites which were rehabilitated and the Saida dumpsite being rehabilitated, no investments were made on the MSW and CDW dumps which had and continue to "mushroom" in the region.
- BML is being adversely affected by a past neglect of its open dumps, an unsustainable present of its MSW services and a bleak future for replacement alternatives to its major disposal sites. Many ministerial decisions were taken and plans prepared, however, the political economy and crisis management still prevail over a strategic and realistic approach for an integrated SWM system for this region.

Based on the above general conclusions, the following recommendations are proposed for moving towards an integrated sustainable waste management system using BML as a pilot region. Such system would consist of three building blocks: (a) involving the stakeholders; (b) establishing an effective and efficient waste system elements from pre-collection to disposal and the valorisation of the municipal waste; and (c) strengthening the municipal waste management aspects from an institutional, legal, financial, and environmental and social point of view. At this stage, it is important to note that these three building blocks cannot be implemented in parallel over a short and medium terms of 2-5 years, however, it should start by the following elements at pace commensurate with the socio-economic situation in Lebanon.

(a) Stakeholders involvement and participation can be initiated by:

- The Ministry of the Environment and the local NGOs for developing a joint communication strategy that will facilitate the understanding of the MSW services in BML and gain the support and participation of households on the interventions proposed by the municipalities and by CDR;
- The MSW operators and the local NGOs by establishing a pilot community interaction in 1-2 cities such as in Byblos and Aley, whereby the MSW management stakeholders including the informal and formal private sector, and local NGOs contribute their views on the development of city master plans, facility planning /siting and facility monitoring;
- CDR and the MOE soliciting community inputs to address the NIMBY responses of new MSW management facilities and explaining the social, economic and environmental benefits of the proposed new facilities while considering a willingness to accept stated preference for communities living nearby the sites.

(b) An effective and efficient MSW can be achieved by:

- Setting investment priorities that will include: (a) establishing at the caza level or within a group of municipalities, new MSW facilities with technologies that are environmentally proven, technically feasible, cost effective, affordable, and within the management capacities of the municipalities it serves; (b) rehabilitating high risk old dumps (such as Hbaline) in parallel with establishing new MSW facilities as the NPV for old dump rehabilitation is US$ 8.5 million over 20 years; and (c) reinforcing the Council of Ministers reward system for municipalities that would establish new MSW facilities (for which land is scarce) and rehabilitating the old dumps;
- Managing waste materials as an economic resource by decentralizing the composting and recycling activities at the caza level as the benefit cost analysis showed a very high NPV of US$ 135.7 million over 20 years in case the Government will be planning to adopt a zero waste strategy;
- Making use of the Clean Development Mechanism for the Naameh landfill as a new source of revenue to the neighboring municipalities (in case the Naameh landfill will not be closed), that make clean technologies financially attractive, and may also attract new stakeholders and new levels of private sector interest and capability;
- Reviewing the cost effectiveness for MSW Services in the BML by: (a) re-assessing the operations costs of the short term 3-year and 5-year contracts for collection services, sorting plants and the composting plant; and (b) introduce competitive bidding upon expiration of all current contracts, to achieve better cost efficiency.

(c) Strengthening the municipal waste management aspects will include:

- Preparing a MSW management plan that would identify the best solutions based on benefit/cost analysis and on a complete set of actions, including coordination needs among all the stakeholders along these priorities in ways that are protective of the environment, affordable, and responsive to feedback from the public;

- Developing an effective institutional framework within BML that will include clear identification of responsibilities and coordination between the municipalities, the MOE, CDR and the operators in charge of tasks associated with the design, operations, monitoring, and enforcement of waste management systems;
- Establishing environmental criteria and standards for MSW and development of incentives to favor environmentally sound SWM services;
- Introducing a phased approach for cost recovery in BML accompanied by improved MSW management services that is publically acceptable, and based on effective public awareness and communications initiatives;
- Undertaking research, data collection and analysis on the linkages between health and pollution due to MSW to determine the impacts of pollution on public health using the Naameh landfill as a pilot.

1. INTRODUCTION: THE SOLID WASTE SECTOR IN LEBANON

Solid Waste Management (SWM) was one of the priorities of the Government of Lebanon for removing the scars of the civil war which erupted in 1975 and lasted for 15 years during which all public services were deteriorated. To date with a population of 4.42 million (2013)[1] and a GDP per capita of US$ 9,190 in 2012, Lebanon generates an estimated 2.55 million tons/year of waste[2], and made the following valuable progress:

a) The collection services rate has reached 98-100% in urban areas and 90-95% in peri-urban and rural areas, ranking Lebanon first among the Middle East and North African countries;
b) About 53% of the waste generated is disposed in 4 sanitary landfills, the Naameh and Bsalim (rejects) landfill in Beirut and Mount Lebanon (BML), the Zahle landfill covering 18 municipalities of the 33 surrounding villages of this governorate and the coastal landfill in Tripoli;[3]
c) The private sector is fully involved in the collection transport and disposal of MSW but at very high costs in BML;
d) The state of cleanliness in the major Lebanese cities is remarkable;
e) The solid waste sector ranks first in terms of the Government related spending with a total of US$ 647 million over the 1998-2008 periods;[4]
f) The two largest dumpsites in Beirut, in Bourj Hammoud (a gas venting system was installed but the pile was not removed) was controlled and Normandy was rehabilitated respectively so was the dump site in Tripoli that was controlled. Moreover, the Zahle dumpsite was closed downed and a new landfill is being operated by the municipality, and Saida coastal dumpsite is currently being rehabilitated.

Despite such improvements, there has been very slow progress on the institutional, legal and financial front:

a) There has been a series of SWM policies, strategies and master plans[5] since 1998 till now that have been approved by successive governments but remained inapplicable. These strategies called for an integrated SWM to be established either in governorates or group of municipalities using sanitary landfill where composting and recycling were encouraged. Recently in 2012, waste to energy[6] was agreed by the Council of Ministers as a disposal method, but could not yet be implemented as it is perceived to be very costly and was delayed as a result of the COM changes;[7]

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1 - World Development Indicators (2013), the World Bank.
2- Waste generation growth rate was estimated at 1.65% as per SWEEP-NET country report of Lebanon, 2013.
3- Lebanon Country Environment Analysis, The World Bank, 2011.
4- Lebanon Country Environment Analysis, The World Bank, 2011.
5- Council of Ministers decisions number 27 dated 11/07/2002, number 16 dated 14/08/2003, number 1 dated 13/11/2003, number 22 dated 28/03/2004, and number 12 dated 8/04/2004, the CDR plan of 2005, the household SWM Plan proposed by CDR and the MOE, pursuant to Decision No.1 dated 28/6/2006, the strategy developed by the MOE in 2010, The 2010 SWM Plan, which was initiated pursuant to the COM Decision No. 1 of 3/2010, and endorsed by the COM on September 1, 2010.
6- The 2010 SWM Plan, which was initiated pursuant to the COM Decision No. 1 of 3/2010, and endorsed by the Council of Minister on September 1, 2010.
7- Ramboll, Preparation of Pre-qualification Documents and Tender Documents for Solid Waste Management in Lebanon, Contract No. 17653.

b) A comprehensive SWM strategy was submitted to the Council of Ministers in 2006 and updated and approved in 2010. It is waiting to be ratified by the Parliament whose sessions are currently suspended (Box 1.1);

c) The institutional framework is still unclear and confusing. The Council of Development and Reconstruction (CDR) contracts the private sector for the services of the collection, transport, treatment and disposal of the municipal waste for BML, as well as the rehabilitation of landfills. The municipalities of Tripoli and Zahle manage by default their landfills using their own resources and transfers through the Independent Municipal Fund for the former. Most other municipalities manage their waste chain on their own. The Council of Ministers gives financial incentives to host waste coming from other municipalities. The Office of the Minister of State for Administrative Reform (OMSAR), which is not supposed in its prerogatives to deal with the waste sector, is financing through grants from the European Union some solid waste composting and recycling plants. The Ministry of the Environment (MOE) has prepared legislation and contributes to the preparation of plans and strategies with CDR and Ministry of Interior and Municipalities (MOIM);

d) Lebanon suffers from major budget deficits in the SWM sector and the system is not sustainable as cost recovery is minimal. Municipalities perceive a small fee for solid waste collection, sweeping and sewer network services (Arsifa wa Majarir) that were estimated at 10% of the cost of operation and maintenance of SWM;[8]

e) Public participation in planning, policy and implementation is absent. There is persistent distrust vis-à-vis the provision of waste management services by the Government as well as resistance to pay for municipal waste services.

BOX 1.1. THE 2006 AND 2010 SOLID WASTE MANAGEMENT STRATEGIES

SWM is considered a priority issue in Lebanon. Whereas a dramatic improvement has been achieved in terms of collection and street sweeping without however a demand-management effort to reduce waste, a major problem resides in the remaining SWM chain management and its cost-effectiveness: from segregation to proper disposal.

2006 SWM Plan

The COM initially approved the Household SWM Strategy proposed by CDR, pursuant to Decision No.1 dated 28/6/2006 but the implementation of the comprehensive plan was perceived as very costly. Accordingly, CDR started studying several contracting proposals and alternative methods for securing funding sources, in order to reduce the cost. This included the resort to low interest loans, risk reduction and increasing competition by allowing Lebanese contractors to participate in the supply of equipment, as well as in the construction, treatment and landfill works. CDR sub-

8- *Lebanon Country Environment Analysis, The World Bank, 2011.*

mitted these proposals to the COM, which approved in its Decision No. 88, dated 10/11/2007 to: (i) commission a committee formed of representatives of the MOIM, MOE, MOF and CDR, which will work under the supervision of the Prime Minister. This Committee shall propose the proper solutions for the Plan tender in the light of the options provided by CDR, to be submitted to the COM for approval; and (ii) extend the sweeping, collection and landfill contracts for 3 years under the same conditions, in order to ensure continuity of work.

The Plan approved by the COM was based on the following principles: recycling and composting to the greatest extent in order to reduce the quantity of dumped waste; and distribution of recycling, sorting and composting plants on all Cazas, with one or more sanitary landfill in each service area. For this purpose, Lebanon was divided into four service areas: BML, Southern Lebanon, Northern Lebanon and Beqaa and Baalbeck. The Plan also considers the provision of incentives to municipalities whose lands will be used for sorting stations, composting plants, sanitary landfills or incinerator centers. Moreover, the plan gave incentives to municipalities on the basis of US$ 2 per ton for hosting a sorting and composting facility and US$ 4 per ton for hosting a sanitary landfill.

2010 SWM Plan

The formulation of the SWM Plan revolved along: ways and means; siting; financing; and prerogatives. Moreover, a committee was set up headed by the Prime Minister and including: the Ministers in charge of the Ministry of Displaced, MOE, MOEW, MOIM, OMSAR; and the CDR President to formulate the Plan. The SWM Plan, which was endorsed by the COM in September 2010, was formulated along these principles:

1. Consider the waste to energy (WTE) in large cities by regarding waste as a source of energy.
2. Implement the 2006 Plan in the remaining parts of the country by also considering the WTE option.
3. Engage the private sector and facilitate its involvement in various SWM stages through turn-key or different options.
4. Mandate the MOE and CDR to merge the two proposed strategies in conjunction with the above;
5. Mandate the MOEW to propose a legislation allowing the private sector to produce and sell the energy generated through the WTE process. A recent legal text was recently enacted with this regard.
6. Provide incentives to the municipalities that will host the SWM activities including WTE, segregation, composting, recycling and landfilling through an increase of IMFU transfers that will be determined by the MOF and the MOIM.
7. Mandate the CDR in coordination with the MOE to select an international consulting firm to: (i) propose a suitable solution and best alternative that fits the Lebanese context; (ii) carry out due diligence to short list only proven technologies; (iii) assess and categorize the companies; (iv) elaborate the tender; (v) evaluate the bids; and (vi) supervise the implementation.
8. Mandate the MOE to select an international consulting firm to supervise the implementation of the Plan in conjunction with its timetable and ensure quality assurance.
9. Mandate the MOE to select a local consulting firm to elaborate an awareness campaign to raise the WTE public acceptability.

Source: cited in World Bank Lebanon CEA (2011).

It is expected that for the years to come, the quantities of the municipal waste will increase given the increase of population, the existing flows of the Syrian refugees and increase in consumption. It is anticipated that the projected waste generation will reach 3 million tons in 2020 (exclusive of the Syrian refugees) in a country that is scarce in land disposal and minimal cost recovery.

Although there has been a remarkable progress in the collection of municipal waste, the landscape of waste disposal did not change since the nineties. The Naameh sanitary landfill which was established in 1998 to dispose of the waste of BML, have exceeded its design capacity. The life time of this landfill is being extended each time its capacity is reached. The other landfill is in Zahle, with capacity of 300 tons/days was established in 2003. Except of the Bsalim landfill for rejects (see below) and the Baalbeck landfill under implementation, no other sanitary landfills have been operated for the last ten years although Tripoli has a coastal sanitary dumpsite whose capacity was also extended several times given the lack of a clear strategy.

Lebanon is faced with the following important challenges concerning municipal SWM:

- Legal and institutional reforms are absolutely essential if Lebanon were to embark on the path of integrated SWM that would be sustainable in the long term. The integrated SWM law should be enacted and there should be clear definition of responsibilities and mandate between the ministries, the municipalities and the operators;
- The Parliament is currently being debating a new Law as over the years, this Law was hampered because of the NIMBY syndrome, the political economy, the exorbitant costs (such as waste to energy) of disposal and the unwillingness to pay. The appropriate strategy should be based on cost effectiveness and efficiency, realistic disposal options, acceptability of the citizens for the treatment and disposal services and balance of the limited resources that are being drained for delivery of these services;
- Increasing levels of public participation and consultation should take place on such issues as locations for transfer stations and landfills, cost recovery policies, and priorities for environmental enforcement. A comprehensive institutional strengthening on financial and contract management should be programmed and implemented. Only with strong capacity and consensus building at the local level, can there be a sustainable expansion of MSW services;
- A gradual cost recovery system should be designed and implemented. At present the Lebanese citizens and especially those who are living in BML do pay for a fraction of the collection services while the remaining MSW service chain is not. For example, CDR paid in 2010 an amount of US$ 130 million[9] year for MSW services in BML with a population of 1.87 million; i.e., US$ 69.5 (Table 5.1) per capita/year one of the highest among developed countries. Cost recovery should be gradually introduced, with the GOL considering that the initial capital costs are sunk costs and cost recovery would cover the operational and maintenance costs first. International experience shows that citizens are willing to pay for services, provided the costs and quality of solid waste services meet their expectations.[10] A 1% disposable income in BML is equivalent to US$ 83.6 per capita/year in 2012 which could easily cover the excessive collection and sweeping cost in BML.

9- SWEEP-Net Lebanon Country reports 2010.
10- Lebanon Country Environment Analysis, The World Bank, 2011.

In addition, Lebanon's potential economic prosperity would induce an increase in the generation of municipal waste which could corresponds to the GDP growth rate. The optimum solution for sustainable management, would be to improve the current situation, by adopting options that are already proven economic and feasible in the local context. For the coming years, it is expected that the amount of waste continue to increase following the growth of population, consumption and influx of refugees. Similarly, waste composition will change as it is expected with the improvement of the quality of life, hence an increase in the share of packaging. This development requires the rapid adaptation to modern environmental and technical standards through the provision of technical know-how of the private sector. A general objective would be to comprehend and apply the possible collections, treatment and disposal methods, to achieve a sustainable situation both from the technical and environmental point of views by internalizing the costs of environmental degradation.

2. SWEEP-NET SUPPORT TO THE SUSTAINABLE AND INTEGRATED MUNICIPAL WASTE MANAGEMENT

CONTEXT OF THE STUDY

It is within this general context that the cost of environmental degradation due to municipal waste in the Mashrek and Maghreb Partner's countries[11] is being supported by SWEEP-NET. SWEEP-NET is the Regional Solid Waste Exchange of Information and Expertise Network for strengthening the institutional and human capacities for integrated resource and SWM. SWEEP-NET's objective is to establish a common regional platform for exchange on best practices, expertise, experiences, technical assistance, and policy advice in the field of resource and SWM through[12]:

- Stimulating and facilitating exchange and sharing of information, experiences, and knowledge using a combination of communication means;
- Allowing its members to share information and knowledge and support each other's work through its information and communication systems and tools;
- Providing advocacy and policy support for sustainable and integrated SWM;
- Facilitating and promoting the successful application of policies, planning tools, financing mechanisms, and technologies that are environmental sound, socially acceptable economically viable.

The problems of municipal waste and their impact on the economy have been assessed at the national level (see Chapter 4). The situation is however different in the country's capital or its major cities, as no precise identification of problems and no assessment costs associated with degradation at the local level have yet been undertaken. Although the private sector was contracted by the CDR for the collection and disposal and treatment of municipal waste for BML, it is expected that in the future, the municipalities of BML will play a major role for ensuring the integrated and sustainable management of municipal waste as it is at the local and municipal level that decision should be made on waste management. The cost of environmental degradation due to municipal waste would allow the local institutions to have the necessary tools to defend on the basis of cost figures including the cost of environment externalities, their policy in the field of sustainable and integrated waste management and the investments needed to reduce these costs which are prohibitive for BML.

Through its focal point, Lebanon has requested SWEEP-Net assistance in assessing the cost of environmental degradation due to municipal waste. The selection of BML was for the following reasons:

- Beirut, the capital is the smallest governorate (19.5 Km^2) but is the most important governorate in view of its economical, political, cultural, and social activity. Greater Beirut include the suburbs of the capital with no clear delineation. Beirut is enclaved by Mount Lebanon Governorate which extends 170 Km parallel to the Mediterranean Sea. Although the administrative boundaries between the two governorates are not well delineated, however for the purpose of SWM, BML is served by the same group of operators for collection, street sweeping, transport, treatment and disposal of municipal waste with the exception of the district of Jbeil;

11- The 10 SWEEP-NET partners Countries are: Algeria, Egypt, Jordan, Lebanon, Mauritania, Morocco, Palestinian Territories, Syria, Tunisia and Yemen.
12- SWEEP-NET Website: www.sweep-net.org.

- The population in the two Governorates of BML is mostly urban and peri-urban, and is estimated at about 2.17 million inhabitants[13] which represent 50% of the total population of Lebanon. These two Governorates generate about 2,850 tons/day[14] of waste equivalent to 50%-58% of Lebanon's total waste generation;
- The two Governorates are considered to be the first economic pole of Lebanon. They include a myriad of economic activities: Banking and financial services, tourism, small and medium industrial enterprises and agriculture on the outskirts of Mount Lebanon.

OBJECTIVE AND STRUCTURE OF THE STUDY

The main objective is to value the cost of environmental degradation due to municipal waste to assist decision-makers at national and local levels to identify and prioritize specific actions to improve the integrated waste management through potential funding of projects related to environmental benefits and the reduction of externalities.

The expected results are:

(a) An overview of the economic aspects of municipal waste management problems in Lebanon;
(b) An assessment of the cost of the environmental degradation to encompass environmental health and ecological degradations;
(c) An economic analysis of certain response alternatives;
(e) Concrete recommendations to internalize environmental benefits for improving municipal waste management.

The COED can be understood as a measure of the lost welfare of a nation due to solid waste degradation. A loss in welfare includes but is not necessarily limited to:

- Loss of healthy life and well-being of the population (e.g., burden of disease);
- Economic losses (e.g., efficiency losses, competitiveness, forgone revenues); and
- Loss of environmental opportunities (e.g., loss of tourism, fisheries, biodiversity).

The study is divided into three main parts, and specific sub-categories valuation techniques and calculations available in Annexes 1, 2 and 3):

a. Part 1: Background, objective and legal, regulatory, institutional and policy assessment (Chapters 1, 2 and 3).
b. Part 2: Review of the cost of environmental degradation, methodology, aggregate and detailed valuation of sub-categories and selected remediation interventions (Chapters 4, 5, 6 and 7).
c. Part 3: General conclusions and recommendations (Chapter 8).

13- CAS website: www.cas.gov.lb
14- SWEEP-Net Lebanon country report 2013.

3. MUNICIPAL WASTE IN BEIRUT AND MOUNT LEBANON

A. SOCIOECONOMIC DEVELOPMENT OF BML

Beirut and Mount Lebanon consist of two distinctive Governorates with a total areas of 2,004.5 Km^2 which is 19.4% the total area of Lebanon with an average density of 1,000 people/Km^2. Greater Beirut is a de facto defined geographic boundary that includes roughly the lower part of the district of Metn, Baabda, Aley and Chouf.[15] The Mount Lebanon governorate is subdivided into the following six districts (or cazas) which themselves consist of 307 municipalities, each enclosing a group of cities or villages. The BML governorates and respective districts are listed below and are shown in Figure 3.1:

- Beirut Governorate: 1 district
- Mount Lebanon Governorate consists of six districts or cazas (and their capitals or Chef Lieu) namely:
  - Baabda (Baabda)
  - Aley (Aley)
  - Metn (Jdeideh)
  - Keserwan (Jounieh)
  - Chouf (Beiteddine)
  - Jbeil (Byblos)

Figure 3.1: Administrative map of Lebanon and of Beirut and Mount Lebanon

Source: http://en.wikipedia.org/wiki/Lebanon

BML is the first economic and industrial pole of Lebanon. In addition to the tourism industry and the financial sector, small and medium enterprises play a major role in the economic and social development

15- *Lebanon Sate of the Environment report 2001, MOE/LEDO.*

of this area. There is a strong concentration of industries in the BML area which together comprise 57% of industrial units (13,400 units) and 70% of the industrial workforce of 100,000 people[16] a large number is within the residential areas, especially in the southern suburbs of Beirut. The vast majority of the industries operate in food and beverage manufacture, trading, clothing, tanneries, metal products manufacturers and textile finishing companies. Olive oil production, slaughter houses, agro food and agro business industries are located in several industrial zones.[17] Most of the industrial zones are located within territories with hardly any natural protection against groundwater contamination with no waste water pre-treatment. Very little is known about the quality of the groundwater underlying these facilities, but it should be expected that given the poor soil and very karstic ground, the aquifers would be contaminated.

In fact based on the evaluation of the hydrological and geological features,[18] it can be concluded that there are relatively few areas which can justifiably be considered to be of low vulnerability for contamination of ground and surface water. These areas can be found primarily around Beirut. Due to a predominance of karstic limestone, many areas in Lebanon are considered of high vulnerability. Such areas include the Mount Lebanon Range and the Chouf Mountains. In these areas, the natural disadvantages may be so substantial that protective measures to avoid contamination are costly.

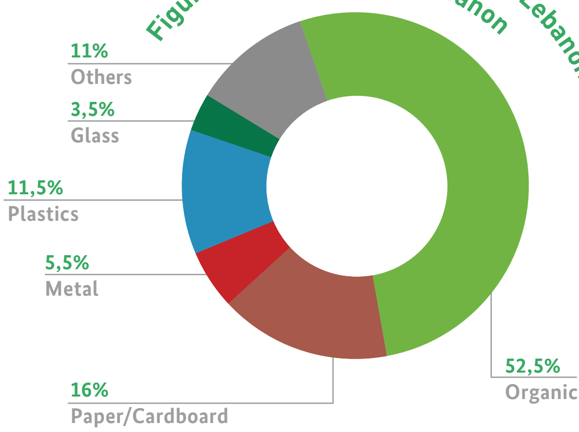
B. CHARACTERIZATION OF MUNICIPAL WASTE IN BEIRUT AND MOUNT LEBANON

BML daily generation is 1.18 Kg/capita/day[19] with a municipal waste collection coverage of 100%. The average household size is 3.75 in Beirut and 4.0 in Mount Lebanon.[20] Waste characterization has a moisture content of more than 60% with the composition shown in Figure 3.2.[21] Nevertheless, a share of the recycling material is usually picked up by waste pickers and a figure ranging between 12.5% and 25.2% of solid waste generated in Beirut was suggested by Laceco in 2009 and seems excessive.[22]

In accordance with the MSW emergency plan for BML (with the exception of Jbeil) which is still in effect since the Council of Minister Decision of 1997, the CDR has contracted on a sole source basis, and renewed several times the BOT services of the Averda Group consisting of two local operators, a Holding company of Sukleen for collection services and Sukomi for treatment and disposal services. The Group has established integrated MSW system consisting of:[23]

- Sorting and baling in two facilities: Qarantina (1,700 tons/day) in the northern suburbs and Amrousieh (1,150 tons/day) in the southern suburbs next to the airport;

Figure 3.1: Administrative map of Lebanon and and Mount Lebanon



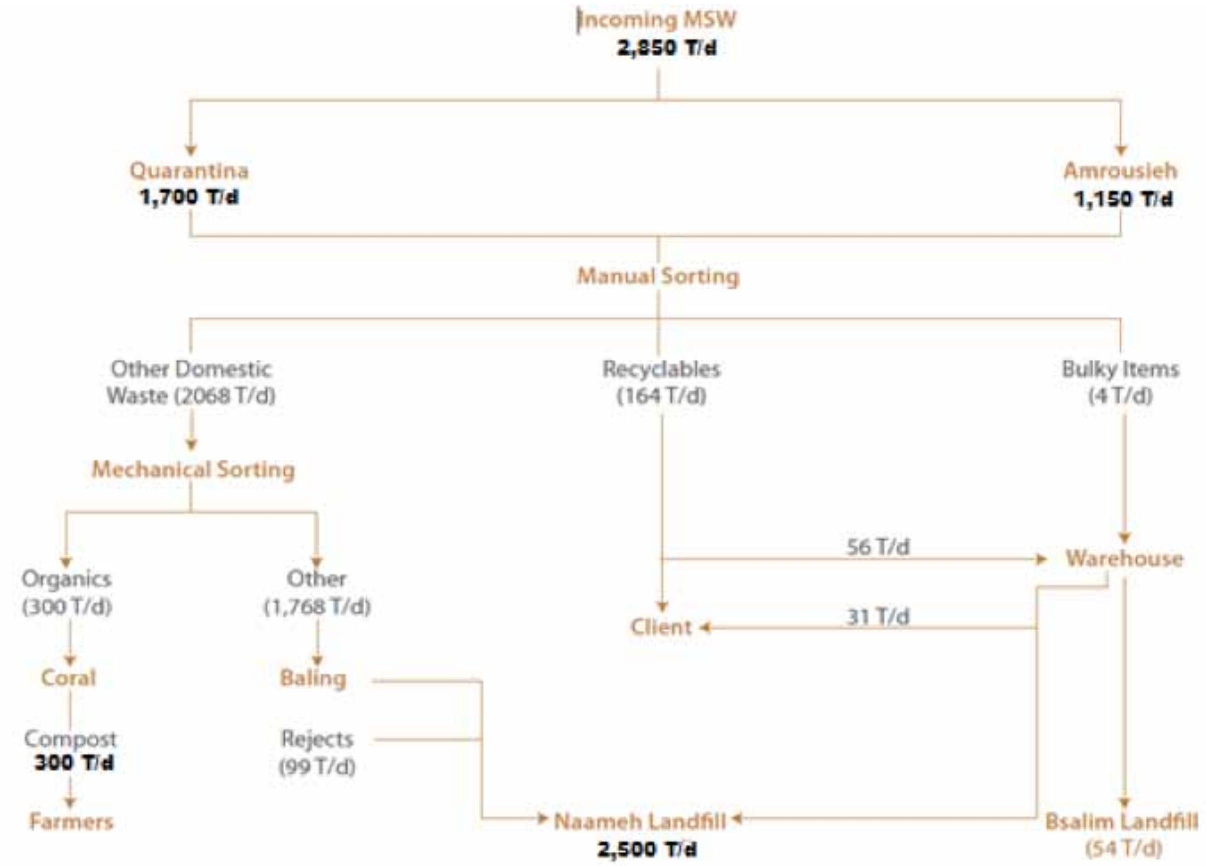
Source: SWEEP-NET Lebanon Country Report (2013).

16- http://chekka.info/pollutioninchekkanews_files/PollutioninLebanon33.htm
17- State of the Environment Report, 2001.
18- The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughout the country of Lebanon, ElARD, May 2011.
19- Lebanon Country Environment Analysis, the World Bank 2011.
20- Central Administration for Statistics website: www.cas.gov.lb.
21- Waste Composition in Urban Areas (ref : Sukomi company) and SWEEP-Net : Lebanon country report 2010.
22- Recycling For Sustainable Waste Management Practices. The first annual "sustainability week" June 17-19, 2009 Beirut, Lebanon. Presented by Nisrine Hougeiri, LACECO Architect & Engineers.
23- State of the Environment Report, 2010.

- Composting of organic material at the Coral facility (300 tons/day);
- Temporary storage of bulky and recyclable materials at the warehouse facility located near the Bourj Hammoud dump;
- Disposal of sorted MSW at the Naameh Landfill site (2,500 tons/day; and
- Disposal of inert and bulky items at the Bsalim Landfill (54 tons/day).

The MSW facilities have the following configuration as shown in Figure 3.3.

Figure 3.3: The Integrated MSW configuration for BML (with the exception of the district of Jbeil)



Source: Adapted from CDR-LACECO, 2010; and SWEEP-NET Lebanon country report (2013).

The Federation of the municipalities of Byblos assumes the responsibility of carrying out SWM services for the district of Jbeil with a waste generation estimated at 108 tons/day in 2012. The Municipal waste is disposed in the open dump of Hbaline with a volume of 375.000 m^3 for the last 30 years and has been operated with minimal human, equipment and civil works resources.[24] The dumpsite is located 230 m above sea level and 5 Km east of the Jbeil coastline and within a 1 Km radius from the Ghorfine, Kfar Massehoun, and Hbaline villages. The dumpsite is located within a perennial water stream-draining wadi Edde. Over the years, the dump expanded to encompass the banks of the wadi along with the natural drainage waterway. The dumpsite is awaiting rehabilitation with the establishment of a sorting station of 77 tons/day[25] financed by OMSAR and the European Union[26] which also provided MSW containers, and vehicles for MSW collection.

24- The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughput the country of Lebanon, ElARD, May 2011.
25- State of the Environment Report 2010.
26- http://www.localiban.org/spip.php?article4834

Based on the MSW configuration in Figure 3.3, the suggested 1,803 tons/day have reached about 2,850 tons/day that are currently disposed in the Naameh sanitary landfill in 2012. This landfill with a footprint area of 200,000 to 300,000 m^2 according to various sources, is an old quarry site situated in the Chouf district of Mount Lebanon at 15 Km south of Beirut and 4 Km from the coast line. It has been in operation since 1997. The landfill was originally designed to dispose of 3 million tons of solid waste, but it reached now approximately 12 million tons with a 20 meters height[27] in its three major cells. No other landfills was identified as the landfill reached over capacity and is a source of nuisance from odors, gases and perceived ill health by neighbors living in its vicinity. What is collected in terms of leachate is supposed to be transported to Al Ghadir's pre-treatment wastewater plant in Khalde next to the airport.

Figure 3.4: BML Municipal and Debris Dumps Needing rehabilitation and Bourg Hammoud Coastal Dump

Source: The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughput the country of Lebanon, ElARD, May 2011; and courtesy of Google Earth.

The inert materials are disposed of by SUKOMI in the Bsalim landfill which is also a quarry on the northern side of Nahr El Mot in the Metn district. The capacity of this landfill is one million m^3 and can dispose of 730,000 tons. The type of inner materials are subsoil, topsoil, rock, stone, clay, sand, tree branches, tiles and slates, brick and concrete, timber and wood, silica, glass, pottery and shredded woods and tires[28].

There are numerous open dumps in Mount Lebanon where waste is occasionally dumped and were not rehabilitated. They constitute a major source of pollution. These major dumps in the Mount Lebanon, which are among the 20 highest open dumps that need to be rehabilitated, include[29] Hbaline (in Jbeil, 375,000 m3), Zouk el Khrab (in Metn, 8,500 m3) and Roayset el Ballout (in Baabda, 5,000 m3). Also 17 of the construction and demolition waste dumps are among the 20 highest ranked Construction and Debris Waste (CDW) that need to be rehabilitated (Figure 3.4). [30]

Recycling of most of the industrial packaging waste and part of the MSW (such as glass, batteries, paper, plastics and metal scraps) is at a reasonable high level. All recycling is based on market conditions without any regulation, price guarantees or Government support. Waste pickers and some transport compa-

27- *http://dailystar.com.lb/News/Lebanon-News/2013/Jul-27/225239-closure-of-naameh-landfill-unlikely.ashx#axzz2px7eft3T*
28- *State of Environment Report 2010.*
29- *The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughput the country of Lebanon, ElARD, May 2011.*
30- *The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughput the country of Lebanon, ElArd, May 2011.*

nies are active in collecting waste on demand and various private sector entrepreneurs have established formal and informal market for uncertified organic compost and recyclables.[31] Recently, recyclables have been exported as some plastic is being compressed, filled in containers and shipped to China.

The cost of collection, street sweeping, sorting, treatment and disposal in the sanitary landfill consist of more than US$ 130-140/ton, which is the highest in the Middle East and North Africa Region and higher in many countries in Europe.[32] Clearly, the regional imbalance in favor of MSW services in BML is inequitable and unsustainable. It is draining public finance that prevent the Government from providing adequate MSW services to other regions of Lebanon. The Government has no immediate plan to introduce cost recovery system in BML though a reasonable expectation of affordable cost recovery would be in the range of approximately US$ 15/capita/year equivalent on average to about US$ 60/household/year to cover at least operation costs.

C. THE INSTITUTIONAL FRAMEWORK FOR MUNICIPAL SOLID WASTE IN THE BML

The major public actors involved in the MSW management are:

- The Ministry of the Environment;
- The Ministry of Interior and Municipalities;
- The Ministry of Finance;
- The Office of the Minister of State for Administrative Reform (OMSAR);
- The Council for Development and Reconstruction;
- The Federation of Municipalities of Mount Lebanon (Kesrouan and Metn);
- The Federation of Municipalities of Byblos.

The Ministry of the Environment (MOE) is the regulatory agency of the Government. MSW is addressed by the Service of Protection of Urban Environment. The functions of this service is to assist in the preparation of the MSW policies, strategies and plans in collaboration with other sector ministries; prepare and propose legislation for MSW; review and approve environmental impact assessment reports; participate and review all studies related to SWM; and develop standards and guidelines for waste management technologies and monitoring and control landfills.

The Ministry of Interior and Municipalities (MOIM) is responsible for governorate, caza, municipality and village matters as well for political parties and organizations[33] participating in the development of the national strategy. It coordinates and assists in the development of local waste management plans. Most importantly, the MOIM is managing with the Ministry of Finance (MOF) the Independent Municipal Fund (IMFU). The IMFU is provisioned by the MOF through 13 taxes and fees collected at the country level. Initially, the MOIM and MOF used to allocate a discretionary initial share of the envelope towards development projects that was usually channeled through the CDR and line agencies. The residual amount was distributed as a bloc grant, and as capital grant for development projects to the municipalities and Federation of Municipalities. Since the 1997 emergency Plan for BML, the MOIM/MOF deduct the payments from the IMFU at the source. The BML municipalities (with the exception of Jbeil) have no say on this

31- Lebanon Country Environment Analysis, 2011.

32- Cowi Consult, 1992, "Municipal Solid Waste Management for the Mediterranean Region", synthesis report, METAP.

33- MOIM website: www.moim.gov.lb.

arrangement as the IMFU covers the contract services of the private sector operator Averda negotiated with and renewed by CDR, hence reducing the municipalities' room of maneuver to implement development projects.

The Ministry of Finance is responsible for providing the budget to the MoIM, and also manages with the MoIM the IMFU as stated in the previous paragraph.

The Office of the Minister of State for Administrative Reform (OMSAR) is the government organization[34] that is responsible for providing technical assistance, assurance and institutional strengthening to ministries, public agencies and municipalities. OMSAR received a grant of € 14.2 million from the EU for the Assistance to the Rehabilitation of the Lebanese Administration including the improvement of SWM services in several municipalities through the provision of SWM equipment, medium size sorting and composting units. Through USAID, OMSAR provided financial assistance to the Federation of Municipalities of Jbeil to establish a sorting and composting station in Hbaline (see para. 18 above).

The Council for Development and Reconstruction (CDR) manages all the major infrastructure projects through local financing and international agreements, CDR is responsible for financing, contracting out and overseeing the implementation of the Emergency Plan for SWM in BML (with the exception of Jbeil) through private sector operators and contactors.

The Federation of Municipalities of Kesrouan and Metn are responsible for: (a) their participation in the National strategy and plan through the Waste Management Board; (b) for proposing and implementing local waste management plans for non-hazardous municipal waste; and (c) establishing / implementing waste Management programs, providing lands fo MSW disposal and for the management of waste collection[35].

The Federation of Municipalities in Byblos consists of 14 member municipalities. The federation is responsible for the collection and disposal of solid waste in these municipalities.

D. CONCLUSIONS

The diagnostic and analysis undertaken in the above institutions showed the following conclusions:

- The unclear responsibilities between the CDR, MOIM, MOE and the municipalities are also affected by a lack of qualified and motivated human resources in waste management. Generally, there is a limited technical, managerial, environmental knowledge in all public agencies responsible for waste management.
- The legal framework in waste management is still absent and monitoring and enforcement is practically non-existent. This vacuum created by the absence of legal framework has weakened the MOE role and responsibility as a regulatory agency. Lack of monitoring and enforcement is further aggravated by the complex socio-political conditions and strong private interest groups, and the lack of legislation and enforcement has resulted in serious public outcry relayed by the press and NGO activists.
- MSW expenditures in BML are excessive and continue to drain the Government and municipal budgets in the absence of well designed funding mechanisms for resource mobilization which is not yet forthcoming. The Government continues to pay excessive costs for all these services on the ground that it is repairing the scars of the civil war. Though, there is not yet evidence that such investments are effective and

34- *State of the Environment Report, 2010.*
35- *SWEEP-NET country report 2013*

efficient, e.g., outsourcing treatment and disposal contracts lacked tariff capping and proper incentives in BML as contracts were based on solid waste treatment input instead of an input/output ratio that would have improved composting and recycling output efficiencies. Also, the Emergency Plan for SWM in BML was meant to be momentarily before formulating a strategy that should focus on SWM at the district level hence reducing the significant transportation costs, and increasing the shares of recycling and composting while striving to reduce the volume of waste that needed landfilling. This disproportionate level of spending has occurred now for the last 17 years on the ground that Beirut should be clean to attract investments and tourism. Already benefiting from presumably these quasi-free services, the inhabitants of BML are still growing at a faster pace than other Governorates and the BML demand would continue to grow and no increase in cost recovery is anticipated in the near future. Moreover, the Government (CDR and MOE) Waste to Energy options for the coastal zone have a very high price tag with potential health hazards and environmental risks if these plants are not properly managed.

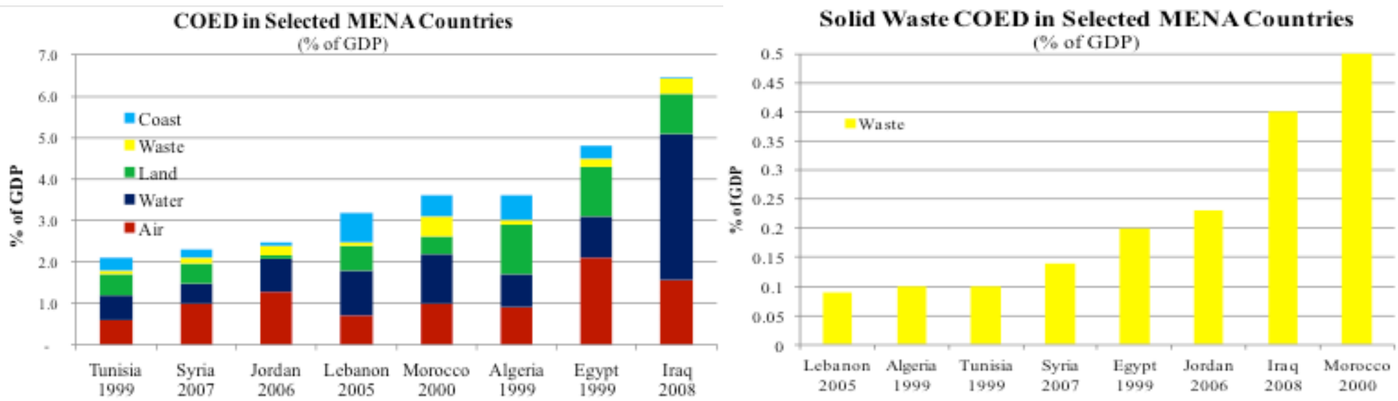
- Lack of treatment/disposal sustains environmental, water and groundwater hazards. Concerns about the lack of waste treatment/disposal facilities in the old dumps that require mitigating measures include health risks and environmental degradation that are both perceived and real. However the environmental issues related to air pollution, litter/odor were evident from burning waste in old dumps as well from aerobic waste decomposition.

It is because of the lack of economic impact assessment that a cost assessment of solid waste degradation (CASWD) due to municipal waste is timely. This assessment will allow to quantify, even approximately, and within an order of magnitude, the economic costs associated with environmental impacts due to municipal waste. This valuation will also allow, through the sectoral breakdown of the costs of degradation, decision makers to establish priorities for action in the field of integrated municipal waste management.

4. TAKING STOCK OF COST OF ENVIRONMENTAL DEGRADATION IN LEBANON

Many studies on CASWD at the national, regional and sectoral levels or the benefits accruing thanks to pollution reduction were conducted in Lebanon over the past twelve years. Also, the Cost of Coastal Zone Environmental Degradation with a 2005 base year[36] and the Cost of Hostilities with a 2006 base year[37] were performed to get a better understanding on the degradation in the northern coastal zone and the cost associated with the 2006 War (debris) with Israel but are not reflected below. The results of the national valuations, which cover various base years, are shown in Figure 4.1.

Figure 4.1: Costs of environmental degradation in MENA



Source : World Bank (2004); World Bank (2011); EC ENPI (2011); USAID (2012); and Authors.

METAP Project/World Bank and the European Commission estimated national cost assessment of environmental degradation, each using different methodologies. The results are as follows:

- In 2004, the METAP/World Bank calculated the national cost assessment of environmental degradation using data from 2000 covering six categories: air, water, waste, soil and biodiversity; coastal and cultural heritage, and global environment. These costs have been estimated at US$ 655 million in 2000 per year, or 3.9% of GDP including global environment. The CASWD was estimated at 0.05% of GDP or US$ 10 million in 2000. In comparison with other countries in the region, these costs rank relatively high in terms of percentage of GDP among the seven countries of the Mashreq and Maghreb countries region where the cost of the damage was assessed. However, these costs are significant and indicate that the greatest damage would be in two areas: (i) public health, especially in regard to water-borne diseases related to poor sanitation in the rural areas, respiratory diseases related to air pollution and the impact of the lack of disposal and treatment of waste and (ii) the productivity of natural resources, including the loss of agricultural productivity due to soil degradation, and impact on property values due to lack of disposal and treatment of waste.[38]

36- Ministry of Environment website: www.moe.gov.lb/getattachment/cc55ae33-fb34-4c08-a3c8-cc9202ce0dec/Integrated-Coastal-Zone-Management-in-Lebanon.aspx.
37- World Bank website: www.worldbank.org.
38- Sarraf et al. 2004. Cost Assessment of Environmental Degradation, World Bank Environmental Economics Series. Paper number 97. Washington, D.C.

- In 2011, the World Bank produced a rapid update of the national cost of environmental degradation in the Country Environmental Analysis which almost resulted in the same damages: US$ 800 million in 2005 per year equivalent to 3.7% of GDP including global environment. The CASWD was estimated at US$ 19 million equivalent to 0.09% of GDP in 2005.[39]

- In 2011, the European Commission estimated the increased environmental benefits at the national level covering 5 categories: air, water, nature, waste, and global environment. The benefits were estimated at 4% of GDP including global environment of € 2 billion in 2020 in 2008 prices if pollution were to be reduced by ± 50% in 2020 compared to 2008. The proportion of solid waste in these benefits was estimated at 0.2% of GDP in 2020 equivalent to € 106 million. In other words, in the case where pollution could not be reduced by 50 % in 2020, the cost of degradation considered could reach at least the equivalent of 0.4% of GDP in 2020.[40]

The study of the CASWD of the Greater Beirut takes into account these preliminary estimates, but will focus effectively on the damage caused by solid waste pollution and degradation of natural resources.

39- World Bank CEA (2011). Op. cit.

40- Doumani and Mucharrafiyeh. 2011. EU Benefit Assessment, Lebanon Report. Brussels. ←www.environment-benefits.eu→.

5. METHODOLOGY, CALIBRATION AND LIMITATIONS OF THE VALUATION, AND WASTE SUB-CATEGORIES

1. INTRODUCTION

In addition to urban and rural domestic waste, the solid waste chain could include sludge from wastewater treatment plants, agricultural waste (including slaughterhouse), CDW as well as medical and hazardous waste. The mismanagement of the waste chain can result in several impacts such as: air (PMx, H2S, VOC, NMOC, NO_x, NH_4C_l, CO_2, CH_4, dioxins, etc.), soil and water (runoff leachate contaminate aquifers), noise, odor and sight pollution as migrating landfill gases can cause serious discomfort, ill-health and safety hazards to the surrounding population, especially for waste pickers through the entire waste chain (occupational health).

Diseases once contracted by waste pickers can then be spread more generally through the population. Transfer stations, dumps and landfills could also become mosquito, fly and rodent breeding grounds that would transmit vector-borne diseases (Table 5.1). Such sites hence attract large rodent populations which accommodate fleas. During the rainy period, stagnant water ponds are commonly found on such sites and increase the likelihood of vector-borne disease transmission. The most common health risks are: eye irritation, tuberculosis, diarrhea, typhoid, dysentery, coughing, and scabies. Moreover, solid waste dumps can cause explosions as well as self-ignited (combination of methane and oxygen) or human-made fires (as a last resort), and reduce the price of land/buildings/apartments around them, etc.

Table 5.1: Possible Transmission of Main Vector-Borne Diseases through the Waste Chain

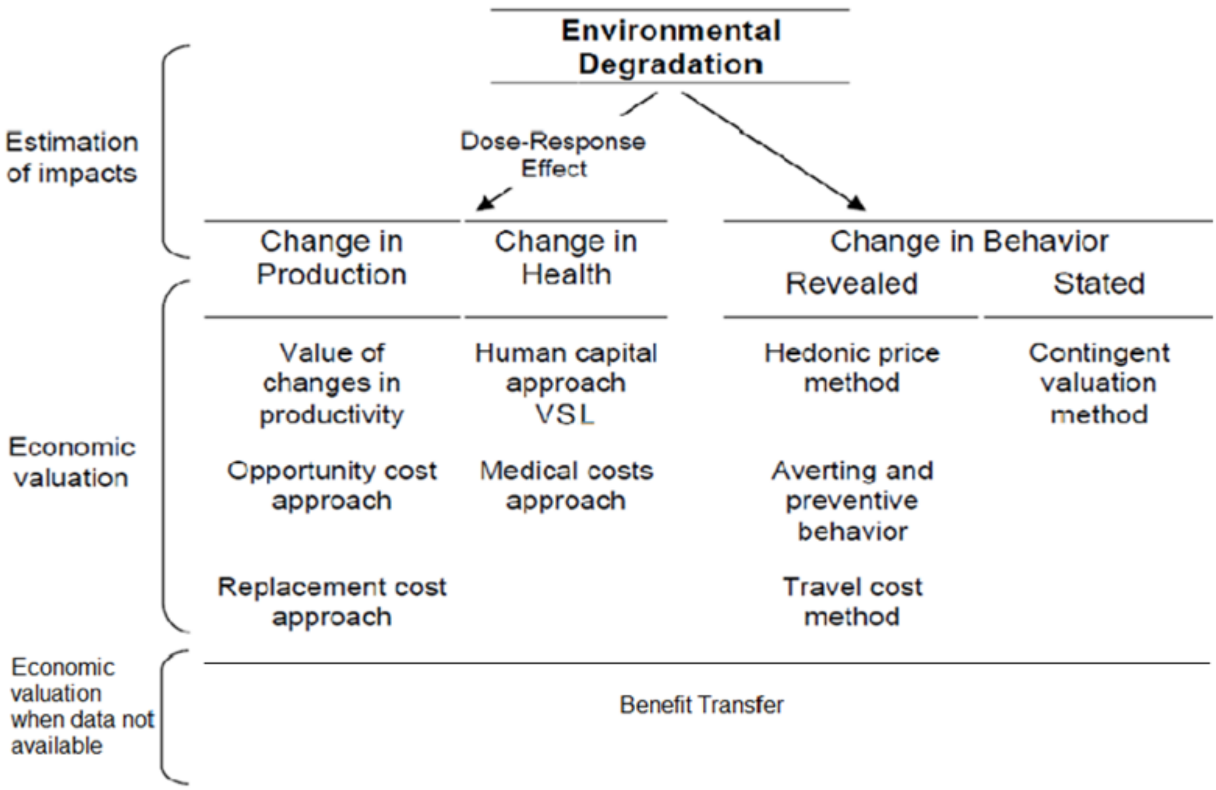
Disease Vector	Breeding Environment and Primary Means of Transmission	Diseases
	Mosquitoes	
Anopheles	Fairly clean, slow-moving brackish or fresh water, e.g., irrigation water, ponds, and marshes. Flight range up to 5 kilometers.	Malaria and filariasis
Aedes	Clean, fresh, and salt standing water, e.g., water pots, cisterns, small containers, temporary pools, and periodic flooding. Potential flight range of up to 160 kilometers. Feeding flights most likely 1.6 kilometers.	Dengue, filariasis, yellow fever, and Rift Valley fever
Culex (which survives through the winter in the adult stage)	Fresh and salt water polluted with organic matter, e.g., pit latrines, clogged storm drains, open sewers, waste stabilization ponds, and soaking pits. For the West Nile Virus, mosquitoes transmit this virus after they bite an infected bird and then bite a person. Flight range up to 16 kilometers. Feeding most likely less than 8 kilometers.	Filariasis and West Nile Encephalitis (inflammation of the brain)
	Other Vectors	
Rodents (rats)	Breed in and feed on uncollected solid waste and waste disposal sites, urine and feces can spread disease through direct contact or ingestion.	Leptospirosis (Weil's disease) and plague
Water flea (Cyclops)	Breeds in small freshwater ponds. Humans ingest water flea (copepods) in drinking water." "Flea" develops into a worm that causes ulcers on leg and foot. Worm sheds eggs into water, completing the cycle.	Guinea worm (dracunculiasis)
Sandfly	Breeds in forest areas, caves, or the burrows of small rodents. Wild and domesticated animals, and humans themselves can act as a reservoir of infection. Flight range is more than 200 kilometers.	Leishmaniases

Source: Adapted from Listorti and Doumani (2001).

2. METHODOLOGY

The economic valuation of environmental projects are proven methods that are summarized in the Handbook of the World Bank on the Cost Assessment of Environmental Degradation,[41] the European Commission's Manual on the Benefit Assessment[42] and other reference sources such as The Economics of Ecosystems and Biodiversity (TEEB), also funded by the European Commission in cooperation with the German Government.[43]

Figure 5.1: Estimation of Impacts and Associated Economic Valuation Techniques



Source: Adapted from Bolt et al. (2005).

- Change in production.
  - Value of changes in productivity such as reduced agricultural productivity due to salinity and /or loss of nutrients in the soil;
  - Approach the opportunity cost of such shortfall of not re-selling the recycled waste;
  - Approach replacement cost when for example the cost of construction of a dam to be replaced by a dam that was silted.
- Change in condition with the dose-response function to establish between pollutant (inhalation, ingestion, absorption or exposure) and disease.
  - The value associated with mortality through two methods: the future shortfall due to premature death, and the willingness to pay to reduce the risk of premature death. Only the latter method is currently used.
  - The approach to medical costs such as the costs when a child under 5 years is taken to the hospital to be cured of diarrhea.

41- *Website of the World Bank : www.worlddbank.org*
42- *Website of the EU ENPI BA: www.environment-benefits.eu*
43- *Website of TEEB: www.teebtest.org*

- Changing behavior with two sub-techniques: revealed preferences, and stated preferences.
  - Revealed preferences by deriving the costs associated with behavior: e.g., hedonic method where for instance the lower value of land around a landfill is derived; trying to derive travel costs to visit a specific place like Lake Titicaca; and preventive behavior as when a household buys a filter for drinking water.
  - Stated preference where a contingent valuation is used to derive willingness to pay through a survey for example, improve the quality of water resources.

In cases where data is not available, a benefit transfer can be based on studies made in other countries by adjusting the results for the differential income, education, preferably, etc. The original results that are used for the benefit transfer are based on one of the economic valuation methods under the 4 pillars as illustrated in Figure 5.1.

The base year 2012 was chosen to estimate the CASWD. The valuation of benefits (reduced CASWD over a year) was used to derive the cost of remediation that are calculated for selected priority sub-categories. After determining the alternative remediation cost, the most suitable cost is selected and used in a cost/benefit analysis (CBA) to determine the profitability of the project. The cost/benefit analysis allows to present the decision-maker/investor with the most efficient choice. Three indicators are taken into account in analyzing the CBA to determine the profitability of the project:

- The net present value (NPV) is the difference between benefits and total discounted costs;
- The internal rate of return (IRR) is the discount rate that resets the NPV or the interest rate that makes the NPV of all cash flows equal to zero; and
- The present value B/C ratio, which is the ratio of the present value of benefits over the present value of costs over the life of the project must be equal or greater than 1.

3. CALIBRATION AND LIMITATIONS OF THE VALUATION

In addition to resource constraints and binding time, the techniques used have their own methodological limitations. In the process of fact finding it became clear that availability, accessibility and topicality of information relevant for the assignment posed problems. Information has been very scattered, not up-to-date and sometimes inconsistent. Inconsistencies have been experienced with similar types of information from different sources. Approaching local authorities helped generate response, feedback and clarifications in terms of facts and figures.

The results allow for a margin of error through sensitivity ranges (lower bound, upper bound) that were taken into account. Most valuation techniques used have inherent limitations in terms of bias, hypothetical premise, uncertainty especially when it comes to non-tradable goods. Moreover, the results are of course sensitive to the context. The use of benefits transfer could therefore exacerbate the results and uncertainties. Therefore, some results are described in the text and should be subject to further analysis when investments will be considered.

4. SUB-CATEGORIES AND TECHNIQUES CONSIDERED IN THE ANALYSIS

The degradation costs include the entire chain of domestic waste from collection to landfilling and could consider other waste types when these lack proper regulation and handling as they are dumped with domestic waste. The methods used for cost of degradation and loss of opportunity valuation are illustrated in Table 5.2. General and specific description of the methods used for the sub-categories are developed in Annex I.

Table 5.1 : Cost of Degradation and Opportunity Loss Valuation Techniques

Category	Valuation Technique	
	Cost of Degradation	Opportunity Loss
Collection	1% of Disposable Income (non-collected waste)	Government Subsidies (all collected waste)
Discharge (for non-collected waste)	Clean up cost	
Recycling and composting		Market price of recyclables
Landfill area avoidable		Cost of avoided land
Underground water contamination from active landfills	Water treatment cost	
Loss of land value around waste processing plants	Hedonic (land price decrement)	
Loss of land value around active landfills	Hedonic (land price decrement)	
Loss of land value around passive landfills	Hedonic (land price decrement)	
Loss of land value in active dumps	Cost of avoided land	
Loss of land value in high risk passive dumps	Cost of avoided land	
Health effects	Dose-response or prevalence	
Methane emission avoidable	LandGem Model (CER/global cost)	
Forgone energy generation	LandGem Model (average tariff)	

Source : Authors.

6. COST ASSESSMENT OF SOLID WASTE DEGRADATION IN BEIRUT AND MOUNT LEBANON

6.1. DATASET

The BML dataset used in the analysis is derived notably from the Central Administration for Statistics, the Ministry of Finance, the 2011 World Bank CEA, Lebanon SWEEPNET Report as well as the 2011 MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study.[44] The population of Beirut and Mount Lebanon is estimated at 2.2 million of which less than 100,000 live in the district of Jbeil (Table 6.1).

Table 6.1: Beirut and Mount Lebanon Population, Domestic Income and Waste Cost, 2012 unless specified

Input	Unit	BML except Jbeil	Jbeil	Total BML	Total Lebanon
Population	#	2,081,488	91,255	2,172,743	4,424,888
GDI/capita	US$/capita	8,357	8,357	8,357	8,357
Affordable fee (Rule of thumb: 1% of GDI/capita)	US$/capita	84	84	84	84
Actual cost/capita based on MOF 2012	US$/capita	71	NA	NA	NA
Actual fee collected by Municipalities est.2012	US$/capita	7	NA	NA	NA
Waste services covered by Municipalities through IMFU	US$/capita	64	NA	NA	NA
Cost per ton (World Bank CEA 2008 est.)	US$/ton	144	NA	NA	NA
Cost per ton (SWEEPNET 2010 est.)	US$/ton	NA	NA	NA	130
Cost per ton (current est. based on MOF 2012)	US$/ton	165	NA	NA	NA

Note: Annual fee collected based on World Bank Lebanon CEA (2011). NA stands for Not Available.

Source: MOF website: www.finance.gov.lb; CAS website www.cas.gov.lb; World Bank Lebanon CEA (2011) ; and WDI (2013).

Based on the revenues transferred to pay for waste management by the MOF, the average actual cost per capita for waste services in BML except Jbeil amounts to US$ 71 in 2012 (Table 6.1). Yet, this cost is below the 1% of disposable income equivalent to US$ 84 in 2012 usually used as a rule of thumb. Also based on the figures provided by the MOF in Table 6.2, the cost in BML except Jbeil reaches about US$ 165 per ton in 2012 which is greater than the average figure for Lebanon of US$ 130 per ton in 2010 provided by SWEEPNET and the figure for BML except Jbeil of US$ 144 per ton in 2008 provided by the 2011 World Bank Lebanon CEA.

44- *WDI (2013); and CAS website: www.cas.gov.lb.*

Table 6.2: Transfers from the Independent Municipal Fund to Municipalities and Waste Management, 2008-12, US$ million

IMFU Transfers	2008	2009	2010	2011	2012	5 year Average	BML except Jbeil Averda and Laceco Share
Distribution of Revenues Accruing to Municipalities	190.3	141.2	343.5	76.9	254.6	201.3	
Direct Payment for Solid Waste Management	153.2	153.8	141.2	161.1	179.0	157.7	148.0
Other	6.0	8.0	2.7	6.0	9.9	6.5	
Total	**349.5**	**303.1**	**487.4**	**244.0**	**443.6**	**365.5**	

Note: The Share of Averda and Laceco is estimated at 94% of the Direct Payment based on past breakdowns.

Source: MOF website: www.finance.gov.lb; and World Bank Lebanon CEA (2011).

The theoretical capacity of the BML except Jbeil SWM infrastructure is below the actual needs when considering the sorting and composting Qarantina, Coral, Amrousieh and Hbaline assets are working at full capacity. Yet, the US$ 2.5 million processing plant of Jbeil worked in 2009 and 2010 and was put out of service and dismantled. Currently, Hbaline is sorting about 25% of the incoming 64 tons/day of commingled waste and the rest is landfilled. Hence, the excess waste needing landfilling reaches 119,066 tons in 2012 when compared to the 2008 Laceco plan (Figure 3.3) and the 2004 Federation of Municipalities of Jbeil plan. Hence, should the Government aim is to adopt a policy promoting zero waste, the potential recyclables and composting (estimated at 50% of organic) are estimated at a minimum at 561,137 tons in 2012 (Tables 6.3 and 6.6). Reaching this recycled and composted volume would however require a number of steps to reach or exceed this target, e.g., separation at the source requiring behavioral change, increased processing capacity, composting certification, etc.

Table 6.3: BML Actual and Potential Waste Processing Capacity, 2012, per ton/day and ton/year

Input	BML except Jbeil	Jbeil	Total	BML except Jbeil	Jbeil	Total
	Ton/day	Ton/day	Ton/day	Ton/day	Ton/day	Ton/day
2010 Theoretical Capacity						
Generation	2,234	108	2,342	815,410	39,304	854,714
Recycling	164	52	216	59,860	18,866	78,726
Composting	110	54	164	40,150	19,652	59,802
Landfill	1,857	2	1,859	677,805	786	678,591
2012 Actual Processing						
Generation	2,456	64	2,520	896,497	23,400	919,897
Recycling	164	16	180	59,860	5,850	65,710
Composting	110	-	110	40,150	-	40,150
Landfill	2,182	48	2,230	796,487	1,170	797,657
Additional Landfilled	325	46	371	118,682	384	119,066
Potential Recyclable/comp.	2,211	58	2,268	806,847	21,060	827,907

Source: Chapter 3; and Authors.

6.2 AGGREGATE RESULTS OF COST ASSESSMENT AND OPPORTUNITY LOSS

The results are divided into 2 distinct categories: the CASWD and the opportunity loss from interventions that could reap some benefits and improve the management of the waste sector in the future. The BML CASWD and Opportunity Loss results are shown in Table 6.4 and Figure 6.1. It should be noted that the total costs are compared to both national GDP (US$ 42.9 billion in 2012) and the BML GDP (US$ 21.1 million in 2012), which was extrapolated by using the GDP per capita for the BML (US$ 9,705 per capita in 2012) and multiplying by the number of inhabitants: 2.17 million. The CASWD of BML reaches US$ 66.5 million (LP 100 billion) in 2012 with a variation between US$ 48 and 127 million equivalent on average to 0.3% of GDP in BML and 0.2% of the current national GDP of Lebanon in 2012. Conversely, the opportunity loss from interventions that could improve the waste sector management amounts to US$ 74 million (LP 112 billion) almost equivalent to the same GDP figures.

Broken down by CASWD sub-category, the loss of land value around high risk passive dumps is the most significant in BML with a relative value with 61.5% of the total in 2012. The water contamination due to leachate (21.6%) ranks second followed by the land loss around active waste processing plants and landfills (8%), methane emission avoidable from Naameh (4.7%) and finally by the forgone energy generation (4.2%). Health effects were not valued because they need further investigations as they are perceived as an issue by the people living in the Naameh landfill area.

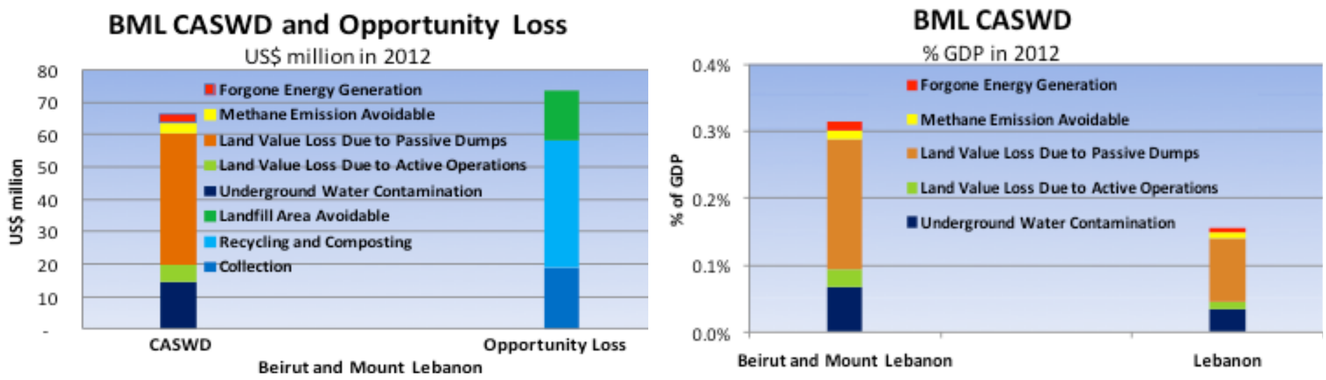
Broken down by opportunity loss sub-category, the forgone value associated with recyclables and composting (53.7%) ranks first and is followed by the opportunity cost of subsidizing the collection (25.3%) as municipal scarce funds are put to better use, and finally by the landfill area avoidable in Naameh and Hbaline landfills (21%) should all recyclables and composts mentioned above are processed.

Table 6.4: BML Cost Assessment of Solid Waste Degradation and Opportunity Loss, 2012, US$ million

Typology of Degradation Costs	BML except Jbeil	Jbeil	Total	BML except Jbeil	Jbeil	Total
	US$ million	%	US$ million	%	US$ million	%
Collection	0.0	0.0%	0.0	0.0	18.7	25.3%
Discharge	0.0	0.0%	0.0	0.0		
Recycling and composting	0.0	0.0%	0.0	0.0	39.7	53.7%
Landfill area avoidable	0.0	0.0%	0.0	0.0	15.5	21.0%
Underground water contamination from active landfills	14.3	21.6%	5.5	65.4		
Loss of land value around waste processing plants	2.5	3.8%	2.0	3.0		
Loss of land value around active landfills	2.8	4.2%	2.2	3.4		
Loss of land value around passive landfills	0.0	0.0%	0.0	0.0		
Loss of land value in active dumps	0.0	0.0%	0.0	0.0		
Loss of land value in high risk passive dumps	40.9	61.5%	32.7	49.1		
Health effects	NA	0.0%	NA	NA		
Methane emission avoidable	3.1	4.7%	2.9	3.3		
Forgone energy generation	2.8	4.2%	2.6	3.0		
Total	**66.5**	**100.0%**	**47.9**	**127.2**	**73.9**	**100.0%**
% GDP Beirut and Mount Lebanon	**0.3%**		**0.2%**	**0.6%**		**0.4%**
% GDP Lebanon	**0.2%**		**0.1%**	**0.3%**		**0.2%**

Note: NA stands for Not Available. Source: Authors.

Figure 6.1: BML Cost Assessment of Solid Waste Degradation and Opportunity Loss, 2012, US$ million



Source : Authors.

6.3 WASTE SUB-CATEGORIES

The CASWD subcategory typology is as follows:

- Collection and the remaining waste chain;
- Discharge;
- Recycling and composting;
- Landfill area avoidable;
- Contamination of underground water;
- Land value losses around transfer stations and processing plants;
- Loss of land value around active landfills;
- Loss of land value around passive landfills;
- Loss of land value in active dumps;
- Loss of land value in passive dumps;
- Health effects;
- Methane emission avoidable;
- Forgone energy generation.

Some categories are however considered an opportunity loss and are not aggregated within the CASWD valuation.

6.3.1 Collection and the Remaining Waste Chain

Collection coverage in BML is effective and is near 100%. However, the collection and sweeping efficiency was not reviewed due to the lack of readily available data. Yet, collection and sweeping cost recovery barely reaches 10% and is not sustainable in the future. Moreover, the opportunity cost of the subsidy provided by the municipalities own resources through the IMFU to cover not only collection and sweeping but also the remaining MSW chain was calculated. Hence, the BML except Jbeil municipalities are covering the entire MSW chain cost which contradicts the 2010 CDR/MOE strategy (see Box 1.1) where collection and sweeping should be assumed by municipalities and transfer, processing and landfilling should be assumed by the Government.

The CASWD of collection is considered to be nil. However, in this particular case, the BML except Jbeil municipality opportunity cost by providing subsidy for collection and sweeping cost and the costs associated with transfer to landfilling amount to US$ 133.2 million for BML except Jbeil. Figures on Jbeil could not be obtained (Table 6.5).

Table 6.5 : BML except Jbeil Opportunity Losses from Covering most Waste Cost Operations, 2012

Input	Unit	BML except Jbeil	Jbeil	Total BML	Lower Bound	Upper Bound
Population	#	2,081,488	91,255	2,172,743		
Cost per capita for the entire chain	US$/ capita	71				
Cost per capita for collection and sweeping	US$/ capita	16				
Municipal Fee paid	US$/ capita	7				
Cost covered by Municipalities for the entire chain	US$/ million	64				
Cost covered by Municipalities for collection and sweeping	US$/ million	9				
Opportunity Losses for the entire chain	US$/ million	133.2			113.2	153.2
Opportunity Losses for collection and sweeping	US$/ million	18.7			15.9	21.5
Additional Landfilled	**325**	**46**	**371**	**118,682**	**384**	**119,066**
Potential Recyclable/comp.	**2,211**	**58**	**2,268**	**806,847**	**21,060**	**827,907**

Note: Annual fee collected based on World Bank Lebanon CEA (2011).

Source: Table 6.1; MOF website: www.finance.gov.lb; CAS website www.cas.gov.lb; World Bank Lebanon CEA (2011) ; and WDI (2013).

6.3.2 Discharge

Given that all BML waste generated is collected, processed and landfilled, there is no CASWD associated with discharge clean up. Existing dumps that need to be rehabilitated are covered below.

6.3.3 Recycling and Composting, Landfill Area Avoidable

The potential composting and recycling is illustrated in Table 6.6 where the landilled generated amount in BML reaches 827,907 tons in Naameh and Hbaline in 2012. Out of this amount, a possible amount equivalent to 561,137 tons is potentially recyclable and compostable provided there is little resistance to behavior change when it comes to separation at the source and adequate sorting, recycling and composting facilities are set up. The cost per ton of recyclable and compost materials are at current market prices. Hence, the opportunity loss of recycling and composting for BML amounts to US$ 40 million in 2012 with a lower and upper bound ranging between US$ 32 and 48 million. (Table 6.6).

The recycling and composting lost opportunity also translates in terms of landfill area avoided. A density conversion factor for compacted waste was applied to the possible recycling and composting weight and amounts to a volume of almost 2 million m^3. A lower and upper bound was considered in terms of the landfill height, i.e., 10-20 m for Naameh and 5-10 m for Hbaline. With US$ 100 per m^2, the land cost is pretty depressed around the Naameh and Hbaline landfills servicing BML. Hence, the savings in terms of land for landfilling amounts to US$ 15.5 million in 2012 with a bracket ranging between US$ 10 and 21 million (Table 6.7).

Table 6.6: BML Composting and Recycling Opportunities, 2012, US$ million

Input	Break down	Possible recycling/ comp.	Daily generation	Yearly generation	Market Price	Lost Oppor-tunity	Lower Bound	Upper Bound
	%	%	Ton/day	Ton/year	US$/ton	US$ million	US$ million	US$ million
Waste Generated			**2,520**	**919,897**				
Potential Recyclable/comp.			**2,268**	**827,907**				
Possible Recycling/ comp.	**100%**		**1,537**	**561,137**		**39.7**	**31.7**	**47.6**
Organic	55%	45%	630	229,974	49.9	11.5		
Paper	15%	91%	343	125,106	39.9	5.0		
Plastic	10%	100%	262	95,669	106.4	10.2		
Glass	3%	100%	81	29,437	29.9	0.9		
Metal	5%	96%	121	44,155	266.1	11.7		
Textile	3%	80%	60	22,078	10.0	0.2		
Wood	2%	80%	40	14,718	10.0	0.1		
Other	7%	0%	-	-				
Methane emission avoidable	3.1	4.7%	2.9	3.3				
Forgone energy generation	2.8	4.2%	2.6	3.0				

Source: Section 3; World Bank Lebanon CEA (2001); SWEEPNET (2013); WDI (2013); and Authors.

Table 6.7: Forgone Landfill Area Needed due to Recycling and Composting, 2012, in US$ million

Forgone landfill area	Possible Recycling/ comp.	Density Conversion for Bulk Waste	Weight Compacted Volume	Area saved Considering 10-20 m landfill height	Area saved Considering 5-10 m landfill height	Land Cost	Lost Oppor-tunity
	Ton/year	Ton/m³	m³	m²	m²	US$/m²	US$ million
Naameh	546,863	(compacted) 3.4	1,847,506	92,375	184,751	100	13.9
Hbaline	14,274	(not com-pacted)7.6	108,962	21,792	21,792	100	1.6
Total	**561,137**		**1,956,468**	**103,271**	**206,543**		**15.5**
Lower Bound							10.3
Upper Bound							20.7

Note : Cost of land around both Naameh and Hbaline is US$ 100 per m².

Source: Table 6.6; Australian Environment Protection Authority; and Authors.

6.3.4 Contamination of Underground Water by Active Landfills

There no testing results of underground waters around and downstream landfills and dumps in Lebanon in general and Naameh in particular. Lebanon's volume of aquifers is estimated at 1,360 million of m^3. The presence of fissures and fractures encourages snowmelt and rainwater to percolate and infiltrate deep into the ground and feed these aquifers. Water reappears at lower elevations as springs that flow into rivers with a number of them found along the coast and even in the seabed.[45] In BML, underground water is usually tapped into by dwellers, farmers and industrial enterprises alike, especially during summertime due to the poor service provision and both Hbaline and Naameh like all the coastal zone is built on top of karstic fractured rocks rich where underground water flows towards the sea. BML's Hbaline waste processing operations are considered less sanitary than Naameh's although the latter does not qualify as being a full proof sanitary landfill. The several landfill extensions that were not always been properly implemented and the NGOs and people living around the landfill growing alarm provide ground for concern when it comes to seepage from Naameh whereas Hbaline operations are no longer up to the standard after the replacement of the operator and the dismantling of the premises.

Nevertheless, a very conservative contamination of underground water was considered for Naameh and less conservative for Hbaline. Based on the 2012 waste quantity landfilled and when using the volumetric weight conversion factor, 2% and 10% respectively of leachate seeping in the aquifer is considered which contaminates 50 m^3 of underground water flow/m3 of leachate. The cost associated are the net costs from treating this highly contaminated water which is almost twice the BML water treatment cost.[46] Hence, the CASWD amounts to US$ 14.3 million in 2012 with a bracket ranging between US$ 5.5 and 65.4 million (Table 6.8). This cost is also supposed to partially capture other damages notably done to ecosystem services.

Table 6.8: Leachate Seepage into the Aquifer, 2012, US$ million

Input	Unit	Naameh Landfill	Hbaline Landfill	Total
Waste Quantity Lanfilled	ton/day	2,211	108	2,318
Density Conversion of compacted waste	ton/m^3	0.30	0.30	0.3
Waste Volume	m3/day	7,468	364	7,832
Lechate Level	%	50%	50%	50%
Leachate Quantity	m3/day	3,734	182	3,916
Leachate Infiltration rate	%	2%	10%	2%-10%
Quantity of Water polluted/m3 of leachate	m3/day	50	50	50
Daily Water polluted by leachate	m^3/day	3,734	909	4,643
Yearly Water polluted by leachate	m^3/day	1,362,914	331,955	1,694,870
BML Water treatment OMEX Cost	US$/m^3	7	7	7
Extra Water treatment OMEX Cost	US$/m^3	15	15	15
Net Water treatment OMEX Cost	US$/m^3	8	8	8
CASWD	**US$ million**	**11.5**	**2.8**	**14.3**
Lower bound at 1% Infiltration rate	US$ million			5.5
Upper bound at 12% Infiltration rate	US$ million			65.4

Source: World Bank (2003); World Bank Lebanon Water PER (2010); and Authors.

6.3.5 Land Value Losses Around Transfer Stations and Processing Plants

The land value losses around transfer and processing stations were calculated for Bourg Hammoud (reported as Qarantina and Coral in section 3) and Hbaline separation, recycling and composting plants, and for Amrousieh separation and recycling plant. The valuation of land depreciation is based on current lot prices as listed on the website of real estate companies[47] with two concentric circle with the first ring

45- *FAO AQUASTAT website: www.fao.org.*
46- *World Bank Lebanon Water PER (2010).*
47- *Hayek Group website: www.hayekgroup.com.*

providing a depreciation of 15% and the second ring providing a depreciation of 10%. The depreciation value of apartments was not considered due to the lack of data but could have significantly increase the depreciation value associated with this category. The CASWD, which was annualized over 12 years of operations for the Bourg Hammoud and Amrousieh plants and 4 years for the Hbaline plant, amounts to US$ 2.5 million in 2012 with a bracket ranging between US$ 1.8 and 2.7 million (Table 6.9). It is worth mentioning that the Bourg Hammoud land is almost on the coast (See Figure 3.4) and has a touristic development potential although the site is meant to host the new wastewater treatment plant for northern Greater Beirut in the future.

Table 6.9: Land Depreciation Around Transfer Stations and Processing Plants, 2012, in US$ million

Transfer, Segregation, Recycling and Composting Station	Area	Land cost	15% Losses 1st Ring	10% Losses 2nd Ring	Total	15% Losses 1st Ring Over # years of Operations	10% Losses 2nd Ring Over # years of Operations	CASWD Over years of Operations
	m^2	US$/$m^2$				US$ million		
Amrousieh	20,000	750	2.0	3.7	5.7	0.2	0.3	0.5
Bourg Hammoud	40,000	2,000	7.2	12.8	20.0	0.6	1.1	1.7
Hbaline	117,000	100	0.6	1.0	1.6	0.1	0.2	0.4
Total	**177,000**		**9.8**	**17.5**	**27.3**	**0.9**	**1.6**	**2.5**
Lower Bound								2.0
Upper Bound								3.0

Note: Hbaline land includes the processing plant and the landfill.

Source: Real Estate websites; and Authors.

6.3.6 Land Value Losses Around Active Landfills

The same method used for processing plants is used for landfills although Hbaline landfill is accounted for above and the value was annualized over 12 years. Hence, the CASWD amounts to US$ 2.8 million in 2012 with a bracket ranging between US$ 2.2 and 3.4 million (Table 6.10).

Table 6.10: Land Depreciation Around Landfills, 2012, in US$ million

Landfill	Area	Land cost	15% Losses 1st Ring	10% Losses 2nd Ring	Total	15% Losses 1st Ring Over # years of Operations	10% Losses 2nd Ring Over # years of Operations	CASWD Over years of Operations
	m^2	US$/$m^2$				US$ million		
Bsalim	350,000	1,000	9.9	16.0	25.8	0.8	1.3	2.2
Naameh	3,600,000	100	3.1	4.8	7.9	0.3	0.4	0.7
Hbaline (Listed above)	117,000	100						
Total	**4,067,000**		**12.9**	**20.8**	**33.7**	**1.1**	**1.7**	**2.8**
Lower Bound								2.2
Upper Bound								3.4

Source: Waste Atlas website: www.atlas.d-waste.com; Real Estate websites; and Authors.

6.3.7 Land Value Losses Around Passive Dumps

The same method used for processing plants is used for passive dumps although the land depreciation factors are different and the dumps were categorized by the risk sensitivity index developed in Closure and Rehabilitation of Uncontrolled Dumps study (2011). Few dumps were rehabilitated since the end of the Civil War. In addition to Zahle dump, the Normandy seafront 5 million m^3 dump, which was used for the disposal of all the waste from West Beirut, was rehabilitated in 1995 after the decontamination and stabilization of the site. This allowed to gain some 100 ha that was reclaimed on the sea for an estimated cost ranging between US$ 50-80 million according to various sources. Still, the seabed and coastal water remains somewhat contaminated in the area and the reclaimed area was not partially converted into a public garden as originally planned. Moreover, the Bourg Hammoud seafront 4 million m^3 dump, which was used for disposal of all the waste from East Beirut, was partially rehabilitated in 2000 after a growing concern and peer pressure from the population as it was covered with soil and provided with a gas venting system. Still, some inert material is still dumped in Bourg Hammoud (Figure 3.4). Recently, old tires were set on fires and created a thick smoke that caused some respiratory problems among the population living next to the dump. After the 2006 War with Israel, the spontaneous construction and debris dump along the coast of Khalde next to the airport was never rehabilitated. Hence, the Bourg Hammoud and Khalde dumps are added to the inventory of MSW and CDW dumps that need rehabilitation in BML and prepared by MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study (2011). The aggregated figures are listed in Table 6.11 with a total of 153 dumps having a volume of 6.2 million m^3 with the following breakdown: 60 MSW dumps with a volume of 3.5 million m^3 and 93 CDW dumps with a volume of 2.7 million m^3. When the sensitivity risk index category is considered, three categories of risk were considered: high, medium and low. The CASWD calculation will consider the category of dumps with the high risk bracket so to prioritize the dumps that needed immediate attention.: 15 MSW and CDW dumps in total with an area of 155,425 m^2 and a volume of 1.1 million of m^3 (Table 6.12).

Table 6.11: BML Municipal and Construction Dumps Needing Rehabilitation by District, 2012

Caza/District	Number #	Total Area m^2	Volume m^3
Municipal Dumps			
Aley	5	14,250	10,400
Baabda	9	6,031	15,176
Chouf	11	11,525	16,575
Jbeil	3	26,400	376,100
Kesrwan	20	40,730	44,580
Metn	12	166,820	3,030,320
Total MSW	**60**	**265,756**	**3,493,151**
Debris and Construction Dumps			
Aley	9	11,455	76,605
Baabda	6	87,100	1,465,300
Chouf	14	57,715	612,208
Jbeil	6	9,230	12,600
Kesrwan	30	147,850	267,990
Metn	29	103,280	226,795
Total CDW	**93**	**415,630**	**2,660,498**
Grand Total	**153**	**681,386**	**6,153,649**

Note: figures include Bourg Hammoud and Khalde dumps.
Source: Adapted from MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study (2011).

Table 6.12: BML Municipal and Construction Dumps Needing Rehabilitation by Risk, 2012

Landfill	High Risk: ≥20			Medium Risk: <20-≥15			Low Risk:<15		
	Number	Area	Volume	Number	Area	Volume	Number	Area	Volume
	#	m^2	m^3	#	m^2	m^3	#	m^2	m^3
MSW Dumps	9	32,925	394,175	29	50,705	73,880	22	182,126	3,025,096
CDW Dumps	6	122,500	725,500	42	222,820	1,848,878	45	70,310	86,120
Total	**15**	**155,425**	**1,119,675**	**71**	**273,525**	**1,922,758**	**67**	**252,436**	**3,111,216**

Note: figures include Bourg Hammoud and Khalde dumps with both having a low assigned risk.

Source: Adapted from MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study (2011).

The land value depreciation was segmented by dump area where different factors were assigned for dumps smaller than 500 m^2 and larger than 500 m^2 (see Table A2.1). The land value depreciation associated with the first ring was set at 10% for 20 m and 200 m respectively from the limits of the dump and the second ring at 4% up to 100 m and 1,000 m respectively from the circumference of the 1st ring. The depreciation is considered over an estimated 30 years of the existence of the dumps, therefore, the values were annualized over 30 years. Total depreciation of land value amounts to US$ 302 million in 2012 with a bracket ranging between US$ 242 and 362 million (Table 6.13). Some MSW dumps could possible seep up some leachate but were not considered in this particular case pending further investigations and proofs. Interestingly, the construction boom is not only increasing the damages associated with quarries but also the damages associated with CDW that are 5 times higher than MSW's dumps.

The CASWD amounts to US$ 40.9 million in 2012 with a bracket ranging between US$ 32.7 and 49.1 million (Table 6.13).

Table 6.13: Land Depreciation Around Passive Dumps with High Risk Sensitivity Index, 2012, in US$ million

Transfer, Segregation, Recycling and Composting Station	Area	10% Losses 1st Ring Over # years of Existence	4% Losses 2nd Ring Over # years of Existence	Total Over # years of Existence
	m2	US$ million	US$ million	US$ million
Total Municipal Dumps	**265,756**	**9.5**	**44.1**	**53.6**
Total Debris and Construction Dumps	**415,630**	**42.3**	**206.1**	**248.4**
Total	**681,386**	**51.8**	**250.2**	**302.0**
Lower Bound				*241.6*
Upper Bound				*362.4*
High risk Dumps considered for CASWD				
High risk Municipal Dumps	**32,925**	**1.3**	**7.1**	**8.3**
High risk Debris and Construction Dumps	**122,500**	**5.5**	**27.3**	**32.6**
Total	**155,425**	**6.8**	**40.9**	**40.9**
Lower Bound				32.7
Upper Bound				49.1

Source: Real Estate websites; MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study (2011); and Authors.

6.3.8 Health Effects

Several cases of ill health associated with the mismanagement of waste dumping were reported in the media over the years. However, there was no study to establish any causality between the stressors emanating from waste dumps and the people living in the vicinity of the dumps. The population living in the Naameh landfill area has increase the pressure to stop using the landfill as it reached full capacity and cannot be extended beyond the current capacity. Still, civil society needs to work closely with health researchers to establish the environment-health linkage associated with waste mismanagement. Therefore, this sub-category is not covered here but will require further documentation and sampling among people living around dumps and landfills not only in BML but also in other regions of Lebanon.

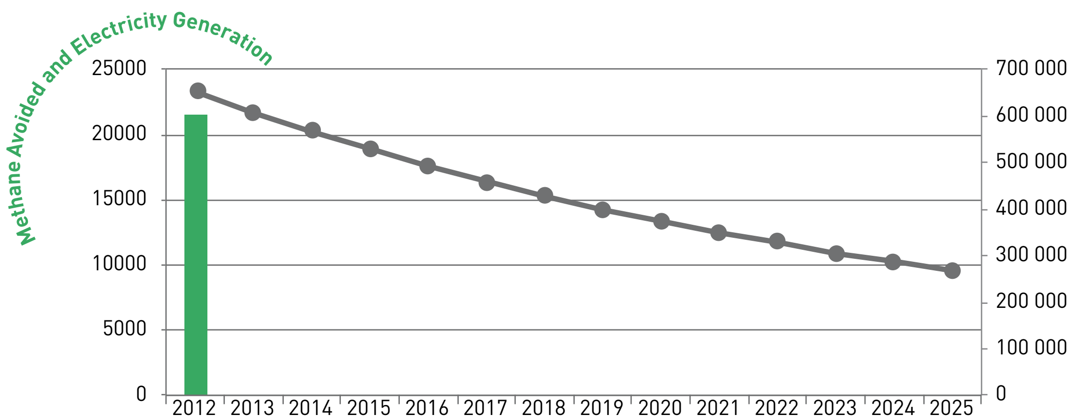
6.3.9 Methane Emission Avoidable

The methane emissions that could be avoided amounts to 23,272 tons in 2012 and 391,767 over 20 years through a better management of the Naameh landfill for the 827,907 tons of waste landfilled in 2012 with a calorific value of decomposing waste of 604,392 tons. NPV discounted at 5% (intergenerational discount rate used for environmental goods and services) CO_2 avoided for the period amounted to US$ 45,470 using the December 2012 rate of certified emission reductions (US$ 0.198). However, when considering the damage to the global environment based on a US$ 13.6 per ton of CO_2 emitted, the degradation amounted to US$ 3.1 million in 2012 with a variation between US$ 2.9 and 3.3 million. The description of the methodology and calculations are developed in Annex I.

6.3.10 Forgone Energy Production

The actual power generation is planned in Naameh and will initially serve the villages around the landfill. The forgone future electricity that could have been generated in cells (net present value discounted at 5% (intergenerational discount rate used for environmental goods and services) for the 2012 waste over 20 years) in Naameh and amounts to US$ 2.8 million in 2012 with a variation of US$ 2.6 to 3.0 million based on the real cost of production of US$ 0.08 cost/kW/h of Lebanon public operator's Electricité du Liban production cost. The description of the methodology and calculations are developed in Annex I.

Figure 6.2 : Forgone methane emission by generating electricity from 2012 waste, 2012-2031



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Landfilled Calorific Waste Tonne	604 372													
Methane avoided Tonne de CO_2	23272	21687	20217	18854	17588	16414	15324	14311	13371	12497	11684	10928	10226	9572

Note: the series is truncated in 2025. *Source: USEPA LanGEM : www.epa.gov; and Authors.*

Table 6.14: Forgone methane emission, electricity production and global environment 2012, US$ million

Input	Unit	2012
Landfilled Calorific Value of Decomposing Waste	Ton	604,372
CH_4 Generated	Ton/CO_2	40,884
CH_4 Generated	Ton/CH_4	1,947
CH_4 Generated	m^3/CH_4	2,716,061
Methane Captured	m^3/CH_4	1,358,030
Methane used for power generation	m^3/CH_4	1,358,030
Energy content of CH_4 captured	Kcal	10,864,242,786
Power Generation Potential	kW	505
Power produced	kW/h	3,537,832
CO_2 emission Avoided from grid	Ton/CO_2	2,830
Methane avoided	Ton/CO_2	23,272
Production cost for Energy	US$ 0.08/kW/h	283,027
Value for CO_2 emission (Certified Emission Reductions)	US$ 0.198/Ton CO_2 equiv.	4,608
Global Environment	US$ 13.6/Ton CO_2 equiv.	316,505
NPV Energy over 20 years	US$ over 20 years @ 5%	2,792,815
NPV CO_2 (CER) over 20 years	US$ over 20 years @ 5%	45,470
NPV Global Environment over 20 years	US$ over 20 years @ 5%	3,123,169

Source: EPA LanGEM : www.epa.gov; and Authors.

6.4 CONCLUSIONS

The estimated cost assessment of solid waste degradation are shedding some new lights on the waste problem in Lebanon in general and BML in particular. The improvement of the valuation techniques and better data helped derive a significantly higher CASWD when compared to the national GDP: 0.2% for BML in terms of the national GDP as compared to barely 0.09% for the entire country in 2005 (see section 4). The largest sub-category (61.5%) remains the liability inherited not only from past neglect due to poor SWM but also from past and current CDW practices where the construction boom is not only taking its toll on quarries but also on spontaneous and possibly not inventoried CDW dumps. In the case of passive dumps, only the high risk passive dumps are considered in the CASWD. Yet, with its current practices, the landfill in Naameh, which is still being used beyond its full capacity, could already generate electricity through the capture of methane hence reducing GHG (9% of CASWD). The landfill seepage and contamination of soils and underground water is a problem that requires further investigation and monitoring not only for active landfill downstream areas (21.6%) but also for passive dumps downstream areas. Land depreciation around processing waste plants and landfills (8%) is a necessary bad but remains a relatively small price to pay compared to the other problems valued in this exercise. Based on these findings, three priorities emerge in the short and medium term and merit further analysis:

- How viable is an increase in recycling and composting in BML and could these efficiencies drastically reduce the land needed for landfilling?
- How viable is the closure and rehabilitation of high risk MSW and CDW dumps?
- A third priority that will require further investigation in the future is as follows: are pollutants emanating from processing waste plants, dumps and landfills causing respiratory (through emission of pollutants) and water-related (through underground water contamination) diseases?

With regards to opportunity loss, recycling and composting has the potential of reducing wastage in terms of recyclables, compost and land for landfilling in BML as demonstrated by the waste processing plant in Hbaline that was unfortunately dismantled in 2011 and seemed profitable according to its first private operator until 2010: a mere 5% of the waste generated in Jbeil ended up in the landfill. Still, it remains to be seen if larger capacity could achieve economies of scale and improve efficiencies when it is compared to the new Government policies to install waste to energy (WTE) along the coast in Selaata and Jyeh to service BML. A serious aspect of opportunity loss is also the lack of cost recovery and considering the introduction of a household fee at least for collection will help put the sector on a sustainable footing.

7. SELECTED SOLID WASTE REMEDIATION COST IN BEIRUT AND MOUNT LEBANON

7.1 REMEDIATION COST AGGREGATE RESULTS

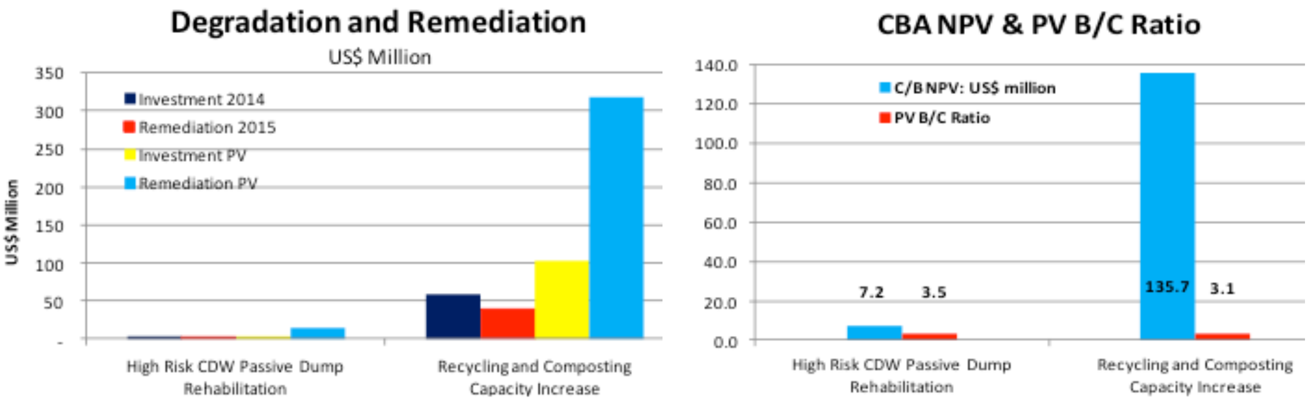
Based on priorities identified in the previous section, two selected remediation interventions were considered in BML by performing a BCA: rehabilitation of the BML passive dumps constituting a high risk; and recycling, composting and avoided landfilling in BML in case the Government adopts a zero waste strategy. The most relevant scenarios were selected and are shown in Table 7.1 and Figure 7.1. Three scenarios were considered for the rehabilitation of dumps where: (i) MSW passive dump rehabilitation; (ii) CDW passive dump rehabilitation; and (iii) MSW and CDW passive dump rehabilitation. For recycling and composting, one scenario was considered where the same amount of waste generated in 2012 was kept constant over 20 years and where treatment reduced 2012 generation by 60% in BML. This BCA analysis is meant to shows that recycling and composting pays when the volume recycled and composted is decentralized at the caza level (each caza is assumed to have a waste processing plant) and when the price of recyclables and certified compost is right. Additional analysis is however needed to do a volumetric analysis (waste generation increase overtime) and include the price of the landfill. The results are a very preliminary estimates that need to be refined should the Government decide to move ahead with these priorities. Both projects are viable with NPV reaching US$ 8.5 and 135.7 million respectively with an IRR of 28% and 36% and a PV Benefit/Cost Ratio greater than 1. Nevertheless, other weighted criteria (e.g., scarcity of land, people resistance and NIMBY syndrome, etc.) should be considered before any selection is made.

Table 7.1: Cost/Benefit Analysis of BML Selected Interventions, 2012, US$ million

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 3 High Risk Passive MSW & CDW Dump Rehabilitation over 20 years	Scenario 1 Recycling and Composting 60% of the Constant Waste Volume Generated in BML in 2012 over 20 years
NPV (US$ million)	>0	8.5	135.7
IRR (±%)	≥10%	28%	36%
PV Benefit/Cost Ratio	>1	3.2	3.1
Project Viability		**Yes**	**Yes**

Source: Authors.

Figure 7.1: Cost/Benefit Analysis of BML Selected Interventions, 2012, US$ million



Source: Authors.

7.2 REHABILITATION OF THE BEIRUT AND MOUNT LEBANON HIGH RISK DUMPS

The BCA for the closure and rehabilitation of the High Risk MSW and CDW passive dumps in BML was performed for each and both groups. The cost and benefits are illustrated in Table 7.2 where the overall benefits are 7 fold the costs. However, the cost of closing and rehabilitating the passive CDW dumps is more expensive than the MSW passive dumps.

Table 7.2: BML Municipal and Construction Dumps Needing Rehabilitation by District, 2012

Caza/District	Number	Total Area	Volume	Total Closing and Rehabili-tation Cost	Total Benefits
	#	m²	m³	US$ million	US$ million
Municipal Dumps	9	32,925	394,175	1.6	8.3
Debris and Construction Dumps	6	122,500	725,500	4.3	32.6
Total	15	155,425	1,119,675	5.9	40.9
Total	**4,067,000**		**12.9**	**20.8**	**33.7**

Source: Adapted from MOE/UNDP/ElArd Closure and Rehabilitation of Uncontrolled Dumps study (2011).

Three scenarios were considered: (i) the remediation costs of High Risk MSW passive dumps; the remediation cost of High Risk CDW passive dumps; and the remediation of the High Risk MSW and CDW passive dumps. The investments are over 20 years and a maintenance fee of 3% is added to the rehabilitation over 17 years as the benefits are annualized and start accruing on year 4.

The results of the 3 scenarios are as follows (Table 7.3):

- Scenario 1 is viable with a positive NPV of US$ 2.5 million, an IRR of 12% and the PV B/C ratio of 1.3;
- Scenario 2 is the most viable and is highly efficient with a positive NPV of US$ 74.2 million, an IRR of 60% and the PV B/C ratio of 3.2;
- Scenario 3 is viable with a positive NPV of US$ 79.8 million, an IRR of 49% and the PV B/C ratio of 4.7.

Table 7.3: Cost/Benefit Analysis of BML Passive Dump Rehabilitation, 2012, US$ million

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 1 MSW Passive Dump Rehabilitation	Scenario 2 CDW Passive Dump Rehabilitation	Scenario 3 MSW and CDW Dump Rehabilitation
NPV (US$ million)	>0	1.3	7.2	8.5
IRR (±%)	≥10%	21%	30%	28%
PV Benefit/Cost Ratio	>1	2.0	3.5	3.2
Project Viability		**Yes**	**Yes**	**Yes**

Note : Benefit flows accrue on second year.

Source : Authors.

In retrospect, the 3 scenarios are profitable but the most salient point is that scenario 2 is the most efficient in BML.

7.3RECYCLING AND COMPOSTING IN BEIRUT AND MOUNT LEBANON

Many projects are underway to increase waste composting and recycling in Lebanon in general and BML in particular. The alternative considered is the effective reduction of 60% of the waste generated in 2012. One assumption is that the volume of waste remains constant over 20 years and the landfill cost is not included in the BCA. These assumptions are made just to show that recycling and composting are viable when the volume and the price of these recyclables are right. The investment is over 20 years with OMEX remaining constant over the lifetime of the project and does not take into consideration the existing waste processing investments in BML. This analysis should lead in the future to a more thorough analysis where the price of land for landfill is included and a sensitivity analysis is performed. Still, the purpose of this analysis is to make the case for recycling and composting at the caza level where each of the BML's caza will have its own waste processing plant and where the current waste will be decrease by 60%. Additional scenarios should be considered to determine the viability of zero waste options when compared to the WTE option as developed for the MOE/CDR by Rambol for BML where 2 plants are considered on the coast: one in Selaata north of Beirut and one in Jyieh south of Beirut where both will be next to a power plant to ease transmission (Table 7.3).

Table 7.3: BML Composting and Sorting Facilities Needed to Reduce Waste by 60%, 2012

Caza/District	Capital Cost	OMEX	Waste Generated	Waste Treated		Total Benefits
	US$ million	US$ million / year	Ton/Year	Ton/Year	%	US$ million /year
Aley	5.2	0.6	60,820			
Baabda	13.3	2.3	236,476			
Beirut	13.3	2.2	225,673			
Chouf	3.0	0.3	26,008			
Jbeil	5.9	0.7	73,224			
Kesrwan	5.9	0.7	74,824			
Metn	13.1	2.2	222,872			
Total MSW	**59.7**	**8.9**	**919,897**	**561,137**	**60%**	**39.7**

Source: World Bank Lebanon CEA(2011); and Authors.

Investment costs and OMEX associated with waste processing facilities are shown in Table 7.3. The results of the investment are as follows (Table 7.4). Of the annual waste generated of 919,897 tons in BML, 561,137 tons are treated. The investment is viable with a positive NPV of US$ 136, an IRR of 36% and the PV B/C ratio of 3.1.

Table 7.4: Cost/Benefit Analysis of Waste Processing in BML, 2012

CBA Indicators	Viability Criteria (10% Discount rate and 20 year investment)	Scenario 1 Recycling and Composting 60% of the constant waste volume generated in BML in 2012 over 20 years
NPV (US$ million)	>0	135.7
IRR (±%)	≥10%	36%
PV Benefit/Cost Ratio	>1	3.1
Project Viability		**Yes**

Source : Authors.

7.4 CONCLUSIONS

The High Risk MSW and CDW passive dump closure and rehabilitation are viable and could create occasional green jobs. However, the risk associated with soil and underground water pollution is probably considered in the Sensitivity Risk Indicator but merit further attention in selecting the priority dumps to be rehabilitated. Increasing the recycling and sorting capacity to reduce the actual waste by 60% is highly viable and needs further investigation and analysis before embarking upon more ambitious and costly investments such as the WTE that could increase the government deficits in the future. More efficient alternatives, such as zero waste, could prove very efficient and economically viable if waste processing is decentralized at the caza level and prices and quality of recyclables and compost are right.

8. GENERAL CONCLUSIONS AND RECOMMENDATIONS

The diagnosis and analysis developed in the previous sections helped reach the following conclusions:

a. The municipal waste management sector especially in BML, is characterized "by many investments carrots and no institutional and regulatory sticks". The key concern in the municipal waste management sector is the lack of appropriate legislation, monitoring and enforcement capacities accompanied by weak public institutions;

b. The municipalities in BML do not have the tax base to be able to provide and sustain adequate MSW services. The Central Government intervention in the decision making process and resource allocation are likely to continue, given the weak municipal infrastructure and lack of cost recovery mechanisms for almost all the municipal services;

c. After 18 years since the emergency plan SWM was approved, the Central Government continues to invest in the SWM services at very high cost when a large segment of the population could afford to contribute at least to the cost of MSW operations;

d. The lack of proper disposal of all types of wastes in the old dumps are adversely affecting the surface and groundwater resources of BML, given the high permeability of its soil;

e. The cost assessment of solid waste degradation is high (US$ 66.5 million) and represents 0.2 percent of the national GDP in 2012. This degradation affects primarily the natural resources until further evidence is provided that pollution generated from MSW also can affect public health;

f. The CASWD is almost equivalent to the opportunity loss (0.2% of GDP) in terms of collection fee subsidy and the forgone revenues that could be generated should recycling and composting is optimized. This means that BML welfare is doubly and reversibly affected: by a loss of revenues due to degradation and a loss of revenues due to missed opportunities which could have generated additional financing in an integrated and sustainable SWM system should it is established;

g. With the exception of two large dump sites which were rehabilitated, no investments were made on the MSW and CDW dumps which had and continue to "mushroom" the region. The major dumps in the Mount Lebanon, are among the 20 highest open dumps that need to be rehabilitated, and include [48]Hbaline (in Jbeil, 375,000 m^3), Zouk el Khrab (in Metn, 8,500 m^3) and Roayset el Ballout (in Baabda, 5,000 m^3). Also 17 of the construction and demolition waste dumps are among the 20 highest ranked Construction and Debris Waste (CDW) that need to be rehabilitated (Figure 3.4);

h. BML has being adversely affected by a past neglect of its open dumps and a bleak future for replacement alternatives to its major disposal sites. Many ministerial decisions were taken and plans prepared, which includes waste to energy technologies for urban coastal areas. However, the political economy and crisis management still prevail over a realistic approach for an integrated SWM system for this region.

Based on the above general conclusions, the following recommendations are proposed for moving towards an integrated sustainable waste management system using BML as a pilot region. Such system would

48- The preparation of a master plan for the closure and rehabilitation of uncontrolled dumps throughput the country of Lebanon, ElARD, May 2011.

consist of three building blocks: (a) involving the stakeholders; (b) establishing an effective and efficient waste system elements from pre-collection to disposal and the valorisation of the municipal waste; and (c) strengthening the municipal waste management aspects from an institutional, legal, financial and, environmental and social point of view. At this stage, it is important to note that these three building blocks can be implemented in parallel over a short and medium terms of 2years-5years as it is should start by the following elements at pace commensurate with the socio-economic situation in Lebanon.

(a) Stakeholders involvement and participation can be initiated by:

- The MOE and the local NGOs for developing a joint communication strategy that will facilitate the understanding of the MSW services in BML and gain the support and participation of the habitants on the interventions proposed by the municipalities and by CDR;
- The MSW operators and the local NGOs by establishing a pilot community interaction interaction in 1-2 cities such as in Byblos and Aley, whereby the MSWM stakeholders including the informal and formal private sector, and local NGOs contribute their views on the development of city master plans, facility planning /siting and facility monitoring;
- CDR and the MOE soliciting community inputs to address the NIMBY responses of new MSWM facilities and explaining the social, economic and environmental benefits of the proposed new facility while considering a willingness to accept stated preference for communities living nearby the sites.

(b) An effective and efficient MSW can be achieved by :

- Setting investment priorities that will include: (a) establishing at the caza level or within a group of municipalities, new MSW facilities with technologies that are environmentally proven, technically feasible, cost effective, affordable, and within the management capacities of the municipalities it serves; (b) rehabilitating high risk old dumps (such as Hbaline) in parallel with establishing new MSW facilities as the NPV for old dump rehabilitation is US$ 8.5 million over 20 years; and (c) reinforcing the Council of Ministers reward system for municipalities that would establish new MSW facilities (for which land is scarce) and rehabilitating the old dumps;
- Managing waste materials as an economic resource by decentralizing the composting and recycling activities at the caza level as the benefit cost analysis showed a very high with NPV of US$ 135.7 million over 20 years in case the Government will plan to adopt a zero waste strategy;
- Making use of the Clean Development Mechanism for the Naameh landfill as a new source of revenue to the neighboring municipalities (in case the Naameh landfill will not be closed), that make clean technologies financially attractive, and may also attract new stakeholders and new levels of private sector interest and capability;
- Reviewing the Cost Effectiveness for MSW Services in the BML by: (a) re-assessing the operations costs of the short term 3-5 year contracts for collection services, sorting plants and the composting plant; and (b) Introduce competitive bidding upon expiration of all current contracts, to achieve better cost efficiency.

(c) Strengthening the municipal waste management aspects will include:

- Preparing a MSW management plan that would identify the best solutions based cost-benefit-analysis and on a complete set of actions, including coordination needs among all the stakeholders along these priorities in ways that are protective of the environment, affordable, and responsive to feedback from the public;
- Developing an effective institutional framework within BML that will include clear identification of responsibilities and coordination between the municipalities, the MOE, CDR and the operators in charge of tasks associated with the design, operations, monitoring, and enforcement of waste management systems;
- Establishing environmental criteria and standards for MSW and development of incentives to favor environmentally sound SWM services;
- Introducing a phased approach for cost recovery in BML accompanied by improved MSWM services that is publically acceptable, and based on effective public awareness and communications initiatives;
- Undertaking research, data collection and analysis on the linkages between health and pollution due to MSW to determine the impacts of pollution on public health using the Naameh landfill as a pilot.

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10. ANNEX I METHODOLOGY FOR THE COST ASSESSMENT VALUATION

COLLECTION

When the waste is not properly collected it creates negative externalities in terms of disamenity and health risks. As a rule of thumb a figure of one percent of the disposable income of households in the areas where there is no collection is used as a guide to derive the cost. Source: People without coverage will be provided by SWEEP-Net; and WDI will be used for the disposable income. Nevertheless, when there is no full cost recovery, the net subsidized services is considered as an opportunity cost that could be put to better use and is listed as an opportunity loss.

DISCHARGE

The cleaning cost per m^3 of the generated waste that is not recycled or properly landfilled will be considered. The same population without coverage will be considered and the generated waste per capita will be derived from SWEEPNET. The following assumptions are used:

- the depth of discharge is from 1 meter.
- The average density of waste dumped is 340 kg/m^3.
- Reducing the volume through the uncontrolled landfill fires is 2/3, and leaving a balance of 1/3.

The total municipal waste generated that is not properly handled will have the potential to pollute an area is: m^2 = (ton/day * 365) * 1/3 * 1/340. For cleaning the dumps, US$ 17 m^3 per ton (1 m^2 per 1 meter deep) was adopted.[49]

SORTING AND RECYCLING

The recyclables using the market rate for non-recycled materials is considered an opportunity loss. Waste management could follow developed formal and informal systems of recovery of waste materials with large impacts on the volume and weight of municipal waste collection and final disposal. The cost of forgone landfill in case a lower waste volume is landfilled is also calculated. The results for the recycling and composting will be derived from SWEEPNET data and used in Table A1.1.

Table A1.1: Potentially Recyclable Waste, 2012

	Population	Generated Waste mishandled		Metal	Glass	Paper/ Cardboard	Plastic	Compost Certified Grade	Total
	#	kg/day	Ton/year	%	%	%	%	%	LC Million
Total									
Cost/ton (LC/ton)									
Degradation									
LC million									
Lower bound LC million									
Upper Bound LC million									

Source: GIZ-SWEEP-Net; and Authors.

49- *Bassi et al. (2011).*

CONTAMINATION OF UNDERGROUND WATER

The absence of an adequate system of waste treatment can affect groundwater. This arises through leachate as well as pollution of coastal and surface water due to direct waste dumping. This impact was estimated in Morocco, based on the additional cost of treating extremely polluted water due to leachate infiltration.[50] In that study, a volumetric weight of 0.4 ton/m^3 of waste was assumed, with a leachate level of about 50%, an infiltration rate of 10% and pollution of 50 m^3 of underground water/m^3 of leachates.

LOSS OF LAND AND LEASE VALUE

The disamenity component is estimated in three parts. The first is the area around transfer stations. The second is for passive landfills, where land surrounding them is judged to have declined in value. The third is for one major active landfill where land values are lower owing to its ongoing operations.

Land value depreciation surrounding transfer stations and processing plants. The methodology of hedonic costs was used to derive the cost of depreciation of land surrounding transfer station.[51] The transfer stations are considered in a circular shape to derive the first ring and the second ring of value depreciation: ± 15 % reduction in land prices in a radius up to 30 m around the discharge, and ± 10% price reduction land in a radius from 30 to 100 m around the transfer station (Table A1.2).

Land value depreciation surrounding active and passive dumps/landfills. The methodology of hedonic costs was used to derive the cost of depreciation of land surrounding the active and passive landfills/dumpsites. In the case of an active landfill/dumpsite the measurement of the amenity loss is also made through a decline in the value of real estate around the site, in this particular case, only land lots as buildings depreciation would require to conduct surveys. Estimates of the rate of decline of land and house prices as you get closer to a landfill/dump sites have been made in the US and Europe and are generally found to be significant. A survey of the studies was carried out by Walton et al. (2003). Based on a wide range of studies they conclude that a loss rate of about 4.2% per kilometer is found as you get closer to a disposal site. The distance at which there is no impact is about 5 kilometers. However the range of loss is wide, with estimates going from 0.4% to 17.6%. Factors that are important in determining this rate include the size of the landfill, the population density and median income. No distinction was made between wild and semi-controlled discharges. The criteria retained for active dumps/landfills is based on Nelson (1978) and passive dumps is based on Walton et al. (2003), and are illustrated in Table A1.2.

Table A1.2: Hedonic Criteria for Land Value Depreciation

Input	Area m^2	Radius 1 m	Radius 2 m	Loss 1 %	Loss 2 %
Active					
Transfer Station and Dump/Landfill	>0	≤30	>31m; <100m	15%	10%
Passive					
MSW and CWD Dump	<500	+20m	>20m; <100m	10%	4%
MSW and CWD Dump	≥500	+200m	>200m; <1,000m	10%	4%

Sources: Nelson (1978); Walton et al. (2003); and Authors.

50- World Bank (2003).
51- Nelson (1978).

Land scarcity and opportunity cost of land due to unsustainable disposal practices in the past have been divided into those relating to active landfills and those arising from closed landfills. The analysis assumed that the use of sustainable disposal practices in the past would have avoided the loss of a certain percentage of the current surface of these landfills in favor of other uses. The market price of land for landfill was collected by SWEEP-Net for each country. Assuming that the presence of the landfill would cause a 20 percent reduction in this value,[52] the market value of active landfills will be estimated. Based on (1) and (2), the loss of landfills due to unsustainable disposal practices in the past will be valued but this loss is attributable to at least 10 to 30 years of unsustainable practices, and so the cost of one year of such practice will be divided by the number of years of neglect.

HEALTH EFFECTS

Health risk associated with people living within close proximity to transfer stations and landfill sites should be considered if higher prevalence of certain diseases could be reported from transfer station, dumps and landfills could be collected. Migrating landfill gases can cause serious health and safety hazards to the surrounding population and the prevalence of vector-borne diseases could increase in the transfer station, dump and landfill vicinity.

METHANE EMISSION AVOIDED AND FORGONE ENERGY GENERATION

Waste dumps can release methane, which, if not captured, adds to the global burden of greenhouse gases and also looses opportunities to produce energy. The solid waste generation that is mishandled will be derived from the SWEEP-Net data. The USEPA LandGEM model was used to generate avoidable emissions and potential power production. A discount rate over twenty years will be used in terms of reducing emissions and electricity production by applying the average price per kW/h per country. The production of electrical energy, which can be generated, using the following formula: 1 m^3 CH_4 = 9.8 k/h with 100% efficiency. The emission of methane per ton, which could be avoided between year 0 and year 20 will be calculated and considered in CO_2 equivalent. In addition, certified emission reductions will be calculated.

As a result of past emissions of CO_2 and other greenhouse gases (GHG), the world is now on course for future climate change. The World Resource Institute identifies 2 tons of CO_2 per year per capita as the threshold not to be exceeded to limit the temperature growth to 2°C, above which irreversible and dangerous climate change will become unavoidable. So, the carbon that will be considered as damage cost will be the marginal carbon emissions that exceed 2 tons of CO_2 per year per capita. The social cost of CO_2 is the present and future (2000-2099) damage from a ton of current emissions in terms of: floods, droughts, sea-level rise, declining food production, species extinction, etc. Several estimations are available for the social cost of CO_2 emissions ranging from US$ 3 to US$ 95 (Nordhaus, 2001; Stern, 2007; and IPPC, 2007). Recently, the European Commission (EC 2008 and DECC 2009) has reported US$ 6 per ton as a lower bound value of CO_2 and the French study (Centre d'analyse stratégique, 2009) as an upper bound value of CO_2 with US$ 11 per ton in 2009. A range of US$ 11-15 per ton of CO_2 in 2008 prices was considered as lower bound and higher bound based on Nordhaus, 2011, which estimated the social cost of carbon for the current time (2015) including uncertainty, equity weighting, and risk aversion at US$ 13.6 per ton of CO_2.

52- By using the hedonic price method, a survey conducted in Tunisia revealed that the presence of unsanitary landfills could result in a land price devaluation of 35 percent (World Bank, 2003).

OTHER ENVIRONMENTAL PROBLEMS

Other environmental problems that could not properly quantified include soil erosion and soil destabilization caused by excavation work leading to increased frequency of odors and visual impacts; hazards from opening abandoned landfills due to gas escapes from earth cracks; detrimental impact on wildlife populations (flora and fauna) and habitat destruction in a scarce terrestrial environment; air pollution and dust during operation of landfill sites; and transportation air pollution, especially if gasoline and gasoil are subsidized, traffic jams and possible traffic accidents.

11. ANNEX II HEDONIC PRICING FOR VALUATION OF LAND DEPRECIATION

The results of the hedonic pricing are illustrated in Table A2.1

Table A2.1: Hedonic valuation of land value depreciation surrounding all passive dumpsites in BML, 2012, US$ million

Area	D2=A/Pi/4	Radius	Radius 1	Radius 2	Area 1	Area 2	Losses 1	Losses 2	Land cost	Losses 1 10%	Losses 2 4%	Total	Annualized over 30 years		
m²	m	m	m	m	m²	m²	m²	m²	US$/m²			US$ million			
6	8	1	21	81	1,436	20,807	1,430	20,801	164	0.0	0.1	0.2	0.0	0.0	0.0
20	25	3	23	83	1,594	21,394	1,574	21,374	301	0.0	0.3	0.3	0.0	0.0	0.0
50	64	4	24	84	1,808	22,161	1,758	22,111	291	0.1	0.3	0.3	0.0	0.0	0.0
75	95	5	25	85	1,946	22,637	1,871	22,562	164	0.0	0.1	0.2	0.0	0.0	0.0
80	102	5	25	85	1,971	22,723	1,891	22,643	312	0.1	0.3	0.3	0.0	0.0	0.0
100	127	6	26	86	2,066	23,042	1,966	22,942	229	0.0	0.2	0.3	0.0	0.0	0.0
100	127	6	26	86	2,066	23,042	1,966	22,942	164	0.0	0.2	0.2	0.0	0.0	0.0
100	127	6	26	86	2,066	23,042	1,966	22,942	312	0.1	0.3	0.3	0.0	0.0	0.0
100	127	6	26	86	2,066	23,042	1,966	22,942	301	0.1	0.3	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	229	0.0	0.2	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	164	0.0	0.2	0.2	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	301	0.1	0.3	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	164	0.0	0.2	0.2	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	291	0.1	0.3	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	291	0.1	0.3	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	291	0.1	0.3	0.3	0.0	0.0	0.0
250	318	9	29	89	2,628	24,840	2,378	24,590	312	0.1	0.3	0.4	0.0	0.0	0.0
250	318	9	29	89	2,628	24,840	2,378	24,590	312	0.1	0.3	0.4	0.0	0.0	0.0
300	382	10	30	90	2,785	25,318	2,485	25,018	301	0.1	0.3	0.4	0.0	0.0	0.0
400	509	11	31	91	3,075	26,178	2,675	25,778	109	0.0	0.1	0.1	0.0	0.0	0.0
400	509	11	31	91	3,075	26,178	2,675	25,778	312	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	163.8	0.0	0.2	0.2	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	164	0.0	0.2	0.2	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	291	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	291	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	312	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	301	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	33	93	3,342	26,948	2,842	26,448	301	0.1	0.3	0.4	0.0	0.0	0.0
525	668	13	213	813	142,434	2,076,124	141,909	2,075,599	291	4.1	24.2	28.3	0.1	0.8	0.9
600	764	14	214	814	143,630	2,080,685	143,030	2,080,085	291	4.2	24.2	28.4	0.1	0.8	0.9
600	764	14	214	814	143,630	2,080,685	143,030	2,080,085	312	4.5	26.0	30.4	0.1	0.9	1.0
750	955	15	215	815	145,830	2,089,034	145,080	2,088,284	291	4.2	24.3	28.5	0.1	0.8	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	300	4.4	25.2	29.6	0.1	0.8	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	250	3.7	21.0	24.7	0.1	0.7	0.8
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	109	1.6	9.2	10.8	0.1	0.3	0.4
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	1122	16.6	94.3	110.9	0.6	3.1	3.7

Area	D2=A/Pi/4	Radius	Radius 1	Radius 2	Area 1	Area 2	Losses 1	Losses 2	Land cost	Losses 1 10%	Losses 2 4%	Total	Annualized over 30 years		
m^2	m	m	m	m	m^2	m^2	m^2	m^2	US$/$m^2$			US$ million			
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	500	7.4	42.0	49.4	0.2	1.4	1.6
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	1200	17.8	100.8	118.6	0.6	3.4	4.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	312	4.6	26.2	30.8	0.2	0.9	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	301	4.5	25.3	29.7	0.1	0.8	1.0
1,500	1910	22	222	822	154,622	2,121,954	153,122	2,120,454	234	3.6	19.8	23.4	0.1	0.7	0.8
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	312	4.9	26.7	31.6	0.2	0.9	1.1
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	500	7.9	42.7	50.6	0.3	1.4	1.7
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	301	4.7	25.7	30.5	0.2	0.9	1.0
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	114	1.9	9.9	11.8	0.1	0.3	0.4
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	312	5.1	27.0	32.2	0.2	0.9	1.1
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	301	5.0	26.1	31.0	0.2	0.9	1.0
3,500	4456	33	233	833	171,108	2,181,895	167,608	2,178,395	400	6.7	34.9	41.6	0.2	1.2	1.4
3,500	4456	33	233	833	171,108	2,181,895	167,608	2,178,395	291	4.9	25.4	30.2	0.2	0.8	1.0
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	149	2.5	13.1	15.6	0.1	0.4	0.5
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	312	5.3	27.3	32.7	0.2	0.9	1.1
4,050	5157	36	236	836	174,833	2,195,147	170,783	2,191,097	1000	17.1	87.6	104.7	0.6	2.9	3.5
4,250	5411	37	237	837	176,134	2,199,749	171,884	2,195,499	653	11.2	57.3	68.6	0.4	1.9	2.3
4,500	5730	38	238	838	177,724	2,205,359	173,224	2,200,859	291	5.0	25.6	30.7	0.2	0.9	1.0
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	229	4.0	20.3	24.3	0.1	0.7	0.8
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	450	7.9	39.8	47.7	0.3	1.3	1.6
8,000	10186	50	250	850	197,077	2,272,272	189,077	2,264,272	229	4.3	20.7	25.1	0.1	0.7	0.8
11,000	14006	59	259	859	211,022	2,319,054	200,022	2,308,054	500	10.0	46.2	56.2	0.3	1.5	1.9
25,000	31831	89	289	889	262,764	2,484,019	237,764	2,459,019	100	2.4	9.8	12.2	0.1	0.3	0.4
150,000	190986	219	419	1019	550,251	3,258,969	400,251	3,108,969	2300	92.1	286.0	378.1	3.1	9.5	12.6
15	19	2	22	82	1,546	21,220	1,531	21,205	291	0.0	0.2	0.3	0.0	0.0	0.0
30	38	3	23	83	1,675	21,689	1,645	21,659	229	0.0	0.2	0.2	0.0	0.0	0.0
30	38	3	23	83	1,675	21,689	1,645	21,659	301	0.0	0.3	0.3	0.0	0.0	0.0
50	64	4	24	84	1,808	22,161	1,758	22,111	312	0.1	0.3	0.3	0.0	0.0	0.0
80	102	5	25	85	1,971	22,723	1,891	22,643	109	0.0	0.1	0.1	0.0	0.0	0.0
100	127	6	26	86	2,066	23,042	1,966	22,942	312	0.1	0.3	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	291	0.1	0.3	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	291	0.1	0.3	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	109	0.0	0.1	0.1	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	312	0.1	0.3	0.4	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	312	0.1	0.3	0.4	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	301	0.1	0.3	0.3	0.0	0.0	0.0
150	191	7	27	87	2,275	23,729	2,125	23,579	301	0.1	0.3	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	229	0.1	0.2	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	229	0.1	0.2	0.3	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	312	0.1	0.3	0.4	0.0	0.0	0.0
200	255	8	28	88	2,459	24,317	2,259	24,117	301	0.1	0.3	0.4	0.0	0.0	0.0
300	382	10	30	90	2,785	25,318	2,485	25,018	301	0.1	0.3	0.4	0.0	0.0	0.0
350	446	11	31	91	2,933	25,762	2,583	25,412	301	0.1	0.3	0.4	0.0	0.0	0.0
400	509	11	31	91	3,075	26,178	2,675	25,778	229	0.1	0.2	0.3	0.0	0.0	0.0
400	509	11	31	91	3,075	26,178	2,675	25,778	312	0.1	0.3	0.4	0.0	0.0	0.0
400	509	11	31	91	3,075	26,178	2,675	25,778	301	0.1	0.3	0.4	0.0	0.0	0.0
450	573	12	32	92	3,211	26,572	2,761	26,122	291	0.1	0.3	0.4	0.0	0.0	0.0

Area	D2=A/Pi/4	Radius	Radius 1	Radius 2	Area 1	Area 2	Losses 1	Losses 2	Land cost	Losses 1 10%	Losses 2 4%	Total	Annualized over 30 years		
m²	m	m	m	m	m²	m²	m²	m²	US$/m²	US$ million					
450	573	12	32	92	3,211	26,572	2,761	26,122	291	0.1	0.3	0.4	0.0	0.0	0.0
500	637	13	213	813	142,017	2,074,533	141,517	2,074,033	312	4.4	25.9	30.3	0.1	0.9	1.0
500	637	13	213	813	142,017	2,074,533	141,517	2,074,033	301	4.3	25.0	29.2	0.1	0.8	1.0
500	637	13	213	813	142,017	2,074,533	141,517	2,074,033	301	4.3	25.0	29.2	0.1	0.8	1.0
600	764	14	214	814	143,630	2,080,685	143,030	2,080,085	164	2.3	13.6	16.0	0.1	0.5	0.5
600	764	14	214	814	143,630	2,080,685	143,030	2,080,085	291	4.2	24.2	28.4	0.1	0.8	0.9
625	796	14	214	814	144,013	2,082,142	143,388	2,081,517	229	3.3	19.1	22.4	0.1	0.6	0.7
700	891	15	215	815	145,122	2,086,351	144,422	2,085,651	291	4.2	24.3	28.5	0.1	0.8	0.9
750	955	15	215	815	145,830	2,089,034	145,080	2,088,284	301	4.4	25.1	29.5	0.1	0.8	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	109	1.6	9.2	10.8	0.1	0.3	0.4
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	1122	16.6	94.3	110.9	0.6	3.1	3.7
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	1200	17.8	100.8	118.6	0.6	3.4	4.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	1200	17.8	100.8	118.6	0.6	3.4	4.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	189	2.8	15.9	18.7	0.1	0.5	0.6
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	301	4.5	25.3	29.7	0.1	0.8	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	300	4.4	25.2	29.6	0.1	0.8	1.0
1,000	1273	18	218	818	149,084	2,101,299	148,084	2,100,299	300	4.4	25.2	29.6	0.1	0.8	1.0
1,200	1528	20	220	820	151,424	2,110,059	150,224	2,108,859	50	0.8	4.2	5.0	0.0	0.1	0.2
1,200	1528	20	220	820	151,424	2,110,059	150,224	2,108,859	291	4.4	24.5	28.9	0.1	0.8	1.0
1,200	1528	20	220	820	151,424	2,110,059	150,224	2,108,859	1200	18.0	101.2	119.3	0.6	3.4	4.0
1,200	1528	20	220	820	151,424	2,110,059	150,224	2,108,859	301	4.5	25.4	29.9	0.2	0.8	1.0
1,500	1910	22	222	822	154,622	2,121,954	153,122	2,120,454	291	4.5	24.7	29.1	0.1	0.8	1.0
1,500	1910	22	222	822	154,622	2,121,954	153,122	2,120,454	1000	15.3	84.8	100.1	0.5	2.8	3.3
1,500	1910	22	222	822	154,622	2,121,954	153,122	2,120,454	1386	21.2	117.6	138.8	0.7	3.9	4.6
1,500	1910	22	222	822	154,622	2,121,954	153,122	2,120,454	1386	21.2	117.6	138.8	0.7	3.9	4.6
1,800	2292	24	224	824	157,543	2,132,737	155,743	2,130,937	50	0.8	4.3	5.0	0.0	0.1	0.2
1,800	2292	24	224	824	157,543	2,132,737	155,743	2,130,937	250	3.9	21.3	25.2	0.1	0.7	0.8
1,800	2292	24	224	824	157,543	2,132,737	155,743	2,130,937	1386	21.6	118.1	139.7	0.7	3.9	4.7
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	229	3.6	19.6	23.2	0.1	0.7	0.8
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	229	3.6	19.6	23.2	0.1	0.7	0.8
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	109	1.7	9.3	11.0	0.1	0.3	0.4
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	1386	21.8	118.5	140.3	0.7	3.9	4.7
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	301	4.7	25.7	30.5	0.2	0.9	1.0
2,000	2546	25	225	825	159,370	2,139,446	157,370	2,137,446	301	4.7	25.7	30.5	0.2	0.9	1.0
2,100	2674	26	226	826	160,253	2,142,678	158,153	2,140,578	250	4.0	21.4	25.4	0.1	0.7	0.8
2,250	2865	27	227	827	161,544	2,147,389	159,294	2,145,139	301	4.8	25.8	30.6	0.2	0.9	1.0
2,500	3183	28	228	828	163,613	2,154,916	161,113	2,152,416	300	4.8	25.8	30.7	0.2	0.9	1.0
2,500	3183	28	228	828	163,613	2,154,916	161,113	2,152,416	1386	22.3	119.3	141.7	0.7	4.0	4.7
2,500	3183	28	228	828	163,613	2,154,916	161,113	2,152,416	516	8.3	44.4	52.7	0.3	1.5	1.8
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	1386	22.8	120.1	142.9	0.8	4.0	4.8
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	1386	22.8	120.1	142.9	0.8	4.0	4.8
3,000	3820	31	231	831	167,496	2,168,949	164,496	2,165,949	312	5.1	27.0	32.2	0.2	0.9	1.1
3,500	4456	33	233	833	171,108	2,181,895	167,608	2,178,395	550	9.2	47.9	57.1	0.3	1.6	1.9
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	1386	23.6	121.4	145.0	0.8	4.0	4.8
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	1386	23.6	121.4	145.0	0.8	4.0	4.8
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	154	2.6	13.5	16.1	0.1	0.4	0.5
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	1000	17.1	87.6	104.6	0.6	2.9	3.5

Area	D2=A/Pi/4	Radius	Radius 1	Radius 2	Area 1	Area 2	Losses 1	Losses 2	Land cost	Losses 1 10%	Losses 2 4%	Total	Annualized over 30 years		
m^2	m	m	m	m	m^2	m^2	m^2	m^2	US$/$m^2$			US$ million			
4,000	5093	36	236	836	174,504	2,193,979	170,504	2,189,979	300	5.1	26.3	31.4	0.2	0.9	1.0
4,500	5730	38	238	838	177,724	2,205,359	173,224	2,200,859	291	5.0	25.6	30.7	0.2	0.9	1.0
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	1122	19.7	99.2	119.0	0.7	3.3	4.0
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	234	4.1	20.7	24.8	0.1	0.7	0.8
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	1250	22.0	110.6	132.5	0.7	3.7	4.4
5,000	6366	40	240	840	180,796	2,216,150	175,796	2,211,150	653	11.5	57.8	69.2	0.4	1.9	2.3
6,000	7639	44	244	844	186,581	2,236,289	180,581	2,230,289	15	0.3	1.3	1.6	0.0	0.0	0.1
7,000	8913	47	247	847	191,981	2,254,890	184,981	2,247,890	500	9.2	45.0	54.2	0.3	1.5	1.8
7,000	8913	47	247	847	191,981	2,254,890	184,981	2,247,890	653	12.1	58.7	70.8	0.4	2.0	2.4
7,500	9549	49	249	849	194,563	2,263,718	187,063	2,256,218	686	12.8	61.9	74.7	0.4	2.1	2.5
7,500	9549	49	249	849	194,563	2,263,718	187,063	2,256,218	1333	24.9	120.3	145.2	0.8	4.0	4.8
10,000	12732	56	256	856	206,562	2,304,212	196,562	2,294,212	30	0.6	2.8	3.3	0.0	0.1	0.1
10,000	12732	56	256	856	206,562	2,304,212	196,562	2,294,212	154	3.0	14.1	17.2	0.1	0.5	0.6
10,000	12732	56	256	856	206,562	2,304,212	196,562	2,294,212	653	12.8	59.9	72.8	0.4	2.0	2.4
12,000	15279	62	262	862	215,329	2,333,279	203,329	2,321,279	185	3.8	17.2	20.9	0.1	0.6	0.7
14,000	17825	67	267	867	223,552	2,360,171	209,552	2,346,171	653	13.7	61.3	75.0	0.5	2.0	2.5
15,000	19099	69	269	869	227,496	2,372,948	212,496	2,357,948	154	3.3	14.5	17.8	0.1	0.5	0.6
15,000	19099	69	269	869	227,496	2,372,948	212,496	2,357,948	312	6.6	29.4	36.1	0.2	1.0	1.2
15,000	19099	69	269	869	227,496	2,372,948	212,496	2,357,948	582	12.4	54.9	67.3	0.4	1.8	2.2
20,000	25465	80	280	880	245,929	2,431,680	225,929	2,411,680	30	0.7	2.9	3.6	0.0	0.1	0.1
20,500	26101	81	281	881	247,674	2,437,162	227,174	2,416,662	1000	22.7	96.7	119.4	0.8	3.2	4.0
50,000	63662	126	326	926	334,197	2,694,752	284,197	2,644,752	1000	28.4	105.8	134.2	0.9	3.5	4.5
74,400	94729	154	354	954	393,448	2,858,557	319,048	2,784,157	1000	31.9	111.4	143.3	1.1	3.7	4.8
681,386	867,568	4,010	25,250	88,970	18,010,773	223,087,487	17,329,387	222,406,101	68,122	1,268	6,184	7,453	42	206	248

Source: Nelson (1978); Bassi et al. (2011); MOE/UNDP/ElArd (2011); GIZ-SWEEPNET Lebanon Report (2012); and Authors.

12. ANNEX III REMEDIATION RESULTS

Gains associated with selected remediation interventions are shown in Table A3.1 to A3.4.

Table A1.1: Potentially Recyclable Waste, 2012

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cost	2.0	2.0	2.0	0.2	0.2	0.2	0.2	0.2	0.2
Benefit				2.4	2.4	2.4	2.4	2.4	2.4
Benefit/Cost	(2.0)	(2.0)	(2.0)	2.2	2.2	2.2	2.2	2.2	2.2

Note: A 3% operations and maintenance is maintained during the rehabilitation of the dump.

Source: MOE/UNDP/ElArd (2011); and Authors.

Table A3.2: Scenario 3 Dump Rehabilitation 2023-2033, US$ million

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cost	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Benefit	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
Benefit/Cost	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2

Note: A 3% operations and maintenance is maintained during the rehabilitation of the dump.

Source: MOE/UNDP/ElArd (2011); and Authors.

Table A3.3: Recycling Capacity Increase 2014-2022, US$ million

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cost	19.9	19.91	19.91	8.92	8.92	8.92	8.92	8.92	8.92
Benefit				39.7	39.7	39.7	39.7	39.7	39.7
Benefit/Cost	(19.9)	(19.9)	(19.9)	30.7	30.7	30.7	30.7	30.7	30.7

Source: adapted from World Bank Lebanon CEA (2011); and Authors.

Table A3.4: Recycling Capacity Increase 2023-2033, US$ million

Year	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Cost	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92	8.92
Benefit	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7	39.7
Benefit/Cost	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7

Source: adapted from World Bank Lebanon CEA (2011); and Authors.

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