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Cost Assessment of Environmental Degradation due to Solid Waste Management Practices

Model guidebook

SWEEPNET

cmi

En coopération avec

ANGed

SWEEPNET

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

Cost Assessment of Environmental Degradation due to Solid Waste Management Practices

MODEL GUIDEBOOK

February
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Requirement

A basic knowledge in MS Excel is required to be able to use the Model.

Citation

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ACRONYMES

BA	Benefit Assessment
B/C	Benefit/Cost
BCA	Benefit/Cost Analysis
BFT	Benefit Function Transfer
CASWD	Cost Assessment of Solid Waste Degradation
COED	Cost of Environmental Degradation
CDW	Construction and Debris Waste
CERs	Certified Emission Reduction units
CH_4	Methane
CO_2	Carbon Dioxide
CV	Contingent valuation
EPA	Environmental Protection Agency of the United States
EU	European Union
GDI	Gross Domestic Income
GDP	Gross Domestic Product
GIS	Geographical Information System
GiZ	Gesellschaft für Internationale Zusammenarbeit (previously GTZ)
Ha	Hectare
Kg	Kilogram
LCU	Local Currency Unit
m	meter
m^2	Square meter
m^3	Cubic meter
MSW	Municipal Solid Waste
NPV	Net Present Value
O&M	Operations and Maintenance
PV	Present Value
SWM	Solid Waste Management
TEV	Total Economic Value
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
WDI	World Development Indicators
WHO	World Health Organisation

1. INTRODUCTION

1.1 BACKGROUND

Municipal Solid Waste Management (MSWM) remains one of the key challenges that is facing the Middle East and North Africa (MENA) Countries benefiting from the Regional Solid Waste Exchange of Information and Expertise Network in the Maghreb and Mashreq Countries (SWEEP-Net). The SWEEP-Net Partner Countries (SNPC) are: Mauritania, Algeria, Egypt, Jordan, Lebanon, Morocco, Tunisia, Palestine and Yemen.

The SWEEP-Net partner countries are increasingly facing critical issues related to sustainable municipal waste management from pre-collection to treatment and disposal in their capital cities. These challenges are taking their toll on health, environmental, economic and/or social issues. Detailed social cost valuations of these issues were not thoroughly performed in the past. The Cost of Environmental Degradation (COED) allows to value national and regional pollution degradation notably from the solid waste chain. Moreover, the COED assessment could lead to better informed decisions and priorities in resource allocation. Also it provides local institutions with the necessary tools to speak in monetary terms to their national ministries and in particular with the ministries of finance, to other relevant authorities and to the public with regards to different types of municipal solid waste degradation costs and the policies required to mitigate these costs.

In early 2014, SWEEP-Net launched in cooperation with CMI (The Center for Mediterranean Integration) a sectoral analysis on the COED and remediation, due to municipal waste management practices in the capital cities and their agglomerations in Greater Beirut (Lebanon), Greater Rabat (Morocco), and Greater Tunis (Tunisia). The principal objective was to: (i) assess the legal, institutional, regulatory and financial framework; (ii) quantify the degradation and remediation of the environment due to municipal waste management practices in monetary terms; and (iii) assist decision-makers at national and local levels to identify and prioritize specific actions to improve the integrated solid waste management (SWM) practices. Three COED reports and policy notes were respectively prepared and discussed at a joint meeting with the three countries' representatives at CMI in Marseilles on April 23-24, 2014 and subsequently presented at the SWEEP-Net Fourth Regional Forum in Amman in May 13-14, 2014.

A comparative policy note was prepared with the purpose to: (a) present similarities and differences of the COED due to municipal waste management in the three capitals and their agglomerations; (b) propose indicators to estimate the COED in other cities of the respective Middle East and North Africa countries; and (c) propose policy implications resulting from the COED studies.

After several meetings, there is a shared vision in order to (i) gather competencies for the realization of knowledge products; (ii) mutualize efforts for dissemination activities; and (iii) gain visibility and reach a broader audience, especially decision-makers.

1.2 SCOPE AND OBJECTIVE

The scope of work is to develop and apply a CASWD methodology to assess costs related to the solid waste management practices in capital cities of the MENA region. The expected results are the development of user-friendly software to calculate the CASWD.

1.3 TASK

The following task consists in the development of a user-friendly software to calculate CASWD based on Excel. Excel note (how to enter data) and sheets (auto-calculation) were developed in English to determine the cost of environmental degradation associated with domestic solid waste.

The cost associated with the following categories were considered: lack of collection, cost associated with the clean-up due to discharge, potential for recycling and composting, landfill areas avoidable due to recycling and composting, loss of land value around waste 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, methane emission avoidable and forgone energy generation.

2. METHODOLOGY, CALIBRATION AND LIMITATIONS OF THE MODEL

2.1 INTRODUCTION

In addition to urban and rural domestic waste, the solid waste chain could include sludge from wastewater treatment plants, agricultural waste (including slaughterhouse), construction and debris, E-waste as well as medical and hazardous waste. The mismanagement of the waste chain can result in several impacts such as: air (PMx, H_2S, VOC, NMOC, NOx, NH_4Cl, 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. 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.

Yet, this Model takes into consideration domestic waste. Although health impacts are acknowledged in certain waste mismanagement cases, they are however not taken into account in the Model.

2.2 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,[1] the European Commission's Manual on the Benefit Assessment[2] 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.[3]

The main methods for estimating impacts are grouped around three pillars with specific techniques under each pillar (Figure 2.1):

Change in production:

- Value of changes in productivity such as reduced agricultural productivity due to salinity and /or loss of nutrients in the soil;

1 Website of the World Bank : ←www.worlddbank.org→.
2 Website of the EU ENPI BA: ←www.environment-benefits.eu→.
3 Website of TEEB: ←www.teebtest.org→.

- The opportunity cost of such shortfall of not re-selling the recycled waste;
- The 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.

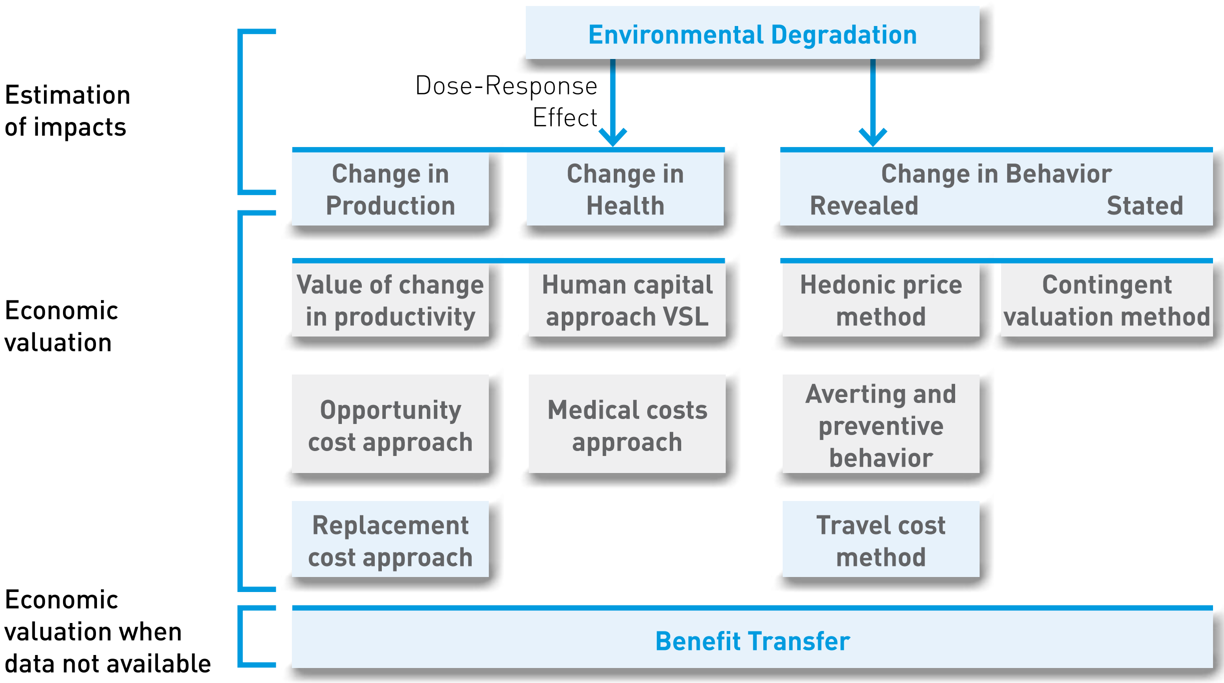
Changing behavior with two sub-techniques: revealed preferences, and stated preferences.

- 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 2.1.

The base year 2012 was chosen to estimate the CASWD but could be altered in the future for the Model.

Figure 2.1: Estimation of Impacts and Associated Economic Valuation Techniques



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

2.3 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.

2.4 SUB-CATEGORIES AND TECHNIQUES CONSIDERED IN THE MODEL

The CASWD includes 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 CASWD Model includes 2 major categories illustrated in Table 2.1: CASWD; and loss of opportunity valuation. Recycling and composting as well as landfill area avoidable, are considered separately to underline the opportunity loss when recycling and composting are not considered. Whereas the pollution associated with waste mismanagement is considered under the CASWD. Moreover, the Opportunity Loss in terms of Collection and Landfilling (subsidized services) was not considered in the Model to simplify the process. Subsidies could however be considered manually to underline the opportunity loss in terms of public fund allocative efficiency. General and specific description of the methods used for the sub-categories are developed in Annex I and in the CASWD SWEEP-Net on Greater Beirut and Mount Lebanon (Lebanon), Greater Rabat (Morocco) and Greater Tunis (Tunisia). [4]

4 *SWEEP-Net website: ←www.sweep-net.org→.*

Table 2.1 : CASWD and Opportunity Loss Valuation Techniques

Category	Valuation Technique	
	CASWD	Opportunity Loss
Collection	1% of Disposable Income that households could afford (non-collected waste) as a defensive cost reflecting the pollution of the environs as well as air (if burnt), sight and odor pollution	
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 and dumps	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 active dumps	Hedonic (land price decrement)	
Loss of land value around passive landfills	Hedonic (land price decrement)	
Loss of land value around passive dumps	Hedonic (land price decrement)	
Loss of land value around passive landfills	Hedonic (land price decrement)	
Loss of land value around passive dumps	Hedonic (land price decrement)	
Methane emission avoidable	LandGem Model (CER/global cost)	
Forgone energy generation	LandGem Model (average tariff)	
Global Environment	Carbon footprint from waste	

Source : Author.

3. THE MODEL

3.1 INTRODUCTION

The Model uses the Excel software and is designed in English and French. It covers SWEEP-Net's 9 countries: Algeria, Egypt, Jordan, Lebanon, Mauritania, Morocco, Palestine, Tunisia and Yemen. It is set for year 2012 but could be updated when more recent data are made available (WDI, 2014): e.g., GDP and GDI figures. Two Excel workbooks are available: the Model; and the Model Sample where 2 countries, an Anglophone and Francophone are sampled.

3.2 FILES

The files in the Model include (Figure 3.1): **Preliminary** where the color-coded functions are described; **Dataset** is the main file where some data is already available, data is meant to be entered and automatic calculations will be performed; 10 Files on **CASWD Results** in English and French will automatically provide the final tables in US$ million and Local Currency Unit (LCU), and in percentage of GDP and figure illustrating the results for each country; and 2 additional Files per country allow to enter the data (area and cost of land) for the land depreciation (**Land Terrain**) and Methane emissions (**Methane**).

Figure 3.1: Model Overview

3.3 PRELIMINARY

The preliminary file is just to describe the Model functions where data entry (in **red**), variables (in **blue**) and automatic data calculations (in **white** and **yellow** for CASWD results) are color-coded (Figure 3.2).

Figure 3.2: Preliminary

	English	Français
Color Coded-Code Couleur	Function	Fonction
	Enter Data	Entrez les Données
	Automated Calculation	Calculation Automatique
	Automated Calculation with Sub-category Results	Calculation Automtique avec le Résultat des Sous-catégories
	Variables that could be Changed as Needed	Variables Pouvant être Ajustées au Besoin
Acronym-Acronyme		
CASWD	Cost Assessment of Solid Waste Degradation	Evaluation du Coût de la Dégradation des Déchets Solides

3.4 DATASET

The Dataset File is the crux of the Model where most of the data will need to be entered. The first part includes already entered 2012 data on population, GDP, GDI and the exchange rate of December 31, 2012. These could be updated as need be. Figure 3.3 illustrates the dataset of the Sample Model. It includes Input, Unit, Variable, Country-specific and Source columns.

Figure 3.3: Dataset 1

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	2012	
Population	#		38 481 705	38 481 705	WDI 2014
Population: Capital(e)	#		2 920 325	2 920 325	WDI 2014
GDP-PIB	$		207 955 103 846	207 955 103 846	WDI 2014
GDI-RIB	$		196 528 564 118	196 528 564 118	WDI 2014
GDP-PIB/capita	$		5 404	5 404	WDI 2014
GDP-PIB/capita	PPP$		8 447	8 447	WDI 2014
GDI-RIB/capita	$		5 107	5 107	WDI 2014
Services @ 1% GDI-RIB/Capita	$		51	51	WDI 2014
Exchange Rate-Taux de Change	US$ 1=LCU		3,00	3,00	Oanda website ←www.oanda.com→

3.4.1 Collection

Several entries in the red cells are needed in terms of domestic waste generation, waste composition breakdown and collection coverage (Figure 3.4). The uncollected CASWD will automatically be calculated based on 1% GDI/capita for the population without coverage.[5] Should a differentiated population targeted with various waste generation per day analysis is sought, e.g., urban vs. rural, the Model workbook could be used multiplicatively and the results aggregated.

5 *Cointreau, 2006.*

Figure 3.4: Dataset 2

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	**2012**	
Population	#		38 481 705	38 481 705	WDI 2014
Population: Targeted-Ciblée	#		1 000 000	1 000 000	Official Data-Données Officielles
Generation-Génération	kg/capita/ day-jour		1	1	Official Data-Données Officielles
Generation/Breakdown-Ventilation de la Génération	tonnes/ year-an		365 000	365 000	
Organic-Organique	%		60%	60%	Official Data-Données Officielles
Paper-Papier	%		7%	7%	Official Data-Données Officielles
Plastic-Plastique	%		5%	5%	Official Data-Données Officielles
Glass-Verre	%		7%	7%	Official Data-Données Officielles
Metal-Métal	%		8%	8%	Official Data-Données Officielles
Textile	%		5%	5%	Official Data-Données Officielles
Wood-Bois	%		5%	5%	Official Data-Données Officielles
Other-Autre	%		3%	3%	Official Data-Données Officielles
Total	%		100%	100%	
Collected-Collecté	%		80%	80%	Official Data-Données Officielles
Uncollected-Non-collecté	%		20%	20%	
Uncollected-Non-collecté	Tonnes/ year-an		73 000	73 000	
CASWD Uncollected-Non-collecté	$		10 214 130	10 214 130	

3.4.2 Discharge (for non-collected waste)

The non-collected waste has a cost in terms of clean up. It is automatically calculated as illustrated in Figure 3.5.

Figure 3.5: Dataset 3

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	**2012**	
Uncollected Waste Volume Reduction-Réduction du Volume des Déchets Non-collectés	m2		26 123	26 123	WDI 2014
Uncollected Waste Clean up Cost-Coût de Nettoyage des Déchets Non-collecté	$/Tonne		9,6	9,6	Official Data-Données Officielles
CASWD Clean up-Nettoyage	$		250 991	250 991	Official Data-Données Officielles

3.4.3 Recycling and Composting

The Recycling and Composting require several entries in terms of actual recycled and composted waste and their market price. If there is no ongoing recycling and composting, 0% should be entered (Figure 3.6).

Figure 3.6: Dataset 4

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	2012	
Actual Compost/Recycling-Compostage/Recyclage Actuel					
Organic-Organique/putrescible	%		20%	20%	Official Data-Données Officielles
Paper-Papier	%		4%	4%	Official Data-Données Officielles
Plastic-Plastique	%		2%	2%	Official Data-Données Officielles
Glass-Verre	%		3%	3%	Official Data-Données Officielles
Metal-Métal	%		3%	3%	Official Data-Données Officielles
Textile	%		1%	1%	Official Data-Données Officielles
Wood-Bois	%		1%	1%	Official Data-Données Officielles
Other(Specify)-Autre(Spécifier)	%				Official Data-Données Officielles
Total	%		34%	34%	
Residuel Compost/Recycling-Compostage/Recyclage Résiduel					
Organic-Organique/putrescible	Tonnes/ year-an		146 000	146 000	
Paper-Papier	Tonnes/ year-an		10 950	10 950	
Plastic-Plastique	Tonnes/ year-an		10 950	10 950	
Glass-Verre	Tonnes/ year-an		14 600	14 600	
Metal-Métal	Tonnes/ year-an		18 250	18 250	
Textile	Tonnes/ year-an		14 600	14 600	
Wood-Bois	Tonnes/ year-an		14 600	14 600	
Other(Specify)-Autre(Spécifier)	Tonnes/ year-an		10 950	10 950	
Total	Tonnes/ year-an		240 900	240 900	
Potential Compost/Recycling-Compostage/Recyclage Potentiel					Professional Judgement-Jugement Professionel
Organic-Organique/putrescible	Tonnes/ year-an Mass-Masse reduction	45%	65 700	65 700	
Paper-Papier	Tonnes/ year-an	100%	10 950	10 950	
Plastic-Plastique	Tonnes/ year-an	100%	10 950	10 950	

Glass-Verre	Tonnes/ year-an	100%	14 600	14 600	
Metal-Métal	Tonnes/ year-an	100%	18 250	18 250	
Textile	Tonnes/ year-an	100%	14 600	14 600	
Wood-Bois	Tonnes/ year-an	100%	14 600	14 600	
Other(Specify)-Autre(Spécifier)	Tonnes/ year-an	100%	10 950	10 950	
Total	Tonnes/ year-an		160 600	160 600	
Market Compost/Recycling Price-Compostage/Recyclage Prix de Marché					
Organic-Organique/putrescible	$/Tonne		50	50	Market Data-Données du Marché
Paper-Papier	$/Tonne		25	25	Market Data-Données du Marché
Plastic-Plastique	$/Tonne		25	25	Market Data-Données du Marché
Glass-Verre	$/Tonne		20	20	Market Data-Données du Marché
Metal-Métal	$/Tonne		100	100	Market Data-Données du Marché
Textile	$/Tonne		5	5	Market Data-Données du Marché
Wood-Bois	$/Tonne		5	5	Market Data-Données du Marché
Other(Specify)-Autre(Spécifier)	$/Tonne				Market Data-Données du Marché

Market Compost/Recycling Price-Compostage/Recyclage Prix de Marché				
Organic-Organique/putrescible	$	3 285 000	3 285 000	
Paper-Papier	$	273 750	273 750	
Plastic-Plastique	$	273 750	273 750	
Glass-Verre	$	292 000	292 000	
Metal-Métal	$	1 825 000	1 825 000	
Textile	$	73 000	73 000	
Wood-Bois	$	73 000	73 000	
Other(Specify)-Autre(Spécifier)	$	-	-	
CASWD Compost/Recycling-Compostage/Recyclage	$	6 095 500	6 095 500	

After entering the actual recycling and composting, the residual and potential recycling and composting will be automatically calculated. Also, the variables for recycling and composting could be altered based on professional judgment. All the variables are set at **100%** except for composting where the mass reduction of organic waste through the process of composting is set by default at **45%** (Annex I). These variables could be altered when better data is available.

3.4.4 Landfill area avoidable

The landfill area, avoidable from recycling and composting is also calculated as an opportunity loss. The recycling and composting mass in a landfill depends on two variables: the compacting set by default at 5.51 tonnes per m^3; and the elevation 15.5 meter of the landfill (Figure 3.7). These variables could be altered when better figures are available. The only data entry under this subcategory is an average price of landfill land. When a differentiated landfill price analysis is sought, the Model workbook could be used multiplicatively and the results aggregated.

Figure 3.7: Dataset 5

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	2012	
Landfill Area Gained-Superficie de la Décharge Gagnée	Compacting-Compactage Tonne/m^3	5,51			Australian Environment Protection Authority
Volume Compacted-Compacté	m^3		884 261	884 261	Australian Environment Protection Authority
Area with Elevation-Superficie avec Elévation (1-30 m)	m^2	15,5	57 049	57 049	Australian Environment Protection Authority
Land Cost-Coût du Terrain	$/$m^2$		30	30	Market Data-Données du Marché
CASWD Landfill Area Gained-Superficie de la Décharge Gagnée	$		1 711 473	1 711 473	

3.4.5 Underground water contamination from active landfills and dumps

Data entry is differentiated for treated and untreated leachate from active landfills and dumps. The volume of untreated leachate with potential runoff is a variable set at **0.28** m^3 per m^2 per year and based on Nas and Nas (2014) where average annual precipitation is considered. This variable could be altered if better data is available. The volume of underground water contamination from leachate runoff could be entered if available. The cost associated with the leachate treatment is the marginal cost of treating the compounds that are not treated by wastewater treatment plants. These costs are variably differentiated by country (Figure 3.8) and could be altered if better costs would be available.

Figure 3.8: Dataset 6

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	2012	
Pollution: Underground Water-Nappe Phréatique	Enter a %/ Entrez un %				Nas and Nas 2014
Waste Sanitary Landfilled and Leachate Treated- Déchets Mis en Décharge Controlée et Lixiviats Traitées	%/Organic- Organique		109 500	109 500	Official Data- Données Officielles
Waste Landfilled and Leachate Untreated- Déchets Mis en Décharge et Lixiviats Non-Traitées	%/Organic- Organique		-	-	Official Data- Données Officielles
Waste Dumped and Leachate Untreated- Déchets Mis en Décharge Sauvage et Lixiviats Non-Traitées	%/Organic- Organique		109 500	109 500	Official Data- Données Officielles
Untreated Leachate- Lixiviats Non-Traitées	%/Organic- Organique		-	-	
Untreated Leachate- Lixiviats Non-Traitées (m^3/m^2/ year-an)	m^3	0,28	61 950	61 950	Nas and Nas 2014
Pollution: Underground Water Volume- Volume Nappe Phréatique: if-si ∃, add-ajoutez volume	m^3		100 000	100 000	Official Data- Données Officielles
Total Pollution	m^3		161 950	161 950	
Net Marginal Treatment/ Traitement Net Marginal	$/$m^3$		5	5	Data Provided but could be updated-Données fournies mais pourrant être mises à jour
CASWD Pollution: Underground Water- Nappe Phréatique	$		761 388	761 388	

3.4.6 Loss of land value around active and passive transfer stations, landfills and dumps

Active and passive transfer station, landfill and dump loss of land value based on hedonic pricing is based on Nelson (1978). The sub-category results are aggregated under the Dataset worksheet (Figure 3.9).

To perform the data entry, the country specific **Land Terrain** worksheet must be selected. Data entry for active and passive transfer station, landfill and dump are in m^2 is needed. Should more than 10 locations exist, a simple action could be performed in Excel: select row, copy row, and insert row. Also, the Total should be adjusted with the cells to be added. So the area and price of land are needed for each entry.

For the variables, the percentage land price decrement used under this sub-category are variables and could be adjusted whenever actual revealed preferences are readily available. Moreover, the CASWD should be divided by the active and passive transfer station, landfill and dump number of years in operations or abandonment. The variable is set at **1** year by default (**6.5** years in the Sample) but should be adjusted for each entry (Figure 3.10).

Figure 3.9: Dataset 7

Input Intrant	Unit Unité	Variable Variable	Francophone Francophone	Anglophone Anglophone	Source Source
			2012	2012	
Land Depreciation- Moins-Value des Terrains					
Transfer Stations- Stations de Transfert	$		85 623	85 623	Official Data- Données Officielles
Landfill Active- Décharge Controlée Active	$		195 377	195 377	Official Data- Données Officielles
Landfill Passive- Décharge Controlée Passive	$		300 978	300 978	Official Data- Données Officielles
Dump Active- Décharge Sauvage Active	$		29 483	29 483	Official Data- Données Officielles
Dump Passive- Décharge Sauvage Passive	$		24 785	24 785	Official Data- Données Officielles
CASWD Land Depreciation- Moins-Value des Terrains	$		636 246	636 246	

Figure 3.10: Land Terrain

Transfer/Segragation Station Station de Transfert/Ségragation	Area / Superficie	D2=A/Pi/4	Diameter/ Diamètre	Radius/ Rayon	Radius 1/ Rayon 1	Radius 2/ Rayon 2	Area 1/ Superficie 1	Area2/ Superficie 2	Losses 1/ Pertes 1	Losses 2/ Pertes 2	Land Cost/ Coût du Terrain	Losses 1 15%/ Pertes 1 15%	Losses 2 10%/ Pertes 2 10%	Total	Losses 1 15% Pertes 1 15%	Losses 2 10% / Pertes 2 10%	Total	Losses 1 15% / Pertes 1 15%	Losses 2 10% / Pertes 2 10%	Over/ Sur
Unit- Unité	m^2	m	m	m	m	m	m^2	m^2	m^2	m^2	$/$m^2$	$	$	$	$	$	$			Years/ ans
1	5 000	6366	80	40	70	109	15 347	37 253	10 347	32 253	100	155 209,8	322 528,6	477 738,3	23 878,4	49 619,8	73 498,2	15%	10%	6,5
2	2 500	3183	56	28	58	97	10 645	29 687	8 145	27 187	20	24 434,4	54 374,1	78 808,5	3 759,1	8 365,2	12 124,4	15%	10%	6,5
3		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
4		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
5		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
6		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
7		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
8		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
9		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
10		0	0	0	30	69	2 827	14 957	2 827	14 957		-	-	-	-	-	-	15%	10%	1
Total	7 500																85 622,6			

3.4.7 Methane emission avoidable, Forgone energy generation and Global Environment

The methane emission that are avoidable, forgone energy generation and global Environment sub-category results are aggregated under the Dataset worksheet (Figure 3.11).

Figure 3.11: Dataset 8

Input	Unit	Variable	Francophone	Anglophone	Source
Intrant	**Unité**	**Variable**	**Francophone**	**Anglophone**	**Source**
			2012	**2012**	
Emission/Energy-Emission/ Energie					
Forgone Energy Generation-Génération d'Energie Perdue	S		814 779	814 779	EPA LanGEM : ←www.epa.gov→
Methane Emission Avoided-Emission de Méthane Evitée	S		168 10	168 10	EPA LanGEM : ←www.epa.gov→
CASWD Emission/Energy-Emission/Energie	S		981 789	981 789	
CASWD Global Environment-Environnement Global	S		644 697	644 697	Nodhaus 2011

Figure 3.12: Methane

Parameters	Units	Values		Waste-Déchets	Breakdown-Ventilation	Breakdown-Ventilation/ Methane	Breakdown-Ventilation/ Methane
Landfill Operational parameters				Organic-Organique	40%	40%	50%
Landfill Starting Year/ Composting Starting Year	Year	2012		Paper-Papier	3%	3%	4%
Landfill Closing Year/ Composting Closing Year	Year	2031		Plastic-Plastique	3%		0%
Daily Waste Disposal Rate /Daily Waste Processed in Compost Plant	Tons/day	1 000		Glass-Verre	4%		0%
No. of Operating days in a year	days	365		Metal-Métal	5%		0%
Total Waste Disposal/year	Tonnes/year-an	365 000		Textile	4%	4%	5%
Total Net Waste Disposal with methane emission/year		171 550		Wood-Bois	4%	4%	5%
				Other(Specify)-Autre(Spécifier)	3%		
				Total	59%	47%	64%
Years		1	2	3	4	5	6
Methane Generation Profile	Unit-Unité	2012	2013	2014	2015	2016	2017
Landfilled Calorific Waste	Tonne	171550	0	0	0	0	0
CH_4 Generated	tCO_2	11605	10814	10081	9402	8771	8185

CH_4 Generated	tCH_4	553	515	480	448	418	390
CH_4 Generated	m^3 CH_4	770949	718437	669740	624568	582655	543752
Methane Captured	m^3 CH_4	385475	359219	334870	312284	291327	271876
Methane used for power generation	m^3 CH_4	385475	359219	334870	312284	291327	271876
Energy content of CH_4 captured	Kcal	3083796918	2873749257	2678961322	2498273953	2330618573	2175009986
Power Generation Potential	KW	143	134	124	116	108	101
Power produced	KWh	1004208	935808	872377	813538	758943	708270
CO_2 emis. Avoided from grid	Tonne CO_2	803	749	698	651	607	567
Methane avoided	Tonne/CO_2	6606	6156	5739	5352	4992	4659
Value for Energy	$/kW/h	100421	93581	87238	81354	75894	70827
Value for CO_2 emission	$/Tonne CO_2 equiv.	1309	1220	1137	1061	990	923
Global Environment	$/Tonne CO_2 equiv.	89839	83720	78045	72782	67897	63364
NPV Energy	20 years-années @ 5%	779 814					
NPV CO_2	20 years-années @ 5%	10 168					
NPV GE	20 years-années @ 5%	697 644					
Value for Energy	Average-Moyenne kW/h	0,1	Data Provided but could be updated-Données fournies mais pourrant être mises à jour				
	CER € end-fin 2012	0,15					
	Rate-Taux 2012	1,3214					
Value for CO_2 emission	$ equiv.	0,19821	Data Provided but could be updated-Données fournies mais pourrant être mises à jour				
Global Environment	$/Tonen CO_2 equiv.	13,6	Data Provided but could be updated-Données fournies mais pourrant être mises à jour				

To perform the data entry, the country specific **Methane** worksheet must be selected. The latter is a shadow file unless the regional average cost per kW/h could be updated with more recent national tariffs, Certified emission reduction (CERs) units market prices and Global Environment externalities cost (Figure 3.11).

3.5 RESULTS

All the results are aggregated in 9 country-specific and currency-specific **Result** Files for the 9 countries (Figures 3.12 and 3.13). The aggregation followed in the CASWD SWEEP-Net on Beirut (Lebanon), Rabat (Morocco) and Tunis (Tunisia).[6]

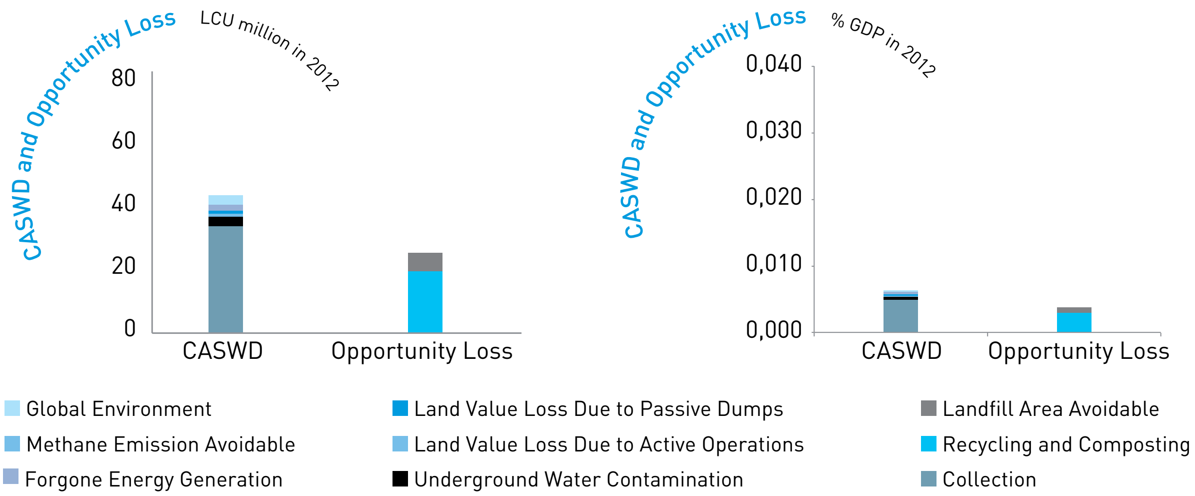
Figure 3.12: Table illustrating the CASWD and Opportunity Cost Aggregate Results in LCU and %/GDP

Anglophone Category	US$ million CASWD	%/GDP CASWD	US$ million Opportunity Loss	%/GDP Opportunity Loss
Collection	10,5	0,005%		
Recycling and Composting			6,1	0,003%
Landfill Area Avoidable			1,7	0,001%
Underground Water Contamination	0,8	0,000%		
Land Value Loss Due to Active Operations	0,3	0,000%		
Land Value Loss Due to Passive Dumps	0,3	0,000%		
Forgone Energy Generation	0,8	0,000%		
Methane Emission Avoidable	0,0	0,000%		
Global Environment	0,7	0,000%		
Total	**13,4**	**0,006%**	**7,8**	**0,004%**
Lower Bound	**11,3**	**0,005%**	**6,6**	**0,003%**
Upper Bound	**15,4**	**0,007%**	**9,0**	**0,004%**

Francophone Categorie	Millions de LCU CASWD	%/PIB CASWD	Millions de LCU Pertes d'Opportunité	%/PIB Pertes d'Opportunité
Collecte	31,4	0,005%		
Recyclage et Compostage			18,3	0,003%
Surface Evitable de Déchéterie			5,1	0,001%
Contamination des Nappes Phréatique	2,3	0,000%		
Moins-Value des Terrains due aux Opérations Passives	0,9	0,000%		
Moins-Value des Terrains due aux Opérations Passives	1,0	0,000%		
Forgone Energy Generation	2,3	0,000%		
Emission de Méthane Evitable	0,0	0,000%		
Environnement Global	2,1	0,000%		
Total	**40,1**	**0,006%**	**23,4**	**0,004%**
Borne Inférieure	**34,0**	**0,005%**	**19,9**	**0,003%**
Borne Supérieure	**46,1**	**0,007%**	**26,9**	**0,004%**

6 *SWEEP-Net website: ←www.sweep-net.org→.*

Figure 3.13: Graphs illustrating the CD and Opportunity Cost Aggregate Results in LCU and %/GDP



4. REFERENCES

- Bassi, S. (IEEP), P. ten Brink (IEEP), A. Farmer (IEEP), G. Tucker (IEEP), S. Gardner (IEEP), L. Mazza (IEEP), W. Van Breusegem (Arcadis), A. Hunt (Metroeconomica), M. Lago (Ecologic), J. Spurgeon (ERM), M. Van Acoleyen (Arcadis), B. Larsen and, F. Doumani. 2011. Benefit Assessment Manual for Policy Makers: Assessment of Social and Economic Benefits of Enhanced Environmental Protection in the ENPI countries. A guiding document for the project 'Analysis for European Neighbourhood Policy (ENP) Countries and the Russian Federation on social and economic benefits of enhanced environmental protection'. Brussels.
- Bolt, Katherine, Giovanni Ruta and Maria Sarraf. 2005. Estimating the Cost of Environmental Degradation. A Training Manual in English, French and Arabic. Environment Department Papers. The World Bank. Washington, D.C.
- Centre d'analyse stratégique. 2009. La valeur tutélaire du carbone. Rapports et documents N.16/2009 - Rapport de la commission présidée par Alain Quinet. Paris.
- Centre for Development and Environment (CDE). 2009. Benefits of sustainable land management. University of Bern. UNCCD, WOCAD, and others. Bern.
- Cointreau, Sandra. 2006. Solid Waste Management Cost Benchmarking. Presentation made at the World Bank. Washington, D.C.
- Department for Energy and Climate Change (DEEC). 2009. Carbon Valuation in UK Policy Appraisal: A Revised Approach. London.
- Matthews, E. and Themelis, N.J. 2007. Potential for Reducing Global Methane Emissions From Landfills, 2000-2030, Sardinia 2007, Eleventh International Waste Management and Landfill Symposium. NASA Goddard Institute for Space Studies, Earth Engineering Center, Columbia Univ. Boston.
- Nas, Salim Serkan and Evin Nas. 2014. "Assessing the Impacts of Seasonal Variations on Predicting Leachate Generation in Gumushane Open Dump Using Water Balance Method." Pol. J. Environ. Study. Vol. 23, No.5, 1659-1668.
- Nelson, J. 1978. "Residential choice, hedonic prices, and the demand for urban air quality." Journal of Urban Economics 5 (3): 357–369.
- Nordhaus, William. 2001. "Global Warming Economics." Science. 294(5545): 1283-1284. Nordhaus, William. 2011. "Estimates of the Social Cost of Carbon: Background and Results from the RICE-2011 Model." NBER Working Paper No. 17540. Oct 2011.
- SWEEP-Net website: www.sweep-net.org
- Ten Brink, P. and S. Bassi. 2008. Benefits of Environmental Improvements in the European Neighbourhood Policy (ENP) Countries – A Methodology. A project working document for DGENV.
- World Bank. 2014. World Development Indicators. Washington, D.C.

5. 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 SWEEP-Net. 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.[7]

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 of a lower waste volume is landfilled is also calculated. Waste composted is considered to loose 40 to 50% of its mass. The results for the recycling and composting will be derived from SWEEP-Net data and used in Table A1.1.

7 Bassi et al. (2011).

Table A1.1: Potentially Recyclable Waste, 2012

	Popula-tion	Generated Waste mishandled		Metal	Glass	Paper/ Card-board	Plastic	Compost Certified Grade	Total
	#	kg/day	Ton/year	%	%	%	%	%	LC Million
Total									
Cost/ton (LC/ton)									
Degradation LC million									

Source: GIZ-SWEEP-Net; and Authors.

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 and based on the additional cost of treating extremely polluted water due to leachate infiltration.[8] In the model, a volume of 1 m^3 is assumed to produce 0.28 m^3 of leachate. The figure is a yearly average of rainy and dry months and based on Nas and Nas (2014). If leachate runoff pollute a known volume of water, the polluted water could be added to the CASWD.

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, active and passive landfills and dumps

The methodology of hedonic costs was used to derive the cost of depreciation of land surrounding transfer station.[9] 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).

Table A1.2: Hedonic Criteria for Land Value Depreciation

Input	Area	Radius 1	Radius 2	Loss 1	Loss 2
	m^2	m	m	%	%
Active and Passive					
Transfer Station and Dump/ Landfill	>0	≤30	>31m; <100m	15%	10%

Source: GIZ-SWEEP-Net; and Authors.

8 *World Bank (2003).*

9 *Nelson (1978).*

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.

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.

The regional solid waste exchange of information
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