Republic of Lebanon
Ministry of Environment

RAPID COST OF ENVIRONMENTAL DEGRADATION 2018

Note Prepared for the Ministry of Environment

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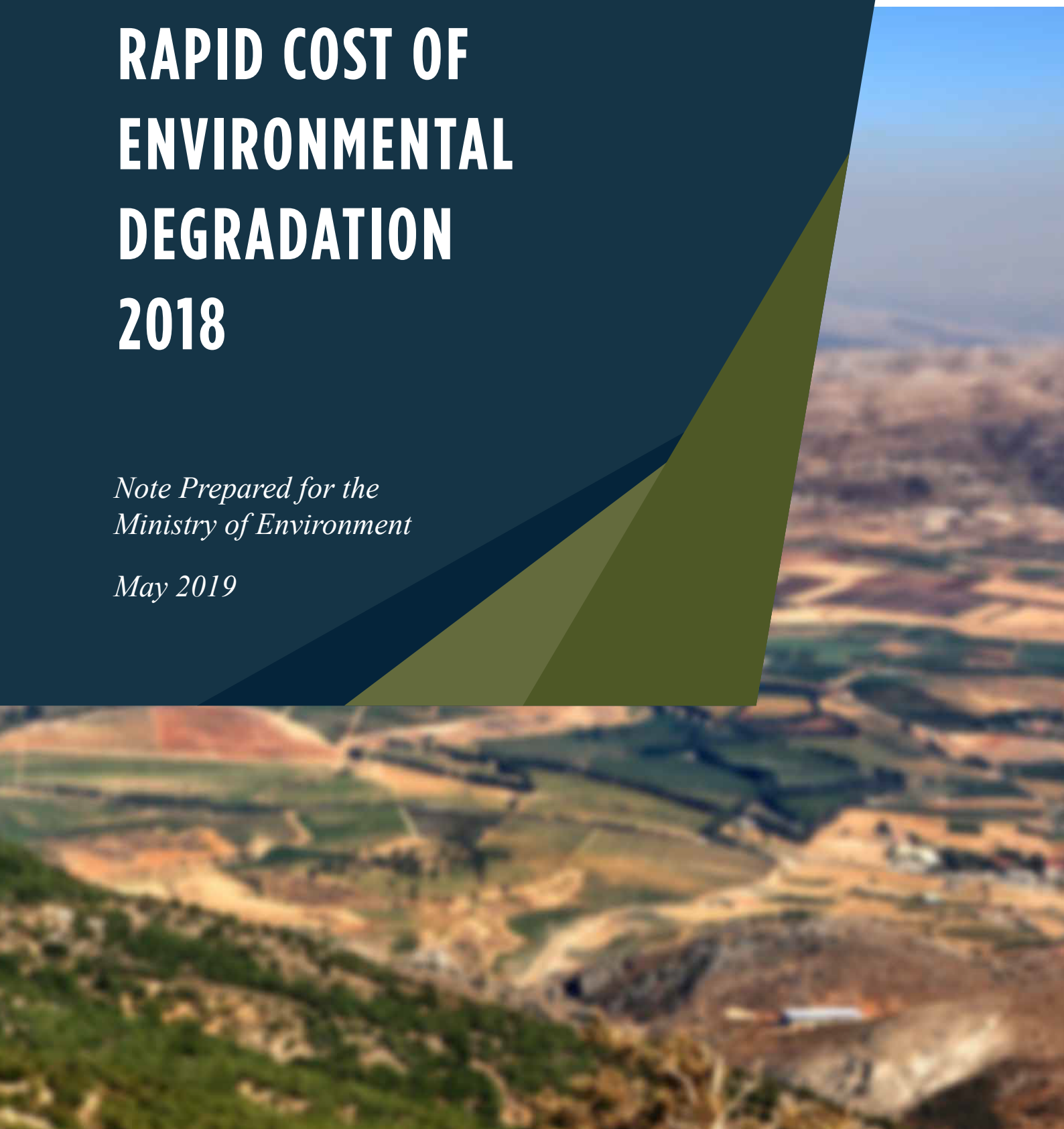

Acknowledgement

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Cover photo of the Cedar *Bonsai* courtesy of Author taken at the Washington, DC Arboretum.

Disclaimer

The content of this Note is the sole responsibility of the Author and do not necessarily reflect the views of the Ministry of Environment of Lebanon.

Exchange Rate

1 United States of America dollar (US$) = 1,507.5 Lebanese pounds (LP)
1 Euro (€) = 1,718.92 LP
(end 2018).
Source: OANDA website: <www.oanda.com>.

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Acronyms

CAS	Central Administration for Statistics
CDR	Council for Development and Reconstruction
CEDRE	Conférence Economique pour le Développement par les Réformes avec les Entreprises
CNRS	Conseil National de la Recherche Scientifique
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COED	Cost of Environmental Degradation
CVM	Contingent Valuation Method
DALY	Disability-Adjusted Life Year
EC	European Commission
EIB	European Investment Bank
EPI	Environment Performance Index
ESAC	Environmental Assessment of the Syrian Conflict
EU	European Union
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIS	Geographical Information System
GiZ	Gesellschaft für Internationale Zusammenarbeit
IHME	Institute for Health Metrics and Evaluation
JMP	Joint-Monitoring Programme of UNICEF/WHO
LCRP	Lebanon Crisis Response Plan
LEPAP	Lebanon Environmental Pollution Abatement Project funded by the World Bank
METAP	Mediterranean Environmental Technical Assistance Program
MOA	Ministry of Agriculture
MOE	Ministry of Environment
MOEW	Ministry of Energy and Water

NAMA	Nationally Appropriate Mitigation Actions
NGO	Non-governmental Organization
NMVOC	Non-methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
O_3	Ground level Ozone
OECD	Organisation for Economic Co-operation and Development
PM_x	Particulate Matter
SEA	Strategic Environmental Assessment
SO_x	Sulphur Oxides
TEV	Total Economic Value
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNICEF	The United Nations Children's (Emergency) Fund
USAID	United States Agency for International Development
VAT	Value-added Tax
VSL	Value of Statistical Life
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WDI	World Development Indicators published by the World Bank
WHO	World Health Organisation
WASH	Water, Sanitation and Health
WTP	Willingness-to-pay

1. INTRODUCTION

This Note relies on a process initiated under the former World Bank Mediterranean Environmental Technical Assistance Program which led to the production of various national and sectoral cost of environmental damage (COED) reports carried out for the Middle East and North Africa region including Lebanon. In addition to reviewing the existing COEDs, the country environmental performance index, adjusted net savings and wealth stock will also be quickly reviewed.

For the Lebanon current rapid $COED_{2018}$ with a 2018 as a base year, the analysis and estimates will be organized into 6 categories: ambient air (household, vehicular, power plant and industrial emissions and dust in terms PM_x, SO_x, NO_x, and O_3): water (water-borne diseases, surface water and water bodies are contaminated or impacted mainly due to the release of untreated or partially treated municipal and industrial effluents, waste leachate, agricultural runoff, water salinity, water scarcity do to irregular flow of perennial rivers, natural resource productivity, etc.); soil degradation, which is being exacerbated by desertification in certain areas and increased uncontrolled urbanization is other areas, is affecting agricultural yields, livestock productivity and forest coverage that are compounded by unsustainable quarrying practices and poor solid waste management, especially since the 2015 Beirut and Mount Lebanon crisis; coastal zone artificialization as well as degradation of the marine environment, the unsustainable fish catch and the disruption of ecosystem services; global environmental impact with an increasing carbon footprint per capita. Lebanon accomplishments in global environmental mitigation and adaptation are lagging due Lebanon inherent political economy and governance which are negatively impacting natural, productive and cultural assets as well as the poor. The environmental degradation categories were exacerbated by the influx of more than 1.5 million Syrian displaced (of which 950,3341 registered as refugees with UNHCR) since 2011[1], but a marginal analysis is not carried out in this Note.

The results of the selected categories addressed below are preliminary (e.g., in-depth analysis for water resources, land degradation) and incomplete (e.g., coastal zone and ecosystem services) and should be better analyzed and fine-tuned as a full-fledge COED should be institutionalized and updated on a regular basis. Still, it is expected that these preliminary results will provide policymakers with a first order of magnitude to better internalize environmental interventions in economic development decisions. Estimates of environmental damage presented in this rapid COED Note should be considered as estimates that are constrained by time, data availability and subject to various assumptions and simplifications. A range of values has been presented to reflect this uncertainty. Nevertheless, the estimates presented indicate the growing severity and magnitude of environmental degradation in Lebanon and provide a rationale for continued environmental management and priority setting for environmental action. The results could be used as an instrument for better integration of environmental issues into economic and social development planning. Despite the difficulties involved in assigning monetary values to environmental degradation, such estimates can be a powerful tool to raise awareness about environmental issues and facilitate progress toward sustainable development. Yet, this rapid COED Note only reflects a side of the overall impacts of human activities. Any policy action that causes environmental damages could also produces economic benefits to society. While the analysis only focuses on environmental degradation costs, understanding and valuing both the costs and benefits of each development actions is necessary for sound policy making especially with the programmed new investments under CEDRE.

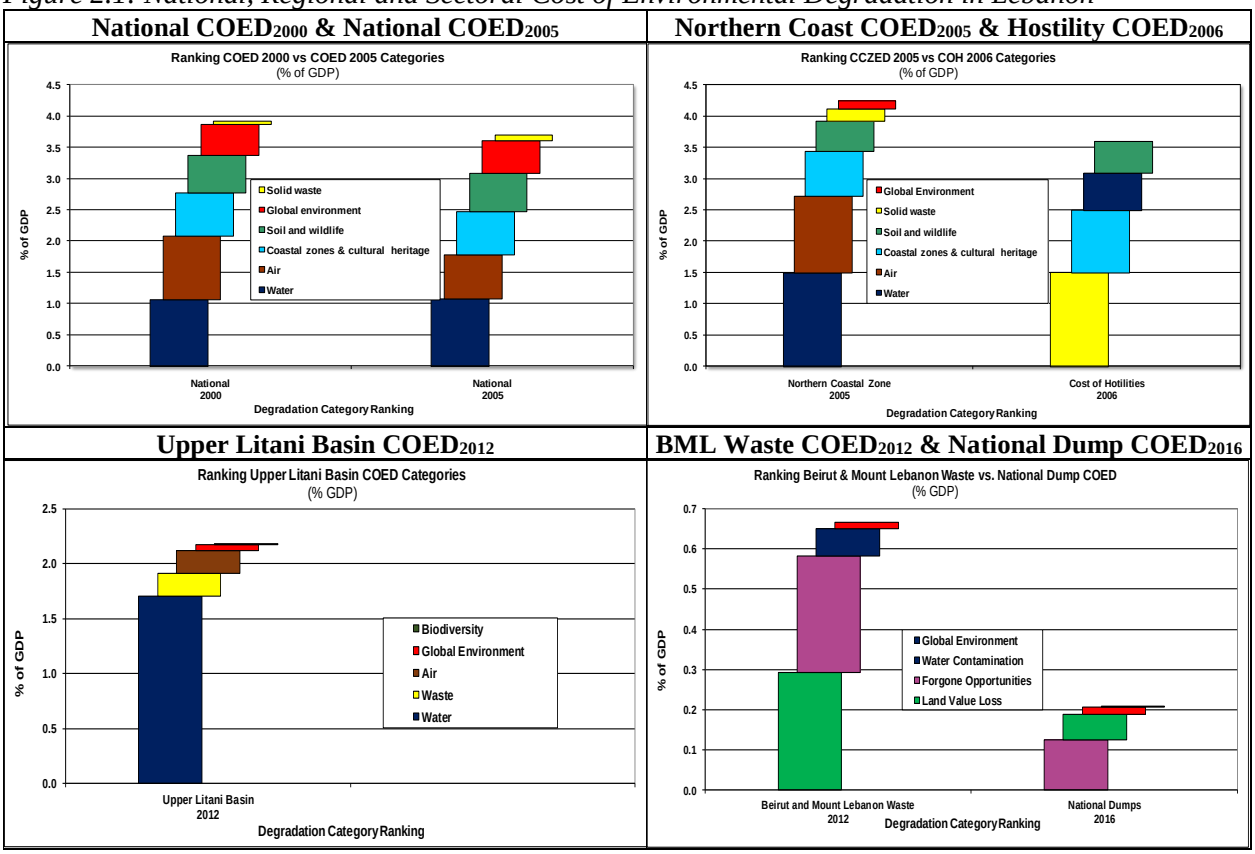
[1] LCRP 2019 website: <https://data2.unhcr.org/en/documents/details/68651>.

2. Taking Stock of Cost of Environmental Degradation, Environmental Performance Index, Net Adjusted Savings and Wealth Stock Results

Cost of Environmental Degradation

Several national, regional (e.g., coastal zone and watershed) and sectoral (e.g., waste) COEDs were carried out in Lebanon between 2004 and 2017 and funded by various International Financial Institutions. Figure 1 gives an overview of the main COEDs where results have fluctuated over the years due in part to a change in the state of the environment and to better valuation techniques. The World Bank National COEDs range between 3.9% in 2000[2] and 3.7% in 2005[3] when the global environment is included as the COED increased in absolute terms but decreased in relative terms when compared to the GDP over the period. The Northern Coast $COED_{2005}$ (multi-donors) exceeds the 4% mark relative to the National $COED_{2005}$ whereas the degradation associated with 2006 conflict (World Bank) is almost equivalent to the National $COED_{2005}$ exceeding the 3.5% mark relative to GDP.[4]

Figure 2.1: National, Regional and Sectoral Cost of Environmental Degradation in Lebanon



Note: Northern Coast, Upper Litani Basin and Beirut & Mount Lebanon (BML) Waste COEDs are relative to GDP in the area under study. Categories are color-coded.
Source: World Bank (2011); Arif and Doumani (2013); Arif and Doumani (2014); and Doumani (2017).

[2] World Bank, 2004.
[3] World Bank, 2011.
[4] World Bank, 2007.

The major categories in terms of degradation are water and air at the national, coastal and basin levels with water ranking first in the Upper Litani Basin (European Commission).[5] Despite better valuation techniques being used over the years, waste represents less than 1% equivalent to GDP for all COEDs (GiZ and MOE/UNDP respectively).[6]

Other partial COED studies were carried out over the years with the most important ones are as follows:

- In 2011, the **European Commission's Benefit Assessment**[7] 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 total GDP including global environment of € 2 billion in 2020 in 2008 prices should pollution were to be reduced by ± 50% in 2020 compared to 2008.
- In 2011, the **Economic Research Forum**[8] estimated a partial cost of damage covering the following 3 categories: air, water (waterborne diseases) and agricultural land degradation. The costs were estimated at about US$ 801 million equivalent to 2.74% of total GDP in 2008.
- In 2012, **USAID**[9] attempted to determine the total economic value (TEV) of the Litani River basin and produced a rough estimate of US$ 78 million equivalent to 0.22% of total GDP in 2009.
- In 2015, the **GEF Governance and Knowledge Generation Socio-economic Evaluation of Maritime Activities**[10] implemented by Plan Bleu and SES came up with a health burden of swimmers associated with polluted sea water that reached US$ 0.3 million equivalent to 0.001% of total GDP in 2008.

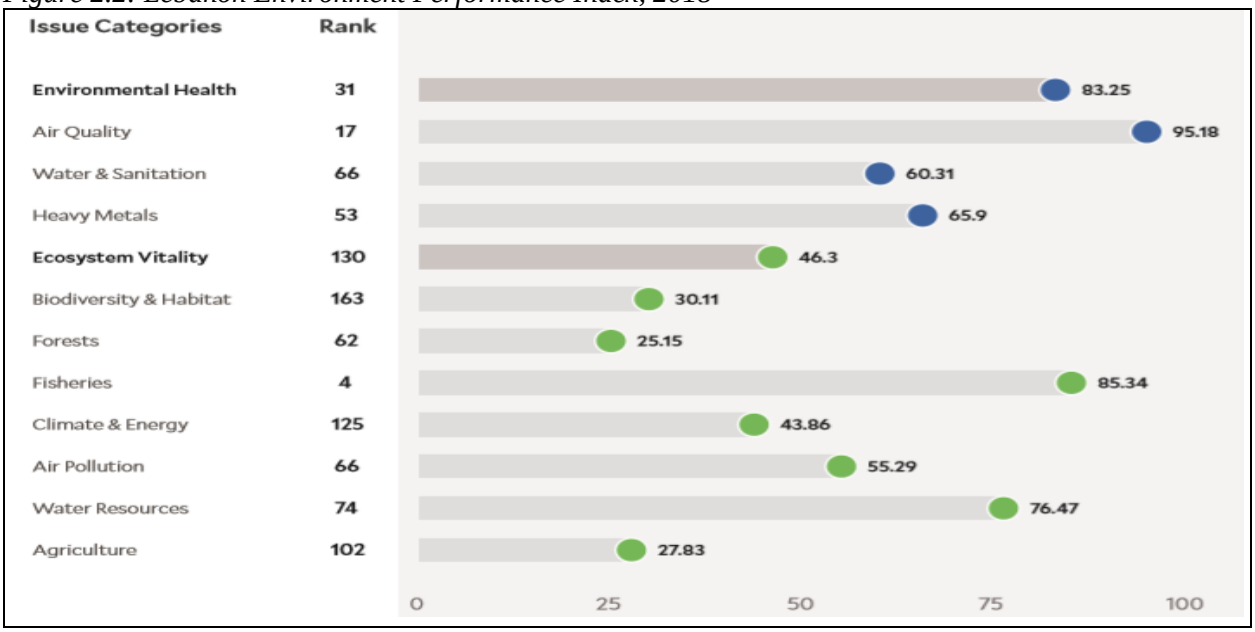
Environment Performance Index

The Environment Performance Index (EPI) was developed to benchmark the environmental performance of a country relative to other countries (Esty and Levy, 2014). The index has two major environmental objectives: (i) reducing environmental stresses on human health; and (ii) promoting ecosystem vitality and sound natural resource management. This index is composed of a combination of 25 performance indicators divided among six well-established policy categories.

The higher the score over 100 the higher the environment performance of the country in achieving environment sustainability. A review of the trend of the EPI in Lebanon shows almost the same rank in 2018 (67) than in 2008 (56 as a baseline) among 180 countries and a score of 61.08 in 2018 towards environmental sustainability for against almost the same score (59.1 as a baseline) 11 years earlier. Lebanon EPI Environmental Health indicators (83.3 overall score) cover households whereas Ecosystem Vitality indicators (46.3 overall score) cover the environment. The Ecosystem Vitality sub-indicator scores are as follows: fisheries (85.3); water resources (76.5); ambient air pollution (55.3); climate and energy (43.9); biodiversity and habitat (30.1); agriculture (27.8); and forests (25.2). However, some of these indicators are questionable, especially those related to water resources (Figure 2.2).

[5] Arif and Doumani, 2013.
[6] Arif and Doumani, 2014; and Doumani, 2017.
[7] Doumani and Mucharrafiyeh, 2011.
[8] Larsen, 2011.
[9] USAID, 2012.
[10] Kanbar, 2015.

Figure 2.2: Lebanon Environment Performance Index, 2018



Source: EPI website: <https://epi.envirocenter.yale.edu/sites/default/files/2018-lbn.pdf>.

Adjusted Net Savings

The Adjusted Net Savings is a general environmental indicator that measures the net saving of a country at a macro-economic level taking into consideration the investments in human resources, depreciation of physical assets, and decrease in natural resources. This indicator is still imperfect as it does not consider the degradation/depletion of groundwater, agricultural soils, etc. Yet, the adjusted net savings, which is a flow, amounts to -5.24 billion in 2016 which means that the Lebanese economy is using more than it is producing and is therefore eroding its assets.[11]

Wealth Stock

Wealth Accounting and Valuation of Ecosystem Services (WAVES) is a global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning and national economic accounts.[12] It includes buildings, manufactured assets such as the machinery used in factories, infrastructure such as highways and ports, and natural assets such as land, forests, fish, minerals and energy although cultural assets are often not considered. WAVES is regrouped around 3 main categories: natural capital, produced capital and intangible capital. Lebanon total wealth, which is a stock, amounts to US$ 365.6 billion in constant 2014 US dollar. The wealth stock amounts to US$ 65,148 per capita for a population of 5.6 million in 2014 with the following breakdown: US$ 31,015 produced capital; US$ 4,131 natural capital; US$ 42,153 human capital; and net foreign assets of US$ -12,151 which reflects each Lebanese foreign net indebtedness and needs to be subtracted from the sum of the capital stock. However, the net foreign assets seem overestimated as the main holders of the Lebanese public debt are Lebanese resident depositors, Lebanese banks and Banque du Liban that are notably subscribing to Lebanese Treasury Bills and Bonds.

[11] World Bank, 2019.
[12] World Bank, 2018.

3. Rapid Cost of Environmental Degradation in 2018

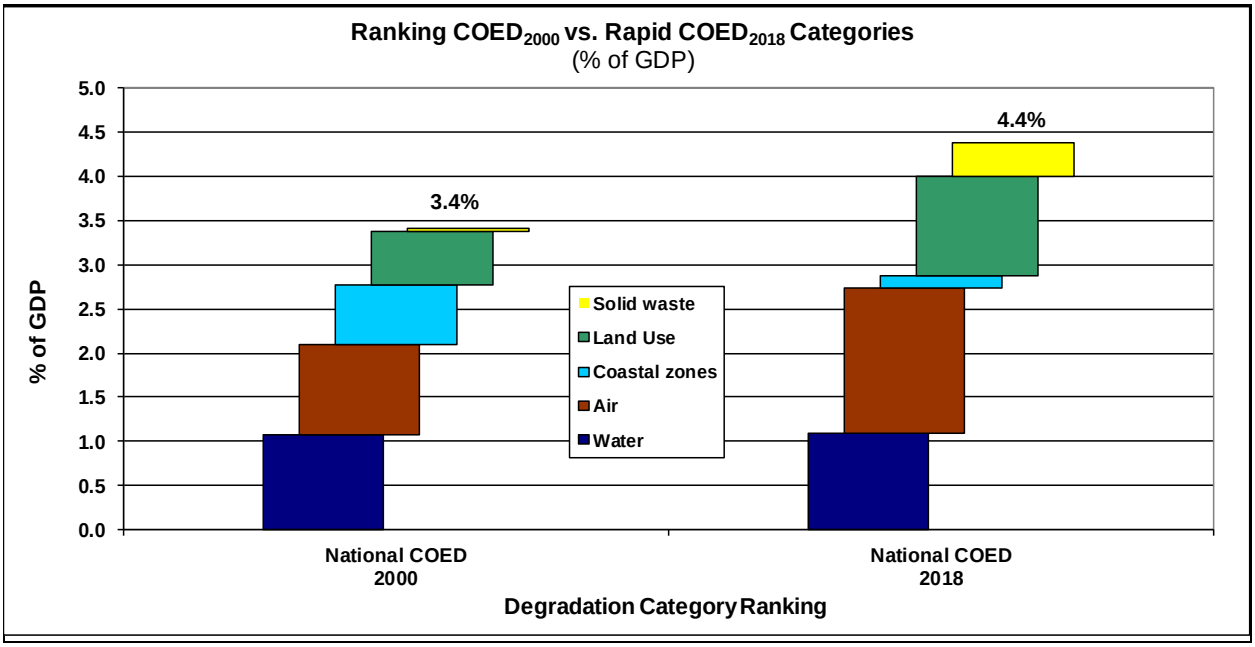
The rapid $COED_{2018}$ in Lebanon ranges between 3.1% and 5.5% of GDP in 2018 with a mean estimate of 4.4% equivalent to about US$ 2.35 billion in 2018 as compared to a mean estimate of 3.4% of GDP in 2000 equivalent to US$ 0.56 billion in 2000 without considering the Global environment. The latter increased substantially due to the increase of the shadow prices of carbon (see Annexes I and II for the methodological process). Still the large difference between $COED_{2000}$ and $COED_{2018}$ could be explained by both a marginal degradation of the environment over the period, and different valuation techniques and monetization used. The rapid $COED_{2018}$ increased in both relative and absolute terms when compared to the $COED_{2000}$. The main sources are: (i) substantial negative impacts to health from mainly ambient air pollution and to a lesser extent indoor air pollution; (ii) water-borne diseases associated with poor water and sanitation provision as well as behavior practices for a small segment of the population, whereas water quantity degradation exceeds water quality; (iii) significant strain on land resources in terms of land, range and forest degradation while active and passive quarries have scared the landscape with a very high rehabilitation cost to restore initial landscapes; (iv) waste whose treatment and disposal remain a problem; (v) coastal zone degradation include coastal ecosystem services area losses due to increased pressures on the marine environment; and (vi) damages affecting the Global environment due to an increasing CO_2 equivalent per capita in Lebanon. These estimated damages are very conservative and preliminary and are organized by environmental category and presented in terms of absolute costs and relative costs as a percentage of GDP in Table 3.1 and Figure 3.1.

Table 3.1: Annual Cost of Environmental Degradation - Mean estimate, 2018

Category	**Population**	**$COED_{2018}$**			
		Lower Bound	**Upper Bound**	**Middle Bound**	
	million	US$ billion	US$ billion	US$ billion	% of GDP
Air		**0.67**	**1.02**	**0.89**	**1.6%**
-Ambient Air		*0.67*	*1.02*	*0.89*	*1.6%*
-Indoor Air		*0.00*	*0.00*	*0.00*	*0.0%*
-Noise and Odor		-	-	-	-
Water		**0.43**	**0.74**	**0.58**	**1.1%**
-Drinking Water, Sanitation and Hygiene		0.06	0.15	0.10	0.2%
-Water Resource Quality		0.08	0.15	0.12	0.2%
-Water Resource Quantity		0.29	0.44	0.37	0.7%
Land		**0.38**	**0.83**	**0.60**	**1.1%**
-Cropland Degradation		*0.02*	*0.04*	*0.03*	*0.1%*
-Rangeland Degradation		*0.00*	*0.02*	*0.01*	*0.0%*
-Forest Degradation		*0.01*	*0.01*	*0.01*	*0.0%*
-Quarry Degradation		*0.35*	*0.77*	*0.56*	*1.0%*
Waste		**0.13**	**0.27**	**0.20**	**0.4%**
-Treatment		*0.04*	*0.13*	*0.09*	*0.2%*
-Disposal		*0.09*	*0.13*	*0.11*	*0.2%*
Coastal Zone		**0.07**	**0.12**	**0.08**	**0.1%**
-Marine Ecosystem Services		*0.06*	*0.09*	*0.06*	*0.1%*
-Coastal Erosion		*0.01*	*0.01*	*0.01*	*0.0%*
-Coastal Disamenities		*0.01*	*0.02*	*0.01*	*0.0%*
Sub-Total		**1.69**	**2.98**	**2.35**	**4.4%**
Global Environment		**1.01**	**2.02**	**1.52**	**2.8%**
Total		**2.70**	**5.00**	**3.87**	**7.2%**
GDP_{2018}				**53.7**	
Lebanon Population 2018	**6.2**				
of which non-Lebanese 2018	*2.1*				

Source: Annexes I and II; and Author.

Figure 3.1: $COED_{2000}$ vs. Rapid $COED_{2018}$ - Mean estimate



Note: Coastal Zone degradation is underestimated in 2018 and needs further analysis.
Source: Table 3.1.

Ambient air pollution *(method: exposure-based approach with annual average of 36 micron/mg where only the urban population with more than 100,000 population and population in special areas are considered).* The cost of degradation amounts to US$ 0.89 billion equivalent to 1.6% of GDP in 2018 and is attributable to point and non-point pollution in terms of motorized vehicles, boats and planes, industries, household emissions, communal/individual power generator emissions, occasional solid waste and tire burning, dust (mining and construction), etc. The main sub-categories include health (mortality and morbidity although cost of illness is not considered per se but the forgone economic value-added is considered as a proxy) whereas the agricultural production yield reduction and infrastructure decay due to air pollution were not quantified although there is a growing body of work emphasizing this evidence. Yet, the 2014 EASC indicates an overall increase of 20% of emissions resulting from the Syrian crisis.

Indoor air pollution *(method: risk factor approach).* The health effects of indoor air pollution afflict the poor and the most vulnerable (refugees, displaced, etc.). The burden of indoor air pollution mean damages is significantly smaller than ambient air pollution as most household use clean cooking and heating fuels: US$ 0.32 million, or 0.001% of GDP.

Noise and odor pollution *(method: contingent valuation method).* Both noise and odor pollution in urban and peri-urban areas in Lebanon are not quantified and monetized but need more attention and research as they affect the quality of life and well-being and can lead to psycho-physical stress.

Water *(methods: risk factor approach for health, stated preference benefit transfer, productivity loss and replacement cost).* The cost of degradation amounts to US$ 0.58 billion equivalent to 1.1% of GDP in 2018 and is similar to $COED_{2000}$ in relative terms. Yet, Lebanon is far from complying with the Horizon 2020

initiative to de-pollute the Mediterranean by the year 2020 as already built wastewater treatment plants along watersheds and the coast are not or barely operational (only about 15 partially or fully operational) whereas poorly managed waste disposal (dumps and sanitary dumps along watersheds and the coast) is affecting water bodies and ecosystem services. The main sub-categories include drinking water and/or sanitation and/or hygiene (WASH), water resource quality and water resource quantity. WASH is derived from the burden of traditional water-borne diseases. So far, micro-plastics is not considered among water-borne diseases because their worldwide deleterious effects still need to be backed by scientific evidence. Still, micro-plastics, which are prevalent in bottled water (93.8%, second to the United States in the world) than in tap water in Lebanon,[13] are also contaminating water bodies' food chain (water, salt, fish, crustaceans, mollusks, etc.) and are detected in the human body. Conversely, water bodies' contamination by chemicals and heavy metals is also prevalent in Lebanon and affects water, the food chain and ecosystem services although their health impact (chemicals and heavy metal accumulation in human bodies above accepted thresholds are dangerous and toxic leading to organ damage, immune system weakening, reproductive problems and birth defects, effects on the children mental cognitive or physical development, and cancer) are, despite the existence of international dose-response functions, more difficult to quantify in the absence of comprehensive data on chemical and heavy metal accumulation in human bodies in Lebanon. Water resource quality in terms of surface, ground and marine water is based on a benefit transfer of a contingent valuation carried out in the United Kingdom due to the multiplicity of the sources of pollution (municipal effluents -only about 8% of wastewater is being treated- and industrial untreated discharge especially in the Litani Basin,[14] agricultural runoff, waste leachate, oil spills, vessel sewage and waste illegal discharge, etc.). Water resource quantity degradation is associated with the unaccounted for water that is lost in the domestic distribution network and is used as a proxy as excess water extraction is affecting basin ecosystem services, allowing salt intrusion in the coastal aquifer and lowering the water table all over the country due to over pumping. Yet, the 2014 EASC indicates a yearly increase of 8-14% of wastewater due the influx of Syrian citizens.

Land *(methods: 2010 UNCCD land based on forgone agricultural opportunity; range and forest based on forgone ecosystem services and 2018 Quarries based on the rehabilitation cost).* Lebanon construction boom since the 1990s has infringed on landscapes and cultural heritage in Lebanon where crop (Law 31-2017 allows the construction on agricultural land), range and forest land areas have been shrinking due to poor land use planning and management practices. Moreover, Lebanon's steep slopes are prone to erosion and topsoil loss which are exacerbated by storms while forest fires are prevalent especially during summertime. The cost of degradation of cropland, rangeland, forest and quarries amounts to US$ 0.6 billion equivalent to 1.1% of GDP in 2018 and comes predominantly from the rehabilitation and better management needed from 1,330 active and passive quarries covering an area of 56.2 km^2 in 2018. Indeed, poorly governed quarrying and haphazard construction since the end of the 1975-1990 Civil War have led to the disappearance of a timeless wealth of cultural heritage: from 40,000 BC paleolithic caves to 1975 AD modernist architecture. Unfortunately, these losses could not be accounted for as they require further

[13] WHO website: <www.who.int>.
[14] Wazne and Korfali, 2016.

time and analyses. The impact of the influx of Syrian citizens on agricultural lands due to the presence of Informal Settlements should also be addressed from two levels:

i. Conversion of agricultural lands into residential areas with an increasing trend of displaced population living in settlements (from 12% in 2015 to 19% in 2018)
ii. Contamination of land and water resources due to lack of proper sanitation (41% of latrines have adopted an environmentally sound practices)[15]

Waste *(methods: collection coverage reached 100% unlike in 2015 where waste was not collected in Beirut and Mount Lebanon; the forgone composting and recycling opportunity is considered for lack of treatment; and for disposal, hedonic pricing around dump/landfill as well as forgone both methane capture and energy generation are considered).* The cost of degradation amounts to US$ 0.2 billion equivalent to 0.4% of GDP in 2018 and comes equally from poor treatment and poor disposal. There is anecdotal but no conclusive evidence with robust data linking health effects with poor waste management in Lebanon although the link exists when notably: (i) mixed waste (including tires) is being burnt in urban areas and/or dumps which were the case during the 2015 waste crisis (air pollution); and (ii) contamination occurs through vectors (ingestion and cutaneous) or through water and food contamination due to waste leachate (ingestion). Conversely, microplastics (see above) and plastics are increasingly contaminating water bodies while the not in my back yard (NIMBY) social resistance closed down the Nahmeh landfill south of Beirut in July 2015 leading to the 8-month long waste crisis and was replaced by 2 coastal landfills north (Bourg Hammoud) and south (Costa Brava) of Beirut. Moreover, the 2014 EASC indicates that a yearly increase of 15% of solid waste was due to the influx of Syrian citizens.

Coastal Zone *(methods: replacement cost for ecosystem service and coastal land losses whereas a willingness-to-pay benefit transfer to preserve coastal amenities and recreations was used).* With a coast not exceeding 220 kilometers in linear length, Lebanon has an artificialization that covers at least 150 km. Moreover, coastal and shoreline erosion is prevalent in Akkar to Chekka, Jbeil, Jyieh, Saida and Tyre to Nakoura leading to loss of sandy beaches whereas the rest of the coast is subject to artificialization and backfilling. The Lebanese CNRS[16] publishes the state of the water bathing quality (marine pollution is covered under Water) sometimes in June of each year and in 2018, out of 25 sampling spots along the coastline, 4 spots were fairly acceptable and 5 spots were heavily polluted with the remaining 16 spots being acceptable although these findings are controversial as they are questioned by academia due to the irregularity and scope of the sampling and challenged by NGOs. Incidentally, the 2013 Marine Strategy lacks funding to be implemented while the fossil fuel offshore drilling is about to star with all the risks that it entails. The cost of degradation amounts to US$ 0.08 billion equivalent to 0.1% of GDP in 2018 where international benchmarks for the coastal zone ecosystem services' losses were used, recent satellite imagery on coastal erosion were considered and a contingent valuation method to preserve coastal amenities and recreation from various stressors was used. Still, it will require more time and analyses to determine the current real cost of degradation of Lebanon coastal artificialization, land reclamation, infringements on the public maritime domain, fisheries, tourism mismanagement, cultural asset obliteration, privatization of amenities and coastal landfills. For instance, the latter (Tripoli, Bourg Hammoud, Costa Brava and Saida despite its rehabilitation) are breaching the 100-meter setback from the coastline of the *Integrated Coastal Zone Management Protocol* of the Barcelona Convention ratified by Lebanon in 2009 and backed by Decree 639-2014. Moreover, the illegal privatization of the coast is more of a governance issue than an

[15] UNICEF Water Assessment Platform. 2017
[16] CNRS website: <www.cnrs.edu.lb>.

environmental issue as this illegal practice of cordoning off the coast goes against the Law of the land. Interestingly, this has recently resulted in the significant increase in Lebanese families travelling to regional resorts mainly located in Egypt and Turkey for summer holidays. This change in behavior could be captured by a *reversed* travel cost method that would help derive a determinant of poor coastal zone governance that could be monetized through analyzing export services (Travel Agent booking trend over the years) that are increasing Lebanon's balance of payment deficit. The increase of population density of urban areas most of which are in the coastal zone due to the influx of Syrian citizens aggravates an already fragile situation and has accelerated haphazard construction.

Global Environment *(method: global damage cost based on carbon emission per capita)*. The social cost of CO_2 equiv. includes uncertainty, equity weighting, and risk aversion at US$ 57.3 per ton of CO_2 in 2018 which much higher than the previous social cost used (US$ 13.42 in 2005). With an estimated amount of US$ 1.52 billion equivalent to 2.8% of GDP in 2018, this is Lebanon carbon footprint on the global environment. Yet, although climate change effects are already being felt in Lebanon, a preliminary analysis projected these damages to reach US$ 1.9 billion in 2020.[17] In other words, the impact of Lebanon carbon footprint at the global level is still below the impact of the global carbon footprint on Lebanon.

[17] MOE/UNDP/GEF, 2015.

4. The Way Forward

These rapid COED$_{2018}$ results are of considerable importance to Lebanon in terms of urgently setting and achieving policy goals in the short to medium term especially since the 2005 Land Use Planning Strategy[18] adopted in 2009 was not implemented. The results also confirm that the environment space is shrinking, and ecosystem services are increasingly at risk. Hence, further collective work bringing together all stakeholders is needed to collect, aggregate and analyze data that is badly lacking to justify policies and measures that address the political economy of the causes of the degradation identified in this Note. Yet, some preliminary conclusions can be drawn from the findings in each of the categories.

Air. With regards to air pollution, concentrations of PM are derived from existing monitoring stations that have been recently installed all over Lebanon (EU and other funding operated by MOE in addition to some others installed by AUB and the municipality of Tripoli). The health costs are considerable, but these can be reduced with some low-cost measures, at least to start with tightened and stricter pollution controls that could be applied to mobile and fixed sources. The introduction of the long-awaited Pigouvian tax (polluter-pay principal) as enshrined in the Environmental Code Law 444-2002 should complement the incentive-based compliance system based on the World Bank LEPAP that needs to be scaled up to cover the remaining large polluters as well as informal and small polluters. With regards to indoor air pollution, improved stoves and better ventilation should target the few households, refugee and displaced camps that are using wood fuels. Noise and odor pollutions remain poorly studied in Lebanon and would require more attention. Priority sectors to be addressed to respond to ambient air quality concerns in Lebanon also include the transport and energy sectors in Lebanon, SEAs for these sectors' strategies can be an entry point for mainstreaming environmental considerations in on-going planning processes.

Water. With regards to water, unimproved water and sanitation, and poor hygiene remain relatively low but is translated into water-borne diseases that usually accrue to the poor and vulnerable people (refugees and displaced population). Due to delays in implementing the 2012 water and wastewater strategies,[19] water quality is affected mainly by untreated domestic and industrial effluents but also by poorly disposed waste, agricultural runoff and marine illegal or accidental littering from vessels (sewage, waste, oil spills, etc.). Indeed, high levels of untreated in situ or released sewage (more than 97% are not properly treated) and industrial effluents in water bodies are affecting the aquifers, water bodies and ecosystem services. Informal settlements of displaced Syrians also constitute a priority environmental threat to water resources especially with increasing trends and dwindling resources for covering their sanitation needs.

Land. Data on land degradation used in this study is still from 2010 except for quarries and urgently needs updating and validation. Indeed, it is expected that more recent data will show increased areas being severely or mildly degraded and deforested. Action to rehabilitate cropland, rangeland and forests are underway albeit on a small-scale basis (EU, FAO, UNCCD, USAID, etc.) but should be better targeted, so priority areas can be identified to focus on areas with vulnerable communities, high biodiversity or other environmental value and vulnerable areas to climate change. Conversely, the 1,330 quarries that scar Lebanon's landscapes are still an environmental challenge where the enforcement of proper environmental management of quarrying is urgently needed while the rehabilitation of some of these passive quarries could

[18] CDR, IAURIF and DAH, 2005.
[19] Ministry of Energy and Water website: <www.energyandwater.gov.lb>.

be an opportunity by transforming them into hill lakes or even landfills.[20] The conversion of agricultural lands into residential areas due to the increasing numbers of Informal Settlements of displaced Syrians should also be considered as part of the Government's strategy for food security and economic development in Lebanon.

Solid Waste. The 2019 Integrated Municipal Solid Waste Management draft Strategy[21] calls for a better system from cradle to grave but should also be considered in the framework of a circular economy. Efforts were initiated on the composting and recycling value chain by municipalities, civil society, private entrepreneurs and NGOs but a continuous drive is required to change domestic waste generator (households, service sector and industrial sector) behavior to initiate separation at the source to climb up the value chain: quality separation is translated by better composting and recycling value. Moreover, construction and debris waste dumps could benefit from facilitating financing for entrepreneurs to start producing bricks from recycled construction waste material. Other wastes are not covered in this Note such as medical wastes (NGOs are collecting and treating a great number of hospital waste but not clinic waste), hazardous, e-waste and agricultural wastes but require heightened attention. An urgent call to ban open dumping and open burning, especially in areas with large number of displaced Syrians and limited financial resources should be prioritized.

Coastal Zone. The effects of degradation of marine services still need to be better analyzed to value the loss of ecosystems, assets and income generating activities. For instance, Lebanon tourism trends seem to be more determined by security risks than by environmental degradation: the 2014-2018 trend is again positive (+9.5% annually over the period)[22] since 2014 for incoming foreign passengers (except Lebanese emigrants and Syrians) despite the drawback of the 2015 waste crisis but have not quite reached the 2010 mark (2.3 million). While the monetary value of such losses may be small compared to other categories, some, such as traditional fishing, salt marshes and coastal archeological and cultural assets are not only part of Lebanon cultural heritage but belong to the world cultural heritage. Therefore, they need to be preserved and promoted as the UNESCO World Heritage cities of Jbeil and Tyre are at risk from coastal flooding and erosion due to sea-level rise.[23] Moreover, infringements on the coastal public domain should duly be addressed by the Government as most permanent structures are affecting the coastline. Efforts should be oriented towards adopting the concepts of sustainable cities, especially in congested coastal areas, and adhering to the principles of urban planning and especially the 2005 Land Use Planning Strategy.[24]

Global Environment. Lebanon carbon footprint per capita is on the rise whereas the climate change effects are already being reported at various spatial and time scales. Implementing smart policies targeting notably energy, transportation, land and waste management could reap co-benefits at the local (local pollution) and global (CO_2 equiv. emissions) level. Also, the introduction of a progressive carbon tax needs to be considered as one of the policy instruments for the transition towards a green economy. Lebanon's commitment to the Paris agreement have been endorsed and confirmed through the NDC, which indicates that global as well as national benefits can be obtained through its implementation.[25]

[20] Darwish et al., 2008.
[21] MOE, 2019 draft.
[22] CAS website: <www.cas.gov.lb>.
[23] Reimann et al., 2018.
[24] CDR, IAURIF and DAH, 2005.
[25] NDC website: <www.ndc-cluster.net/country/lebanon>; NAMA website: <http://climatechange.moe.gov.lb/nama>.

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Annex I: Methodological Framework

The process of estimating the cost of environmental degradation involves placing a monetary value on the consequences of such degradation.[26] The current Note relies on better valuation techniques that were used for the $COED_{2018}$ and differ from those used for the $COED_{2000}$ leading to different results. Still, the methodological framework often relies on a 3-step process:

1. Quantification of environmental degradation (e.g., monitoring of ambient and indoor air quality, river/lake/sea water quality, soil loss, and soil quality).
2. Quantification of the consequences of degradation (e.g., negative impacts on health from air pollution, impact on water body quality, changes in soil productivity, changes in forest density/growth, reduced natural resource based recreational activities, reduced tourism demand).
3. A monetary valuation of the consequences (e.g., estimating the cost of ill health, soil productivity losses, reduced recreational values).

The main methods for estimating impacts are grouped around 3 pillars with specific techniques:

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;
   - 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.
2. Change in health 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 used in this study.
   - 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.
3. Changing behavior with two sub-techniques: revealed 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; and preventive behavior as when households buy filters for drinking water.
   - Stated preference where a contingent valuation is used to derive the willingness-to-pay (WTP) through a survey for example, *improving the quality of water resources*.
   - Choice modeling where respondents are asked to choose their preferred option from a set of alternatives with particular attributes (a variation on the WTP without a monetary value).

When data is not available to use one of these specific techniques, an alternative is to use a benefit transfer method that allows transferring a benefit that can be based on studies made in other countries by adjusting the results for the differential income, education, preference, etc. The original results that are used for the benefit transfer are based on one of the economic valuation methods under the 3 pillars. Additional methodological resources are developed under Annex II.

[26] Dr. Gonzague Pillet (†), former Professor at the **University of Fribourg** and at the **University of Geneva,** contributed to the early COED conceptualization.

Annex II: Methodological Resources

Population

The population was obtained from the Lebanon Crisis Response Plan (LCRP --<www.un.org.lb/lcrp2017-2020>) that is based on various sources such as: Central Administration for Statistics (CAS --2009) and Council for Reconstruction and Development (CDR) shapefile (2002) for Lebanese residents; LCRP for Syrians displaced (2019); and UNRWA for registered Palestinians that are still resident in the camps (2019). Foreign workers were based on the Ministry of Labor (2013) and adjusted upward. The total resident population is derived from World Bank WDI, 2019 with a population of 6.2 million in 2018. A breakdown by Casa and major city/area used for air pollution calculations is illustrated in Table A2.1.

Table A2.1: LCRP Population 2019 update

GOVERNORATE, *Casa* and *City*	**Resident Lebanese**	**Resident Refugees: Palestinians**	**Displaced/ Syrians**	**Foreign Workers**	**Total**
					#
AKKAR	266,020	27,946	143,376	27,339	464,680
NORTHERN LEBANON	554,863	20,978	212,470	57,023	845,333
Tripoli	*265,553*	*3,712*	*64,171*	*27,291*	*360,726*
Chekka	*48,226*	-	*23,482*	*4,956*	*76,664*
BEKAA	279,578	8,158	334,337	28,732	650,804
Zahleh	*179,493*	*6,846*	*232,320*	*18,446*	*437,105*
BAALBEK- HERMEL	275,571	4,208	168,807	28,320	476,907
Baalbek	*237,351*	*4,208*	*158,828*	*24,392*	*424,780*
BEIRUT	403,579	7,579	38,172	41,475	490,804
MOUNT LEBANON	1,507,221	38,140	419,654	154,896	2,119,911
Baabda-Metn	*947,545*	*22,194*	*218,890*	*97,378*	*1,286,007*
SOUTHERN LEBANON	471,925	100,242	111,634	48,499	732,300
Saida	*250,704*	*62,168*	*63,603*	*25,765*	*402,240*
Sour	*200,958*	*38,073*	*43,530*	*20,652*	*303,213*
NABATIEH	276,285	1,551	71,551	28,393	377,780
Nabatieh	*125,448*	*1,401*	*36,559*	*12,892*	*176,300*
TOTAL population	**4,035,042**	**208,802**	**1,500,000**	**414,677**	**6,158,521**
Urban>100,000 Population and Special Areas	2,255,278	138,603	841,382	231,773	3,467,035

Note: Foreign workers were pro-rated by Lebanese residents for their area of residence.
Source: Ministry of Labor (2013); LCRP (2019) website: <www.dropbox.com/sh/4wqtdgihu566i9m/AADYSh1KkrmqYDR0zxkPR6Tva/9.%20Data%20-%20Population%20Package?dl=0&preview=1-2019_LCRP_Population_Package_181026.xlsx&subfolder_nav_tracking=1>; and World Bank WDI (2019).

Ambient Air Pollution

- Risk factors from PM_x and Ozone are used to derive DALY lost are from IHME <wwwhealthdata.org> for year 2017 and used for 2018. Population exposed is the Urban population with more than 100,000 and special areas such as Chekka where the cement industry is a large emitter of PM_x. Although the rest of the population is exposed to a lesser extent to air pollution, it is not considered in the analysis.
- Monetization used is the Value of Statistical Life (VSL) as derived from OECD (2015) and adjusted to 2018 prices is used for premature death using (Navrud, 2009) benefit transfer method, whereas the human capital approach is used for morbidity as follows: the GDP/capita/year in

2018 is used per Disability-Adjusted Life Year (DALY) lost[27] which is a health metric equivalent to 1 lost year of healthy life.

- Navrud (2009) for the benefit transfer method.

- GDP figures are derived from World Bank WDI (2019) with a GDP growth of 0.2% in 2018 applied on the 2017 GDP as reported in the World Bank Economic update of April 2019. <www.worldbank.org/en/country/lebanon/publication/economic-update-april-2019>.

Several epidemiological studies revealed even stronger correlations recently between long-term exposure to $PM_{2.5}$ and **premature mortality** (e.g., Apte et al., 2015;[28] Brauer et al., 2016;[29] Leliveld, 2019;[30] etc.). In this particular case, the Brauer et al., 2016 Dose response functions are used by IHME and were considered for Lebanon.

For the Valuation, the VSL is used as mentioned above whereas the World Bank and IHME, 2016 used the Human Capital Approach based on the forgone labor output, which is calculated as the present value of expected lifetime labor earnings. The estimation considers: the forgone income of people aged 15-64, estimated for each 5-year cohort; the labor force participation rate; the expected annual income growth rate (3 percent per year; and the discount rate (the net present value of the forgone income is discounted at 4 percent. The World Bank and IHME, 2016 results for Lebanon amount, which significantly exceed both $COED_{2000}$ and $COED_{2018}$, are illustrated in Table A2.2. Moreover, the number of premature deaths covers the entire Lebanese territories whereas the $COED_{2018}$ focuses on urban and special areas. Hence, the difference between World Bank and IHME, 2016 (equivalent to 3.6% of GDP in 2013) and he $COED_{2018}$ (equivalent to 1.6% of GDP in 2018 –see below) in premature deaths is almost 3 times more.

Table A2.2: Alternative Results for Lebanon's Burden for Air Pollution, 1990-2013

Country	Annual $PM_{2.5}$ Average		Total Death from Air Pollution		Total Welfare Loss		Total Forgone Labor Output	
	1990	2013	1990	2013	1990	2013	1990	2013
	µg/m^3	µg/m^3	#	#	Million 2011 US$, PPP-adjusted (% GDP equiv.)		Million 2011 US$, PPP-adjusted (% GDP equiv.)	
Lebanon	24.4	23.6	1,160	1,816	683 (3.27%)	2,660 (3.58%)	82 (0.39%)	148 (0.20%)

Source: World Bank and IHME (2016).

The benefit transfer involves transposing existing monetary environmental values estimated at one site (study site) to another (policy site), usually with similar context or physical characteristics.[31] There are two approaches for the benefit transfer: the unit value transfer; and the transfer function. In this particular case, we will rely on the unit value transfer and more specifically on the transfer of the unit to adjust for differences in income value as described in Navrud (2009).

The transfer of the unit to adjust for differences in income value is as follows:

$$WPp = WPs \times (Yp / Ys)^{ß}$$

Where:

WPp = willingness to pay by household in policy country
WPs = willingness to pay by household in study country
Yp = income in the country policy denominated in purchasing power parity dollar (PPP$)
Ys = income in the country of study denominated in purchasing power parity dollar (PPP$)
ß = income elasticity for different environmental goods and services, which are considered normal goods, are

[27] Murray and Lopez, 1996.
[28] Apte et al., 2015.
[29] Brauer et al., 2016.
[30] Lelieveld et al., 2019.
[31] Navrud, 1999.

typically greater than 0 (perfectly inelastic which would have meant that the WPp = WPs only adjusted by income where ß = 1.2).

In this particular case, the income elasticity is assumed to be conservatively set at 1.2 (more inelastic), which means that the percentage responsiveness of quantity demanded (in this case the resource) is significantly and slightly lower to the percentage change in income respectively. Incidentally, a new study, which provides VSL through a benefit transfer method estimates to monetize fatality risks in 189 countries, derives a VSL of US$ 1.326 million for Lebanon in 2015:[32] almost twice the VSL used in this Note.

Hence, the VSL for Lebanon amounts to US$ 665,762 whereas the DALY lost is equivalent to the GDP per capita and amounts to 8,717 in 2018. The results for Ambient Air Pollution (AAP) including $PM_{2.5}$ and Ozone, Indoor Air Pollution (IAP) and Water, Sanitation and Hygiene (WASH) are illustrated in Table A2.3.

Table A2.3: Burden and Valuation of AAP, IAP and WASH

Burden of Disease	**Unit**	**Per 100,000 Population**			**Pop Exposed**	**Pop Affected**	**VSL**	**GDP**	**Total**
		Lower Bound	Higher Bound	Middle Bound	#	#	US$ per mortality	US$ per DALY Lost	US$
AAP $PM_{2.5}$									949,423,051
Mortality	#	26.26	36.46	33.04	2,255,278	1,264	665,762		841,577,713
Morbidity	DALY lost	173.78	356.84	263	2,255,278	12,372		8,717	107,845,338
AAP Ozone									71,093,235
Mortality	#	0.66	3.08	1.86	2,255,278	107	665,762		71,093,235
Morbidity	DALY lost	0.00	0.00	0.00	2,255,278	0		8,717	0
IAP									540,530
Mortality	#	0.0033	0.013	0.0069	6,158,521	1	665,762		533,015
Morbidity	DALY lost	0.034	0.014	0.073	6,158,521	1		8,717	7,516
WASH									152,909,008
Mortality	#	0.58	1.39	0.95	6,158,521	86	665,762		56,991,556
Morbidity	DALY lost	63.98	178.67	119.05	6,158,521	11,003		8,717	95,917,452

Source: IHME website <wwwhealthdata.org>; and Author.

In Lebanon, recent ambient quality studies are reported in the National Strategy for Air Quality Management in Lebanon of 2017. In 2012, a temporally resolved and spatially distributed emission inventory for the year 2010 was developed for Lebanon by Université Saint Joseph (USJ). It provides quantitative information for air pollution studies as well as an input to air quality models (Waked et al., 2012; Waked and Afif, 2012; Waked et al., 2014; and Waked et al., 2015).
According to the inventory, the main sources of pollutants are:

- on-road transport sector, contributing about 93% of CO emissions, 67 % of NMVOC emissions and 52 % of NO_x emissions
- power plants and industrial sources, contributing 73 % of SO_2 emissions, 62 % of PM_{10} emissions and 59 % of $PM_{2.5}$ emissions

Yet, these findings were not used to monetize the air $COED_{2018}$.

Indoor Air Pollution

- Risk factors to derive DALY lost are from IHME website <wwwhealthdata.org> for year 2017 and used for 2018. Population exposed is the entire population (see Table A2.3).
- Monetization used is the Value of Statistical life as derived from OECD (2015) and adjusted to 2018 prices are used for premature death using Navrud (2009) benefit transfer method whereas

[32] Viscusi and Masterman, 2017.

the human capital approach is used for morbidity as follows: the GDP/capita/year in 2018 is used per DALY lost.
- Navrud (2009) for the benefit transfer method.
- GDP figures are derived from World Bank WDI (2019) and World Bank Economic update (April 2019).

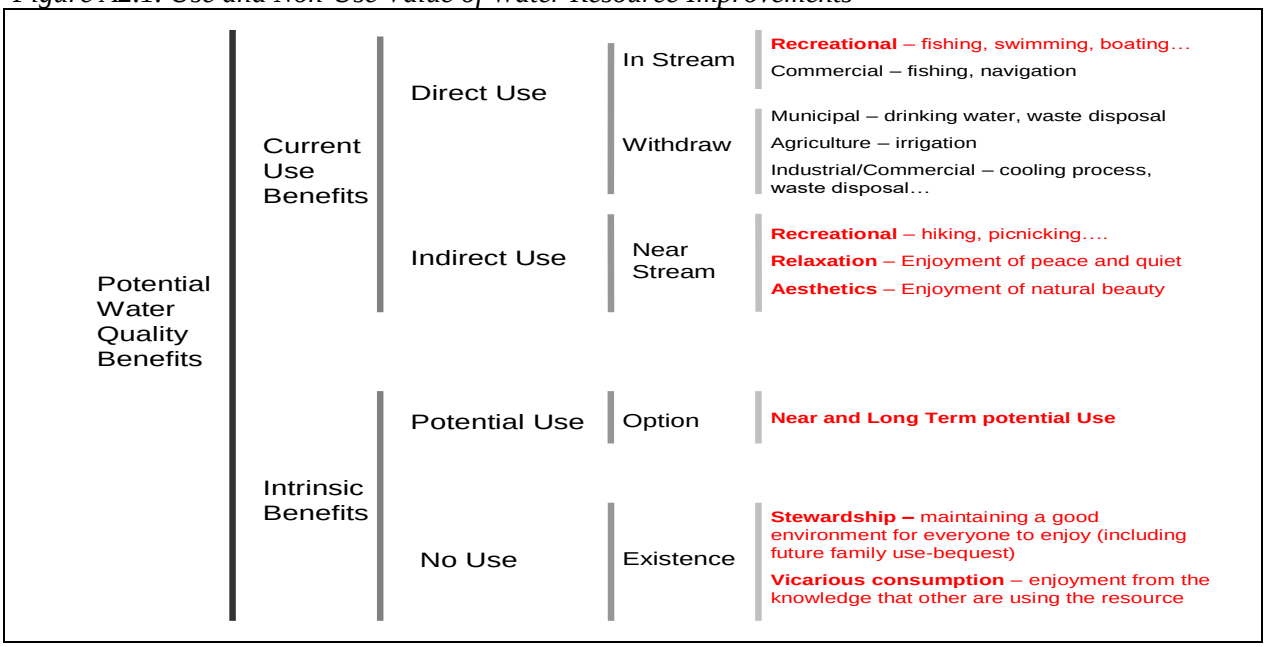
Noise and Odor Pollution
Not covered.

Water
- Unimproved Water, Sanitation and Hygiene
  - Risk factors to derive DALY lost are from IHME <www.IHME.org> for year 2017 and used for 2018. Population exposed is the entire population (see Table A2.3).
  - Monetization used is the Value of Statistical life as derived from OECD (2015) and adjusted to 2018 prices is used for premature death using (Navrud. 2009) benefit transfer method (using adjusting for purchasing power for parity and elasticity for preference) whereas the human capital approach is used for morbidity as follows: the GDP/capita/year in 2018 is used per DALY lost.
  - GDP figures are derived from World Bank WDI (2019) and World Bank Economic update (April 2019).
- Water Resource Quality
  - Arif and Doumani (2013).
  - Baker et al. (2007).
  - Navrud (2009) for the benefit transfer method.
  - GDP figures are derived from World Bank WDI (2019) and World Bank Economic update (April 2019).
- Water Resource Quantity
  - Arif and Doumani (2013).
  - Doumani (2019).

For water resource quality, a benefit transfer was used based on a contingent valuation carried out in the United Kingdom to improve the water quality of all bodies as illustrated in Figure A2.1. Hence, Baker et al. (2007) results of £ 299 per household per year over 8 years to improve water body quality was used and adjusted to 2018 prices due to the difficulty of accounting for the multiplicity of water pollution sources in Lebanon. An elasticity of 1.2 was also used for the benefit transfer that amounted to US$ 70.4 per household per year with a high of US$ 50.5 and US$ 90.13. All Lebanon population was considered where 3.75 members per household is the average as the latest available figure by CAS.

For water resource quantity, the unaccounted-for-water (40% across Lebanon) for the water used for domestic and industrial use was considered as a proxy for accounting for the water that was extracted which affected environmental flow, ecosystem services, rising water table salinity and decreasing water table level. The tariff per household weighted by Water Establishment's population served was considered (US$ 0.70 per m^3). The same unaccounted-for-water could be done for irrigation but was not considered as unaccounted- for irrigation figures are not readily available. Incidentally, the mismanagement (water resources are available but are not efficiently provided to the consumer) cannot account for environmental degradation *per se* as they are the result of poor service delivery. However, alternative water services from wells and trucks could result in water contamination which is partially captured under WASH above although additional diseases such as hepatitis, helminth, blue baby syndrome, etc. could also ensue.

Figure A2.1. Use and Non-Use Value of Water Resource Improvements



Source: Baker et al. (2007).

Land

- Valuation methods used is the replacement cost for cropland. rangeland and forest degradation are based on the net loss of land productivity based de Groot, et al. (2012); and Arif and Doumani (2013).
- UNCCD (2017) for cropland and rangeland and forest loss and rehabilitation (Figure A2.1).
- Atallah (2018) remote sensing Quarry Map with contributions by Elias Sebastien Azzi, Fadi Doumani and Nakhle Hachem (Figure A2.1).
- GDP figures are derived from World Bank WDI (2019) and World Bank Economic update (April 2019).

The UNCCD (2017) provides data with various level of cropland, rangeland and forest degradation (Figure A2.2) from 2000 to 2010. The highest level of these 3 categories of land degradation was considered and the same annual trend over 2000-2010 was used to have the cropland, grassland and forest degradation till 2018. Despite several ongoing forest program in Lebanon that fall within the 40 million Tree program, the targets are ambitious and require donor funding that is lacking in 2018.

The valuation for 1 ha of the highest level of land degradation is based on de Groot et al. (2012 --values in 2007 prices and adjusted to 2018 prices) for rangeland whereas: the valuation of cropland is based on the opportunity cost of 1 ha of cropland and adjusted for 2018 prices as derived from Arif and Doumani (2013); and the valuation of forgone forests is based on Sattout (2014) Total Economic Value of Lebanese Forests in 2010 adjusted for 2018 prices. As for the quarries, the valuation is based on the restauration of 1,330 quarries (Figure A2.4) that scar Lebanon landscapes. The cost of restauration range between US$ 6.6 and US$ 15 per m^2 and accounts for a slope coefficient. The results are illustrated in Table A2.4. The costs of rehabilitation are equally spread over 5 years where the Net Present Value discounted at 3% was applied.

Table A2.4: Land Degradation Results, 2018

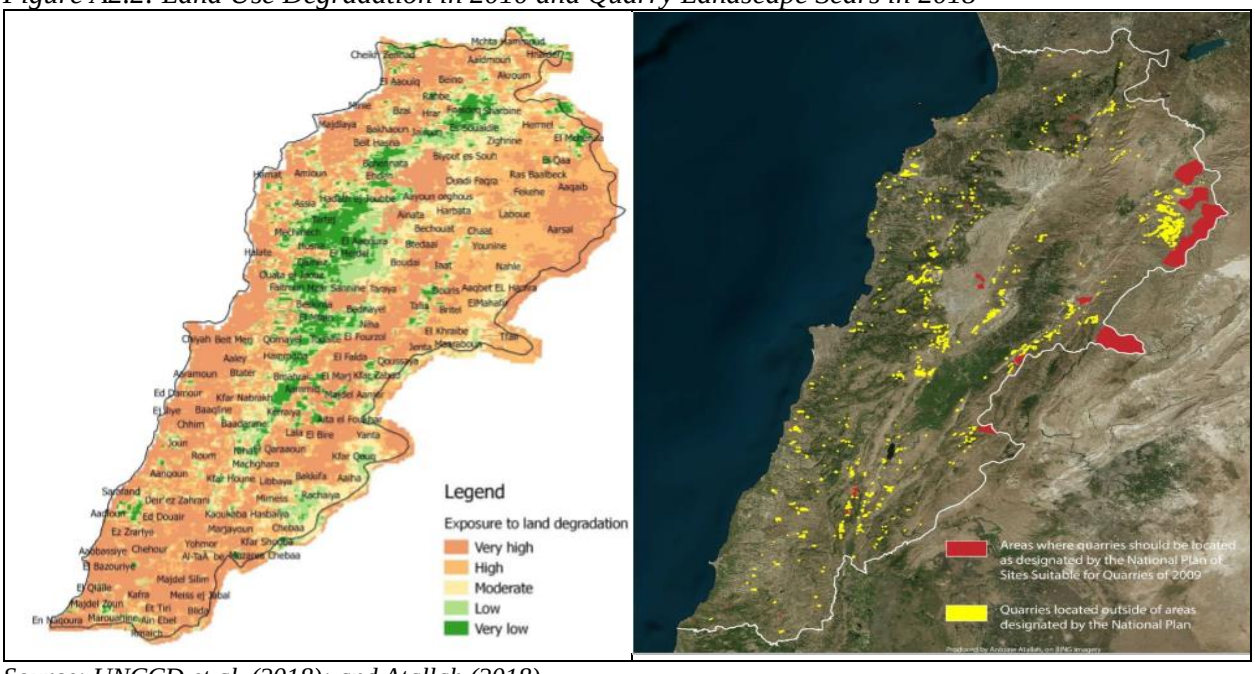
Land Category	Area	Forgone or Rehabilitation mid-Value	Lower Bound NPV at 3% over 5 years	Higher Bound NPV at 3% over 5 years	Middle Bound NPV at 3% over 5 years
	Km^2	US$	US$	US$	US$
-Cropland Degradation	226.7	140,865	25,549,268	38,323,903	31,936,585
-Rangeland Degradation	47.6	191,221	418,321	20,005,167	9,101,845
-Forest Degradation	96.5	73,962	6,437,271	10,258,376	7,135,854
-Quarry Degradation	56.2	10,900,000	381,921,891	842,474,759	612,198,325
Total	427.0		414,326,751	911,062,204	660,372,609

Source: De Groot et al. (2012); Sattout (2014); UNCCD (2017); Atallah (2018); and Author.

The cost associated with quarry degradation was attempted by using a hedonic pricing method carried out in Calgary Canada where a benefit transfer was applied. The results were not retained because there is no record on the number of years in operation while the number of quarries totaling 754 was derived from MOE & EU (2016) as the breakdown by Caza is not available for the 1,330 quarries Satellite compilation by Atallah (2018). The COED for quarries affecting the price of apartments in Lebanon was attempted by Jaroudi (2017) and amounted to US$ 728.8 million that was not spread and discounted over the years.

In Calgary, Campbell (2015) demonstrates that proximity to the operational quarry lowered nearby property values in Calgary. The percentage change in the log linear function of the price of a house was 0.12229 as distance increases. A single coefficient, -0.006715, is applied to all property values in Lebanon, as it represents a weighted average of the impact of a given quarry in a radius around the quarry in which an average of only 42% of the radius includes properties whose values are actually affected by the quarry. The coefficient is applied to average real estate values for 2015 by Caza that are considered unchanged in 2018 as real estate prices have plateaued since 2015. The results are illustrated in Table A2.5 for the average property price and Table A2.6 where the degradation cost of properties is considered without accounting for the quarries time life and the NPV over the years.

Figure A2.2: Land Use Degradation in 2010 and Quarry Landscape Scars in 2018



Source: UNCCD et al. (2018); and Atallah (2018).

Table A2.5: Average Real Estate Value

Mohafaza/Caza	Caza Value	Mohafaza Value
	US$	US$
Beirut		475,377
Mount Lebanon (other Cazas)		158,909
Keserwen	140,169	
Baabda	129,060	
Metn	207,497	
Nabatieh		54,554
Bekaa		37,769
South		77,158
North		51,754

Source: Jaroudi (2017).

Table A2.6: Decrease in Value Due to Quarries

Jurisdiction	Number of households	Number of quarries	Max distance to nearest quarry	Percentage households affected by quarries	Total Property Value	Decrease in value due to quarries
	#	#	Km	%	US$	US$
Beirut	135,755	0			64,534,822,935	
Bekaa	246,395	193	3.32		9,306,097,062	-61,962,400
Baalbeck	92,450	76	3.91	100%	3,491,743,459	-23,445,743
Hermel	10,366	12	4.69	80%	391,501,895	-2,104,249
Rachaya	11,021	16	4.14	100%	416,254,586	-2,794,993
West Bekaa	36,033	27	2.81	100%	1,360,947,009	-9,138,247
Zahle	96,525	51	2.07	100%	3,645,650,112	-24,479,168
Mount Lebanon	487,859	204	2.20	100%	77,966,323,880	-523,514,519
Aley	63,893	59	1.49	100%	10,153,166,161	68,174,689
Baabda	166,160	11	2.98	100%	21,444,579,551	-143,992,280
Chouf	57,914	22	3.31	100%	9,203,022,163	-61,794,830
El Metn	129,421	45	1.72	100%	26,854,451,305	-180,317,533
Jubail	23,119	33	2.53	100%	3,673,741,167	-24,667,789
Kesrouan	47,353	34	2.25	100%	6,637,363,534	-44,567,398
Nabatiyeh	86,934	99	2.36		4,742,570,474	-31,844,576
Bint Jbeil	19,686	18	2.74	100%	1,073,926,588	-7,211,013
Hasbaya	9,891	22	2.45	100%	539,583,251	-3,623,098
Marjayoun	16,147	34	1.96	100%	880,892,090	-5,914,859
Nabatieh	41,210	25	2.47	100%	2,248,168,544	-15,095,606
North	252,843	132	2.73		13,778,250,818	-54,156,882
Akkar	85,211	22	**4.23**	**98%**	4,409,995,478	-29,152,416
Batroun	14,393	56	1.58	100%	744,894,368	-5,001,685
Bcharre	5,439	12	2.61	100%	281,482,126	-1,890,047
Koura	15,411	22	2.00	100%	797,593,307	-5,355,539
Minieh-Dennieh	43,143	5	6.02	**49%**	2,232,847,574	-7,306,013
Tripoli	86,942	0			4,499,600,643	
Zgharta	15,686	15	2.43	100%	811,837,323	-5,451,182
South	137,021	96	2.19		10,572,267,077	-57,295,961
Jezzine	5,824	65	1.36	100%	449,375,424	-3,017,387
Saida	74,257	5	5.23	64%	5,729,538,051	-24,778,858
Sour	56,940	26	2.80	100%	5,729,538,051	-24,778,858
Grand Total	1,346,807	754			180,900,332,246	-728,774,337
Percentage Change in Property Value						-0.4%

Source: Jaroudi (2017).

Waste

- Collection: Chamieh et al. (2016).
- Treatment: Arif and Doumani (2014); and Chamieh et al. (2016).
- Disposal: Doumani (2017).

Waste collection is quasi universal in Lebanon and does not need to be addressed in this Note unless new data shows poor collection in certain areas.

Table A2.7: Waste Treatment Forgone Opportunity

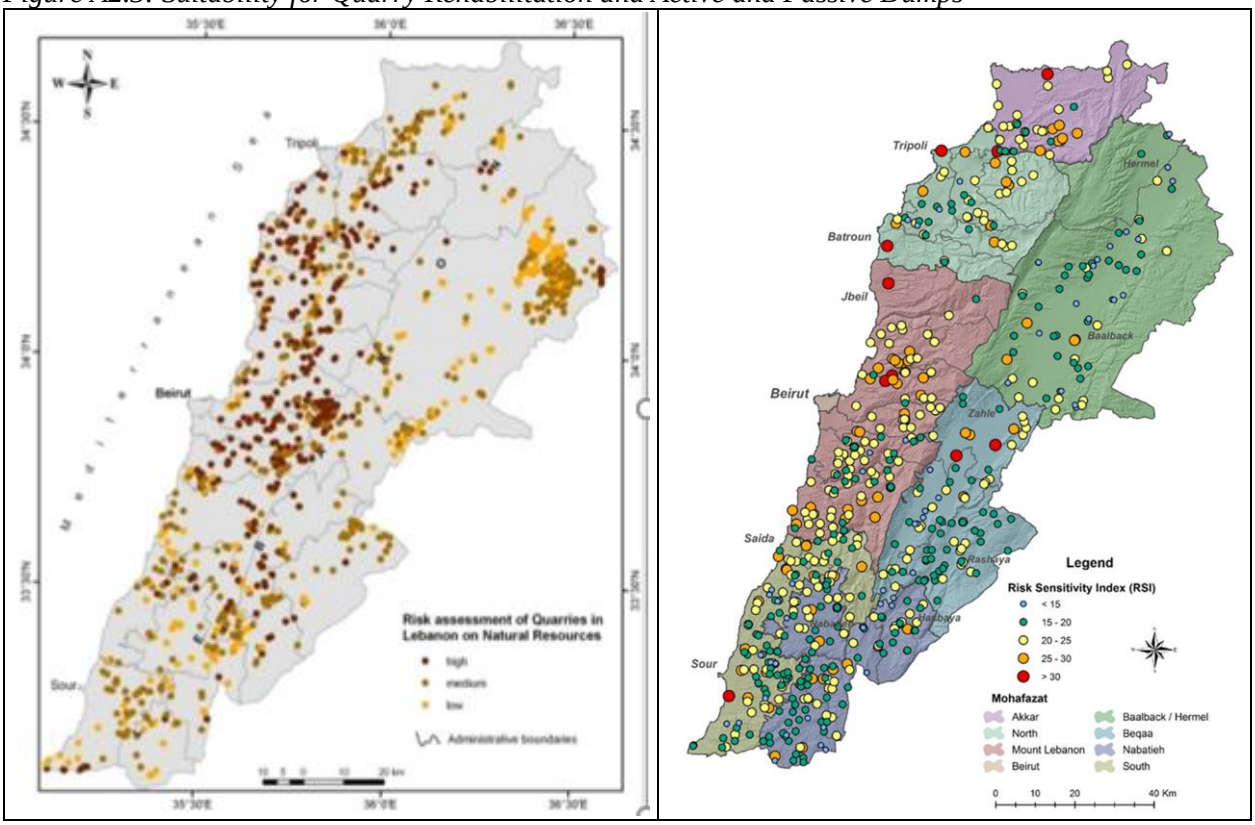
Input	Lebanese	Palestinians	Syrians	Others	Total	Cost/ton Lower Bound	Cost/ton Higher Bound	Cost/ton Middle Bound	Value Low	Value High	Value Middle
	#	#	#	#	#	US$/ton			US$ million		
TOTAL Pop	4,035,042	208,802	1,500,000	414,677	6,158,521						
Gen Kg/day	1.05	0.70	0.70	0.70							
Total Gen Kg/y	1,546,430	53,349	383,250	105,950	2,088,979						
Organic = 30%	231,964	8,002	57,487	15,893	313,347	50	100	75	15.7	31.3	23.5
Plastic = 7%	108,250	3,734	26,827	7,417	146,229	100	600	350	14.6	87.7	51.2
Paper = 8%	123,714	4,268	30,660	8,476	167,118	55	75	65	9.2	12.5	10.9
Glass = 3%	46,393	1,600	11,497	3,179	62,669	30	40	35	1.9	2.5	2.2
Total									41.4	134.1	87.7

Source: Chamieh et al. (2016); and Author.

Although waste treatment has picked up since the 2015 crisis, it is however far from covering all the generated waste. An opportunity cost of a fraction of waste based on Chamieh et al. (2016) is used to provide the COED results. Hence, the forgone treatment concerns 30% of organic, 8% of plastic, 7% of paper and 3% of glass (Table A2.7).

For the waste disposal, the 2017 figures of the dump COED (Figure A2.3) were adjusted to reflect 2018 data. Incidentally, the Costa Brava and Bourg Hammoud landfills were already considered in the analysis where forgone opportunities in terms of capturing methane to generate energy, land value loss and untreated leachate were valued. Also, a 2008 study attempted to determine the suitability of quarry rehabilitation in hill lakes and/or green cover (landfills) without being considered by solid waste policies.[33]

Figure A2.3: Suitability for Quarry Rehabilitation and Active and Passive Dumps



Source: Darwish et al. (2008); and MOE & UNDP (2017).

[33] Darwish et al., 2008.

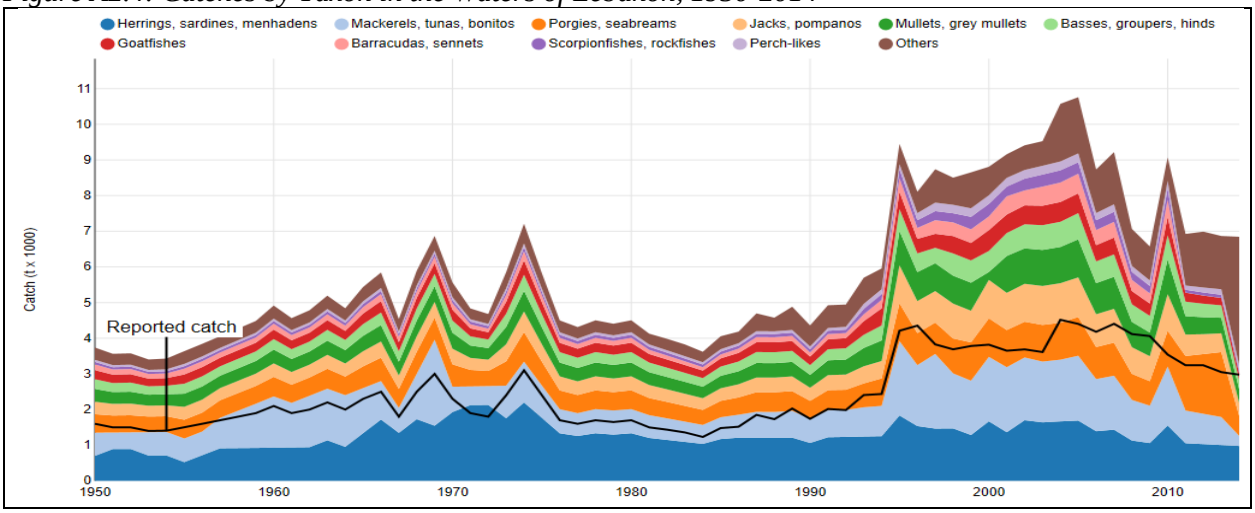
Coastal Zone

- Fisheries (FAO and sea around the world). <www.seaaroundus.org/data/#/eez/422?chart=catch-chart&dimension=taxon&measure=tonnage&limit=10>.
- de Groot et al. (2012) for Marine environment and ecosystem services.
-Coastal Erosion: Abi Rizk (2005); El Hage et al. (2011); and Ghoussein et al. (2018).
-Coastal Disamenities: Ridella et al. (2019).

- Navrud (2009) for the benefit transfer method.
- GDP figures are derived from World Bank WDI (2019) and World Bank Economic update (April 2019).

The degraded marine environment was estimated to spread over 150 km by 200 meters width from the coastal zone. The valuation is based on De Groot et al. (2012 --values in PPP$ 2007 global prices and adjusted to US$ 2018 prices using Lebanon PPP$ to US$ rate). Interestingly, the fish stock seems to have increased since the late 1990s despite the 2006 oil spill and therefore is not considered in the analysis unless better data and analysis could show a dramatic reverse of the current trend (Figure A2.4). Yet, only traditional fishing occurs in Lebanon and there is anecdotal evidence that fishermen have been going further offshore to catch fish. This could be quantified in terms of additional time and gasoline expenditures although this kind of data is not readily available.

Figure A2.4: Catches by Taxon in the Waters of Lebanon, 1950-2014



Source: Sea Around Us website: <www.seaaroundus.org/data/#/eez/422?chart=catch-chart&dimension=taxon&measure=tonnage&limit=10>.

The artificialization of the Lebanese coast is unrelenting whereas coastal erosion seems to be a serious problem along 24 sandy stretches of the Lebanese coast of which 5 stretches are the most impacted based on satellite imagery,[34] where the losses amount to 1.8 km^2 between 1963 and 2003 (Table A2.8): Arida-Al Mouheiteh; Mazraat El Yahoudieh-Ain Abou Abdallah; Sibline-Rmeil es Chouf; Rmeil-Saida; and Sour-El Kleileh. For instance, the coast has receded about 50 meters over a length of about 16 km since 1963 in Akkar whereas long-shore drift (Groins) have been erected towards the sea in Chekka and Bebnin with mixed results.[35] The coastal erosion is due to a convergence of natural and human-made factors notably: the high winds and important south-north drift current especially in winter time; reduction of sediments released by Lebanese rivers due to lower rains over the years and lower sediments released by rivers; reduction of the sediments released by the Nile since the construction of the Aswan dam in the early 1960s;

[34] Abi Rizk, 2005.
[35] Kasparek (2004).

the encasing of the coast and the building of jetties hence deflecting and increasing the dynamics of the waves northward; the sand mining for construction in Akkar and more especially in Cheikh Zennad where dunes were completely sand mined away and a lagoon was created; and the offshore dredging. A Coastal Vulnerability Index for Southern Lebanon was carried out over 2013 and 2015, where interestingly, a 392-meter accretion was noted in Saida due to the construction of the landfill and an 82-meter erosion was noted in Adloun, next to the newly constructed fishermen port (Figures A2.5 and A2.6).

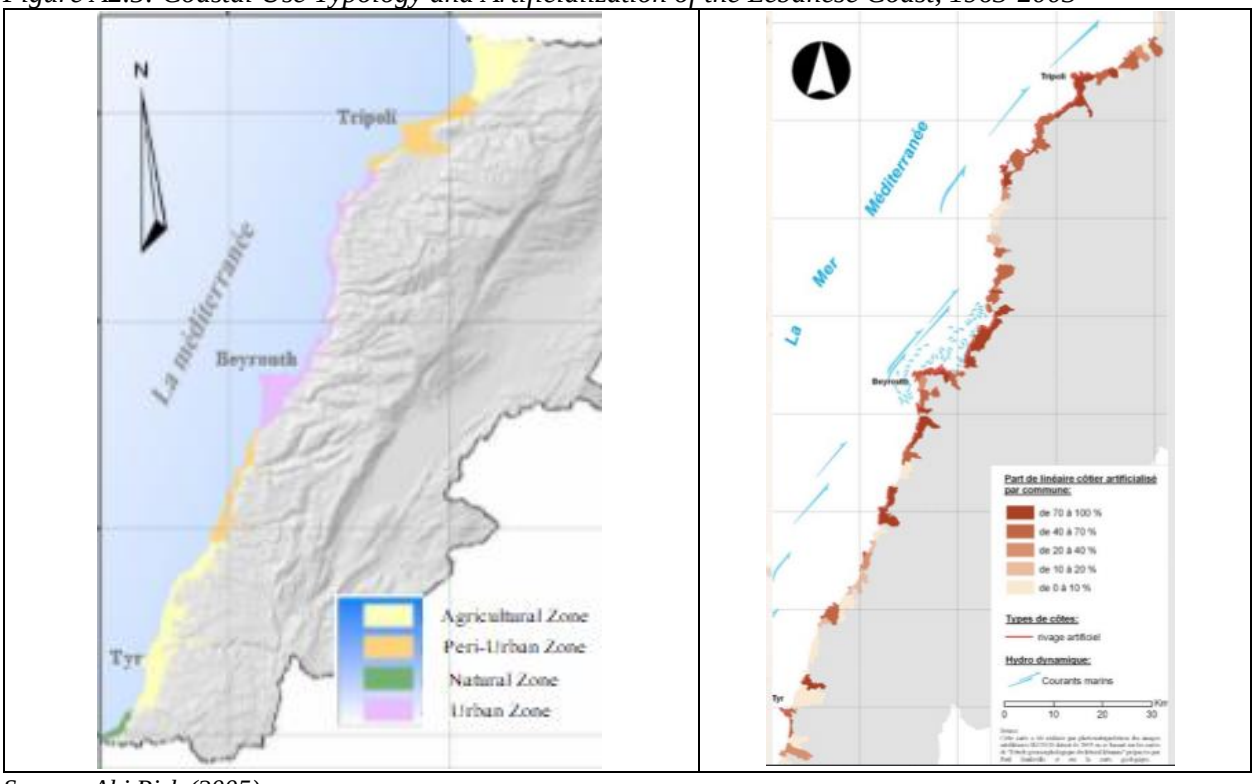
Table A2.8: Lebanon Most Impacted Sites by Coastal Erosion, 1963-2003

Coastal Area from North to South	Length	Erosion 1963-2003	Area Lost	Yearly Area Lost	Mid Land Value Loss
	m	m	m^2	m^2	US$
Arida-Al Mouheiteh	10,000	50	500,000	12,500	1,562,500
Mazraat El Yahoudieh-Ain Abou Abdallah	7,000	109	763,000	19,075	2,384,375
Sibline-Rmeil esh Chouf	1,300	57	74,100	1,853	416,813
Rmeil-Saida	3,800	82	311,600	7,790	1,752,750
Sour-El Kleileh	2,600	70	182,000	4,550	1,251,250
Total	24,700		1,830,700	45,768	7,367,688

Source: Abi Rizk (2005).

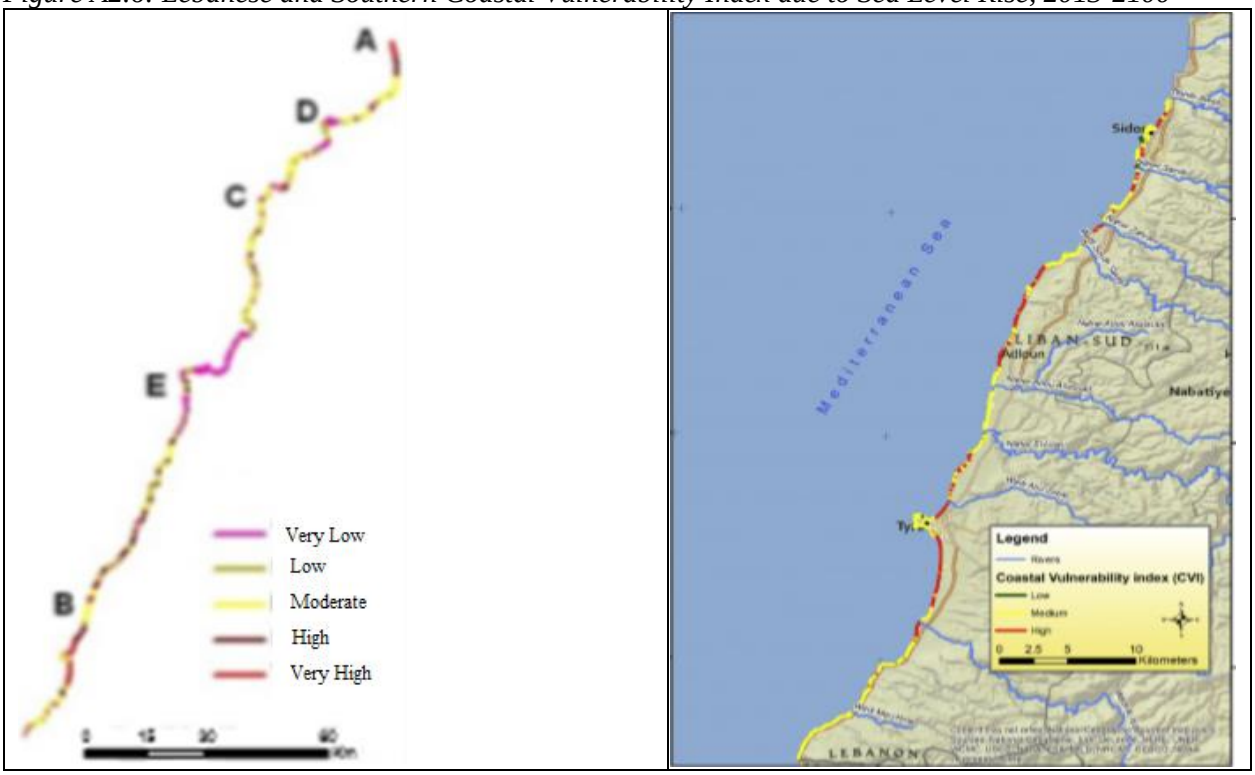
For the calculation of the erosion, the same 1963-2003 erosion trend confirmed in 2013-15 of the most impacted sites that are mainly due to human intervention such as artificialization and sand mining.

Figure A2.5: Coastal Use Typology and Artificialization of the Lebanese Coast, 1963-2003



Source: Abi Rizk (2005).

Figure A2.6: Lebanese and Southern Coastal Vulnerability Index due to Sea Level Rise, 2013-2100



Source: El Hage et al. (2011); and Ghoussein et al. (2018).

For preserving Lebanon coastal zone recreations and amenities, a benefit transfer from a contingent valuation study performed in Italy covering all beaches (sand, pebble and rocky) typology and eliciting a Willingness to Pay to preserve coastal amenities from a sample of 5,000 individuals.[36] The CVM results showed that the overall sample mean value was €14.84 per user in 2018. WTP was € 20.55 for natural, € 15.42 for semi-urban and € 14.48 for urban beaches. A benefit transfer was used to apply this WTP to Lebanon by using the purchasing power parity for the income differential and an elasticity of 1.2 for user preferences: the WTP amounts to US$ 3.72 per user in Lebanon in 2018 with low of US$ 3.63 and a high of US$ 5.16. The population willing to pay for the preservation of coastal amenities are the Lebanese residents living along coastal Mohafazat and totaling 3.48 million: Akkar, Norther, Mount Lebanon, Beirut, Nabatiyeh and Southern.

Table A2.9: WTP to Preserving Coastal Recreations and Amenities in Lebanon

CVM Benefit Transfer	Population	WTP / User Low	WTP / User High	WTP / User Mid	WTP / Pop. Low	WTP/ Pop. High	WTP / Pop. Mid
	#	US$	US$	US$	US$	US$	US$
Preserving Coastal Recreations and Amenities	3,479,893	3.63	5.16	3.72	12,645,172	17,946,014	12,959,555

Source: Rodella et al. (2019); and Author.

Biodiversity

- Implicitly covered for Water Resources and Land and explicitly covered for Coastal Zone.

Global Environment

- Carbon emission per capita figures are considered the same as 2014 and are derived from World Bank WDI (2019).

[36] Rodella et al., 2019.

- The social cost of carbon increased tremendously vis-à-vis previous COEDs as it is derived from High-Level Commission on Carbon Prices' Stiglitz and Stern (2017) projections.

The effects of climate change on Lebanon could be better calculated but need more time. In this case, the emissions of CO_2 equiv. per year, which reached 4.92 tons per capita per year (2014 data considered as similar to 2018)[37] are considered to derive the social cost of Lebanon on the global environment. A range of US$ 38-76 per ton of CO_2 equiv. in 2018 prices was considered as lower bound and higher bound.[38]

[37] World Bank WDI, 2019.
[38] High-Level Commission on Carbon Prices, 2017.