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Lebanon's Second Biennial Update Report to the UNFCCC

Ministry of Environment
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Lebanon's Second Biennial Update Report to the UNFCCC

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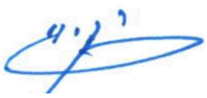
Foreword

Lebanon's Second Biennial Update Report (BUR) to the United Nations Framework Convention on Climate Change (UNFCCC) was prepared with the Enhanced Transparency Framework of the Paris Agreement in mind. Fully aware of the challenges and gaps that it had to face during the preparation of the First Biennial Update Report, and encouraged by the guidance and assessment under the International Consultation and Analysis (ICA) process, the BUR expert team drafted more than a report. It started drafting a vision for efficient institutional arrangements and transparent reporting of emissions, mitigation, finance and MRV for the Paris Agreement implementation era. While this vision is far from being complete and perfect, it has created the much needed national momentum for a broader involvement of national stakeholders and a sense of responsibility towards established and upcoming UNFCCC processes.

The importance of the Second BUR also lies in the appropriation of its dual international and national dimension. While Lebanon understands that preparing a BUR is an opportunity to assess gaps and needs in terms of climate finance and capacity building, and to monitor progress of implementation of national development and sectoral policies with mitigation action components, the country is also fully ready to participate in the international stocktaking cycles. Cautiously and consistently submitting constantly improved BURs shows that we strongly believe in joining efforts to make sure we are collectively efficiently working as parties towards achieving the global temperature goal we have set for the planet under the Paris Agreement.

Concretely, main improvements on the technical level in the present BUR include a detailed trend analysis, an incorporation of all recommendations from the ICA process in terms of reporting capacity building needs, and improved tables with more complete information for reporting mitigation actions and finance and capacity building information in line with discussed suggestions by parties in the Ad Hoc Working Group on the Paris Agreement (APA). Institutionally, Lebanon's Second BUR has been an opportunity to launch work on a national data repository for tracking emissions and progress on the implementation of the Intended Nationally Determined Contribution (INDC), on the design of a climate finance reporting system, and on the establishment of standard procedures for preparation and communication of BURs.

It is with great honour and enthusiasm that I present Lebanon's Second Biennial Update Report to the international community. We hope readers will be able to appreciate our progress and challenges, and we are looking forward to an era of unprecedented multilateral cooperation to advance implementation of climate action through improved reporting.



Tarek El Khatib
Minister of Environment

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Acronyms

AFDC	Association for Forests, Development and Conservation
BRT	Bus Rapid Transit
CAS	Central Administration of Statistics
CCCU	Climate Change Coordination Unit
CCGT	Combined Cycle Gas Turbines
CDR	Council for Development and Reconstruction
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamp
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CNRS	National Council for Scientific Research
CoM	Council of Ministers
COP	Conference of Parties
DGUP	Directorate General for Urban Planning
DM	Dry Matter
DO	Diesel Oil
DREG	Decentralized Renewable Energy Power Generation
EIA	Environmental Impact Assessment
EDL	Electricité du Liban
E/R	Emissions/Removals
FAO	Food and Agriculture Organization
FSRU	Floating Storage And Regasification Unit
FSV	Facilitative sharing of views
GBA	Greater Beirut Area
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit
GoL	Government of Lebanon
GPG	Good Practice Guidance
GPS	Global Positioning System
GWP	Global Warming Potential
HCW	Health Care Waste
HDV	Heavy-Duty Vehicles
HFO	Heavy Fuel Oil
HPS	High Pressure Sodium
HRSG	Heat Recovery Steam Generators
ICA	International Consultation and Analysis
IFAD	International Fund for Agricultural Development
ITS	Informal Tent Settlements

INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producer
IPTEC	IPT Energy Center
IWRM	Integrated Water Resoure Management
KP	Kyoto Protocol
LAF	Lebanese Army Forces
LARI	Lebanese Agricultural Research Institute
LDV	Light-Duty Vehicles
LCEC	Lebanese Center for Energy Conservation
LECB	Low Emission Capacity Building Project
LED	Light Emitting Diode
LIBNOR	Lebanese Standards Institution
LPG	Liquefied Petroleum Gas
LNG	Liquefied Natural Gas
LRF	Lebanon Recovery Fund
LRI	Lebanese Reforestation Initiative
LULUCF	Land Use, Land Use Change and Forestry
MEA	Middle East Airlines
MMS	Manure Management System
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoI	Ministry of Industry
MoIM	Ministry of Interior and Municipalities
MoPWT	Ministry of Public Works and Transport
MPG	Modalities, Procedures and Guidelines
MRV	Measuring, Reporting and Verifying
MRVCE	Measuring, Reporting and Verifying Coordinating Entity
MSW	Municipal Solid Waste
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
NEEAP	National Energy Efficiency Action Plan
NEEREA	National Energy Efficiency and Renewable Energy Action
NCE	National Council for the Environment
NCV	Net Calorific Value
NG	Natural Gas
NGO	Non-Governmental Organization
NREAP	National renewable Energy Action Plan
NRP	National Reforestation Plan
OMSAR	Office of the Minister of State for administrative Reform
PC	Passenger Cars
PRP	Pasture Range and Paddock

Pr	Persons
PV	Photovoltaics
QA/QC	Quality Assurance/Quality Control
RISICO	RISchio Icendi e COordinamento
SLM	Sustainable Land Management
SNC	Second National Communication
SWH	Solar Water Heaters
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
USFS	United States Forest Service
WtE	Waste to Energy
WUI	Wildland-Urban Interface
WWE	Water and Wastewater Establishment
WWTP	Wastewater Treatment Plant

Executive Summary

National circumstances

Lebanon is located on the eastern basin of the Mediterranean Sea with a surface area of 10,452 km^2, characterized by mostly mountainous areas. The country's population is estimated to be 6,131,254 in 2013, including foreign workers, Palestinian and Syrian displaced. It is estimated that 858,641 displaced have settled in Lebanon in 2013, including Syrian nationals, Palestine Refugees from Syria and Lebanese returnees.

Lebanon's economy is relatively diversified with trade, manufacturing, construction and finance representing around half of the economy, and a Gross Domestic Product (GDP) of USD 49.9 billion in 2014 and a GDP per capita of USD 18,052. Lebanon's growth track record is volatile. During the period 2006-2010, real GDP growth averaged 7.7% before falling to 1.9% in 2011-2015 as a result of geopolitical developments.

Lebanon is a sovereign state with a centralized political and administrative structure. The decision-making involves the Lebanese Parliament (128 seats) and the Council of Ministers which enacts regulations in the form of decisions and decrees. The Environmental Protection Law (law no. 444/2002) is the overarching legal instrument for environmental protection and management in Lebanon and the National Council for the Environment (NCE) chaired by the Ministry of Environment is the body responsible for providing environmental policy and planning.

Greenhouse gas inventory

In 2013, Lebanon emitted 26,285 Gg CO_2eq. with the most significant greenhouse gas being carbon dioxide, primarily produced from the burning of fossil fuels. The main contributor to greenhouse gas emissions is the energy sector (including transport) with 79% of GHG emissions, followed by industrial processes (10%) and waste sector (7%). CO_2 removals from the land use, land use change and forestry category amounted to 3,518.80 Gg CO_2, bringing Lebanon's net emissions down to 22,766 Gg CO_2eq.

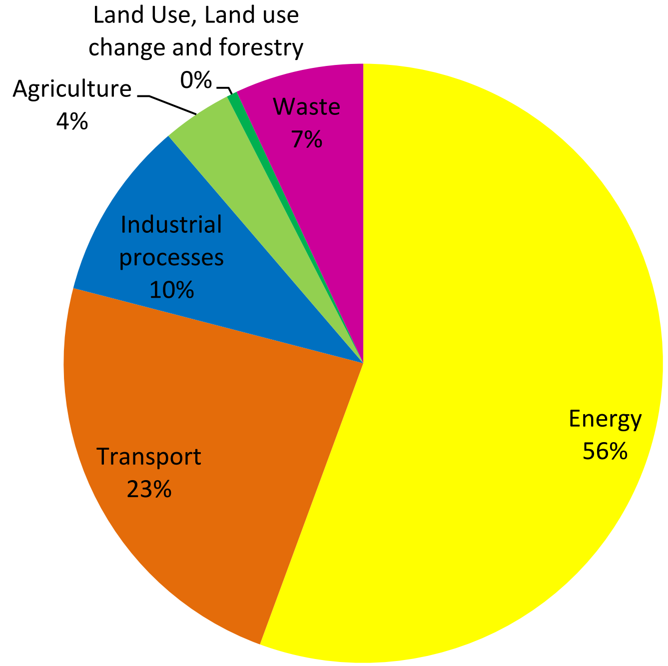

Figure i: Lebanon's national greenhouse gas inventory by category in 2013

Table i: Lebanon's GHG emissions and removals for 2013 per gas and category

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	CH_4	N_2O	N_2O	Total
	Gg	Gg	Gg	Gg CO_2eq.	Gg	Gg CO_2eq.	Gg CO_2eq.
Total national emissions and removals	23,246.21	-3,518.80	96.68	2,030.36	3.25	1,008.53	26,284.69
1 Energy	**20,551.07**		2.12	44.47	0.58	179.56	20,775.10
Energy industries	7,367.39		0.297	6.25	0.06	18.44	7,392.08
Manufacturing industries and construction	4,403.84		0.106	2.23	0.03	9.89	4,415.96
Transport	5,987.93		1.273	26.74	0.46	143.69	6,158.35
Other sectors	2,791.91		0.441	9.26	0.02	7.55	2,808.72
Fugitive emissions from fuels	NO		NO	NO			NO
2 Industrial processes	**2,545.42**						2,545.42
Mineral products	2,545.42						2,545.42
Chemical industry	NE		NE		NE		NE
Metal production	NO		NO		NO		NO
Other production	NA		NA		NA		NA
Production of halocarbons and sulphur							NO
Consumption of halocarbons and sulphur							NE
Other	NO		NO		NO		NO
3 Solvent and other product use	**NE**				**NE**		**NE**
4 Agriculture			14.55	305.55	2.20	682.00	987.55
Enteric fermentation			12.64	265.44			265.44
Manure management			1.91	40.11	0.55	170.50	210.61
Rice cultivation			NO	NO			
Agricultural soils					1.65	511.50	511.50
Prescribed burning of savannas			NO	NO	NO	NO	NO
Field burning of agricultural residues			NO	NO	NO	NO	NO
Other			NO	NO	NO	NO	NO
5 Land use, land use change and forestry	149.67	-3,518.80	0.01	0.23	0.0001	0.04	149.95
Changes in forest and other woody biomass stocks							
Forest and grassland conversion							
Abandonment of managed lands							
CO_2 emissions and removals from soil							
6 Waste	**0.05**		80.00	1,680.11	0.47	146.51	1,826.67

Solid waste disposal on land			60.91	1,279.14		0.00	1,279.14
Wastewater handling			19.09	400.97	0.47	146.51	547.48
Waste incineration	0.05						0.05

NA: not applicable – NE: not estimated – NO: not occurring
Numbers may reflect rounding.

Indirect greenhouse gases such as carbon monoxide (CO), nitrogen oxides (NOx) non-methane organic volatile compounds (NMVOCs) and sulphur dioxide which have indirect impacts on climate and alter the atmospheric lifetimes of other greenhouse gases have also been estimated. In Lebanon, the transport sector is the major source of indirect greenhouses, being responsible for 61% of NO_x emissions, 99% of CO emissions and 65% of NMVOCs. Fuel combustion for energy production is the main emitter of SO_2 with 94% of emissions, mainly caused by the sulphur content in burnt fuel. As for industrial processes, they mainly emit NMVOCs, being responsible for 34% of these emissions.

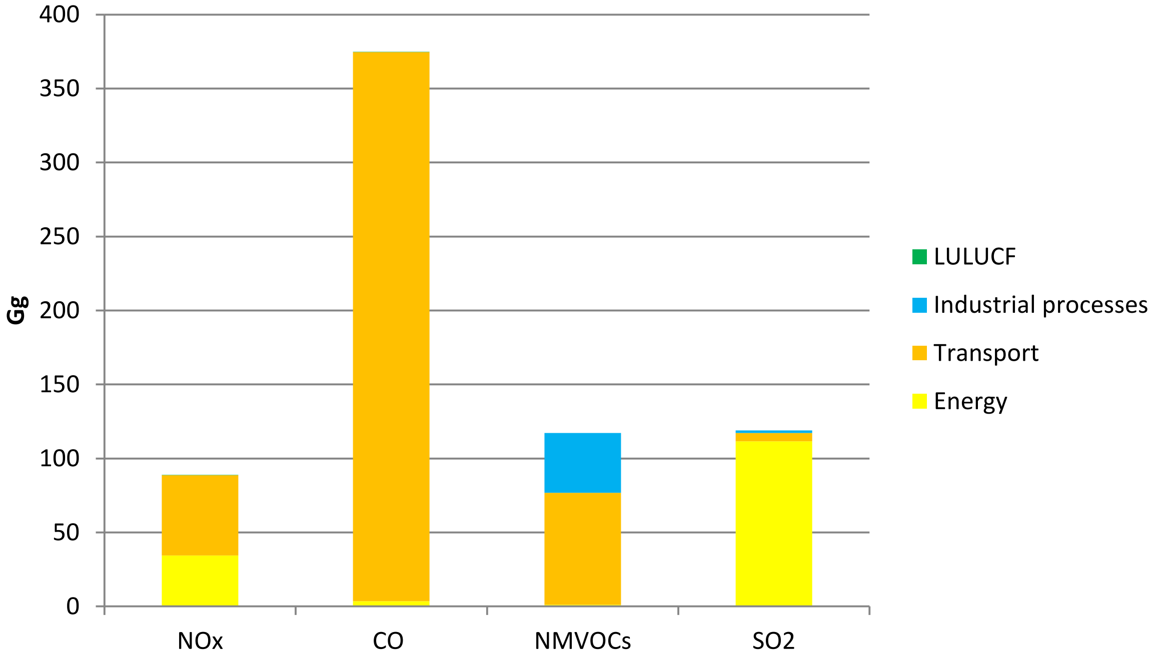

Figure ii: Indirect GHG emissions and SO_2 emissions in 2013

Lebanon's GHG emissions are increasing at an average rate of 3.4% every year, which lead to a doubling of emissions since 1994. The trend of increase in total GHG emissions closely follows the trend of emissions from the energy sector, which constituted 53% to 59% of total emissions during this period. This significant growth in emissions reflects the growing demand for electricity, due in part to the changing socio-economic conditions and to the expansion of the national grid. The 2 detectable drops in 2007 and 2010 and the significant increase in 2009 are mainly due to the impacts of the July 2006 war where significant damage to the road network and electricity infrastructure was inflicted. The rehabilitation of the infrastructure extended over 2 years, and it was not until 2009 that power plants started to run on full capacity again, hence explaining the peak in GHG emissions in 2009.

The sector with the most significant change in emissions is still the transport sector with emissions increasing by a factor of 3.9 reaching 6.1 million tonnes CO_2eq. in 2013. This increase is mostly related to the upturn of the number of registered vehicles in Lebanon from 500,000 in 1994 to 1,640,000 in 2013.

The waste sector also witnessed a significant increase in emissions, increasing by a factor of 2.4 from 1994. With an increase in population, in waste generation and in percent of waste deposited in landfills, methane emissions from solid waste disposal on land have increased by 93% during this period.

The agriculture sector is still showing a decrease in emissions with a reduction of -5% from the 1994 levels, mainly due to the decrease in emissions from agricultural soils and to a lesser extent from enteric fermentation.

As for Land Use, Land Use and Forestry, forests are still constituting important sinks of greenhouse gases. However, changes in forest and vegetation covers due to wildfires and mainly urbanization resulted in a net decrease of 2.37% in CO_2 emissions.

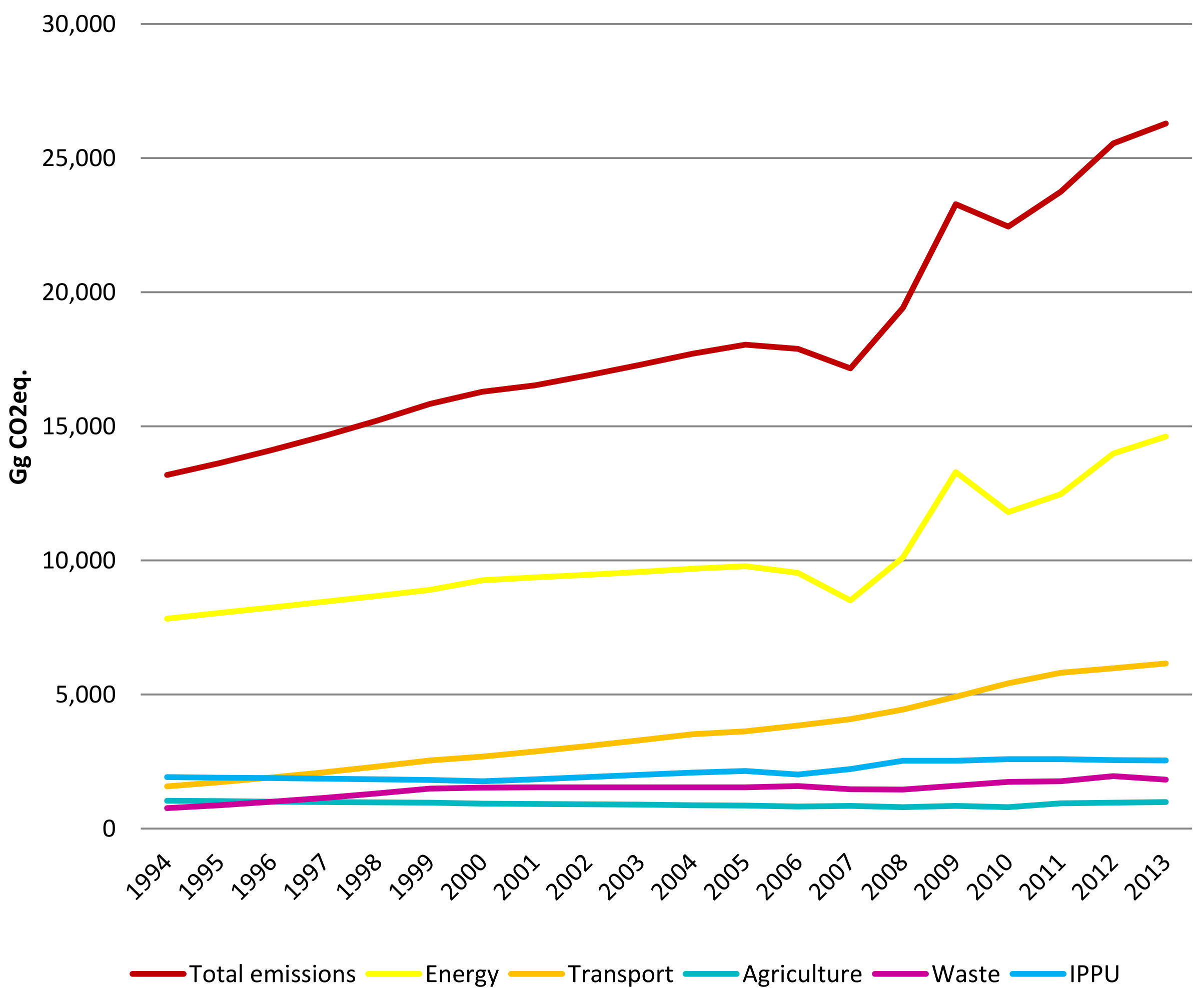

Figure iii: Trend of GHG emissions 1994-2013

Climate change mitigation

As a party to the UNFCCC, Lebanon has made efforts to implement activities that lead to emission reduction based on its capabilities and taking into account its national circumstances. Mitigation measures are mainly achieved in the power and forestry sectors.

In 2013, mitigation measures implemented in the energy sector contributed in reducing emissions by 513,063 tonnes CO_2eq., with the expansion of the solar water heaters and the replacement of incandescent lamps inducing the most significant emission reductions.

As for land use, land change and forestry, afforestation and reforestation activities were sustained and increased by the Ministry of Agriculture and leader organizations in the country such as the Association for Forest Development and Conservation and Jouzour Loubnan. In 2013, the total amount of GHG emissions that has been removed from mitigation actions in this sector to 18.996 Gg CO_2eq. in 2013.

Lebanon's transparency framework, institutional arrangements and MRV system

As part of enhancing Lebanon's readiness to implement the Paris Agreement's article 13 on transparency, several initiatives are being undertaken:

- Minister of Environment decision 99/1 which provides an incentive to the private sector to report on a voluntary basis their GHG emissions and related activity data to the Ministry of Environment. The latter is planning to undertake an assessment to determine the relevance and scalability of the initiative for better informing climate change policy in Lebanon.
- Cooperation between Ministries of Environment and Industry, which entail collection of information by requesting that basic activity data be included as part of the standard procedures followed for industries to acquire their business licenses.
- Cooperation between Ministries of Environment and Finance, which entails data request included in the online tax declaration template. A first round of data collection will be launched starting 2018 for the companies registered at the Large Taxpayer Office.
- The Lebanon Climate Act initiative, which aims to engage the private sector and non-state actors in climate action. A series of trainings have been conducted to support companies in determining their level of engagement, identifying potential partners from civil society and municipalities, and developing implementation, monitoring and reporting plan for their climate actions.
- Transparency law, which give access to information law to the public and which prescribes that all government entities publish online key documents showing performance indicators. The law is a positive step towards improving transparency and public accountability, and work for climate change transparency will benefit from this initiative.
- Management and Information System for Climate Action (MISCA), which is an online information system that tracks progress of implementation of the energy target of Lebanon's Nationally Determined Contribution. The Ministry of Environment aims at expanding the MISCA initiative to include other ministries. This would be an important move towards enhancing Lebanon's effectiveness and transparency.

Some gaps and challenges still exist to coordinate these initiatives and to enforce their efficient implementation.

Constraints and gaps, and related financial, technical and capacity needs, including a description of support needed and received

The main challenge related to the preparation process of the BUR is the absence of sustainability of the team responsible for the climate reporting processes at the Ministry of Environment. Therefore, the main need is the provision of permanent financial and administrative support to the Ministry of Environment in order to guarantee the sustainability, continuity and integrity of the information reported in the BUR. This can be ensured through the establishment of the MRV Coordinating Entity which will be responsible not only for tracking climate change activities and collecting relevant data, but also in identifying needs to strengthen climate reporting processes in Lebanon.

Other significant challenges relate to the preparation of national inventories. They include but are not limited to the centralization of data management, the development of measurement campaigns to better characterize Lebanon's energy systems and vehicle fleet, or even the undertaking of an official census on the population in Lebanon or the manure management systems.

Challenges also exist in the collection and consolidation of information related to existing mitigation actions. They are mainly related to limited availability of data, weak coordination between institutions working in climate change and the difficulty in quantifying emission reductions achieved.

Lebanon also needs to improve its institutional arrangements that would allow exhaustive and accurate reporting of support received for climate change activities. Efforts are underway to define climate finance and devise a process to establish a system for MRV of support received (including capacity-building and technology transfer) and their respective financing and linkages to NDC goals. Lebanon has attempted in the present BUR to gather readily available and trusted information, in a format that, if developed and improved, could inform the global stocktake more easily. Only information on climate related projects that have been approved by donors and whose beneficiary is the Ministry of Environment since the submission of BURI has been considered in this report and presented in tabular formats. The report also includes a table which lists the participation of representatives of Lebanon in capacity building events related to climate change since the submission of the first BUR.

I. National circumstances

1 Government structure

Lebanon's legislative body, represented by the Lebanese Parliament (128 seats), is organized into specialized committees, among which the Committee for Environment. The Environmental Protection Law (law no. 444/2002) is the overarching legal instrument for environmental protection and management in Lebanon.

The Ministry of Environment is the main national coordinator for climate change and the UNFCCC focal point. The Ministry also chairs the National Council for the Environment (NCE) which is composed of official representatives from 7 ministries (the Ministry of Environment; and the ministries of Finance, Interior and Municipalities, Agriculture, Public Works and Transport, Energy and Water, and Industry) and 7 non-public entities (Order of Physicians, Order of Engineers and Architects, The Bar Association, Association of Banks, Association of Insurance Companies, representative of Non-Governmental Organizations (NGOs), representative of the academic sector). The NCE is mandated to approve environmental policies and strategies and integrate environmental concept, including climate change issues, into national development plans.

Work on climate change in Lebanon is mandated by virtue of law 359/1994 and law 738/2006 relating to the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP) respectively. The Paris Agreement was signed by the Lebanese Prime Minister in April 2016 and the draft ratification law is awaiting approval by the Lebanese Parliament after having been approved by the relevant parliamentarian committees. Under the Paris Agreement, Lebanon submitted its Nationally Determined Contribution (NDC) under which the country has set a 2030 target of reducing its GHG emissions by 15% as an unconditional target and by 30% conditional to financial, technical and capacity building support.

No major legislation directly addresses climate change in Lebanon. However, a number of regulations have addressed issues that could be linked to climate change, such as the reduction of air pollution from transport (law 341/2001), the reduction of energy import by developing local energy including renewable energies (Council of Ministers, decision no. 13/2004), energy efficiency standards and labels, tax incentives on green products as well as large scale renewable energy industries (decree 167 under Law 444) and other decisions relating to the ratification of conventions such as the United Nations (UN) Convention on Biodiversity or the UN Convention to Combat Desertification.

Table 1: Lebanon's Intended Nationally Determined Contribution

Targets	Unconditional Target by 2030	Conditional Target by 2030
National	15% reduction of greenhouse gas emissions	30% reduction of greenhouse gas emissions
Energy	Refurbishment, replacement and extension of conventional power generation capacities and fuel switch to natural gas	
	15%increase in the share of renewables in meeting the power and het demand 3% reduction in power demand through energy efficiency measures	20%increase in the share of renewables in meeting the power and het demand 10% reduction in power demand through energy efficiency measures
Transport	36% stabilization of the share of annual passengers-kilometres driven using public transport	48% stabilization of the share of annual passengers-kilometres driven using public transport 20% increase in the share of fuel efficient vehicles in the fleet by 2030
Waste	waste management through energy recovery, equivalent to avoiding emissions from landfilling of 1,000 tonnes solid waste per day	

	25% recycling rate 51% of municipal wastewater treatment	30% recycling rate 70%% of municipal wastewater treatment
Forestry	20 million trees planted	26 million trees planted

2 Population profile

Lebanon's population is estimated to be 6,131,254 in 2013, including foreign workers, Palestinian and Syrian displaced. Lebanon's population profile has changed drastically between 2012 and 2013 due to the increasing influx of Syrian displaced entering the country, dispersing themselves across more than 1,200 villages in Lebanon. In 2013, it is estimated that 858,641 displaced have settled in Lebanon, including Syrian nationals, Palestine Refugees from Syria and Lebanese returnees (UNHCR, 2013). Although most of the displaced Syrians are living in rented accommodations or hosted within Lebanese communities, 4,231 informal settlements have spread across the country, mainly in the Bekaa and the North Regions. The large influx of displaced has constituted a heavy burden on already fragile environmental resources and has directly impacted energy demand and consumption, solid waste and wastewater generation and management, air quality, food consumption and land use (MoE/EU/UNDP, 2014).

3 Geographic profile

Lebanon is located on the eastern basin of the Mediterranean Sea and is characterized by mostly mountainous areas constituted of the following parts:

- A narrow coastal plain composed of 2 plains, one in the north (Aakar) and one in the south (Tyre) and a succession of little narrow plains separated by rocky headlands in the center.
- The Mount Lebanon chain has an average elevation of about 2,200 m. Cut by deep canyons, and composed essentially of Jurassic thick carbonate sediments, the northern part of the chain is the higher region.
- The Anti Lebanon chain - subdivided into two massives: Talaat Moussa (2,629 m) in the north and Jabal el Sheikh or the Mount Hermon (2,814 m) in the south.
- The Bekaa valley - a flat basin with a length of about 120 km, located between the Mount Lebanon and the Anti Lebanon chains. Its elevation averages at 900 m, peaking at 1,000 m at its center.

Figure 1: Geographical location of Lebanon

4 Climate profile

Lebanon has a Mediterranean-type climate characterized by hot and dry summers (June to September) and cool and rainy winters (December to mid-March). Spring and autumn are warm and pleasant. The average annual temperature is 15˚C.

Along the coast, summers are hot and humid with temperatures crossing 35°C in August. But due to the moderating effect of the sea, the daily temperature range is narrower than it is inland. January is the coldest month, with temperatures around 5 to 10°C. The mean annual rainfall on the coast ranges between 700 and 1,000 mm (Asmar, 2011). About 70% of the average rainfall in the country falls between November and March and is concentrated during only a few days of the rainy season, falling in heavy cloudbursts or violent storms. Rainfall in inland Lebanon is higher with snow in the mountains (1,600 mm according to Asmar, 2011) than that along the coast.

5 Economic profile

Lebanon’s economy is relatively diversified, with four sectors – trade, manufacturing, construction and finance – representing around half of the economy, and a Gross Domestic Product (GDP) of USD 49.9 billion in 2014 and a GDP per capita of USD 18,052. Lebanon's growth track record is volatile. During the period 2006-2010, real GDP growth averaged 7.7% before falling to 1.9% in 2011-2015 as a result of geopolitical developments.

Lebanon’s economy suffers from a number of structural weaknesses, including weak basic infrastructure (e.g., roads, water, electricity and telecommunications). Conflicts over the years have damaged infrastructure, which suffers from underinvestment and inefficient management. Accounting for less than 2% of GDP, the government’s capital expenditure is very low because it is crowded out by large and rising debt-servicing and wage expenditures. The economy continues to face heavy shortages of electricity because of the lack of investment in new capacity and an inefficient energy subsidy system.

6 Energy

In Lebanon, electricity is generated from thermal and hydroelectric power plants, with a rate of 91% and 9% respectively in 2013 (MoEW, 2016a) (hydropower averaged at 6.54% from 2009 to 2015). Almost all of Lebanon’s primary energy requirements are imported, since the country does not have any indigenous energy sources. Out of the 7 thermal power plants in Lebanon, 3 operate on heavy fuel oil and 4 on gas diesel oil. Currently, there is no supply of natural gas to Lebanon although a gas pipeline has been connected and a natural gas station has been constructed at the Tripoli installations. Recent studies and surveys conducted in the deep offshore Exclusive Economic Zones have shown very promising seismic conditions for hydrocarbon deposits, mainly natural gas with some oil. As a result, Lebanon had already started the development phase for the exploration and production era which is expected to have a positive economic impact on the country.

Due to load shedding, technical losses and the aging of power plants, Lebanon’s electricity sector suffers from frequent shortages from the difference between supply and demand. In 2013, Electricité du Liban has supplied 11,728 GWh of electricity while the demand was estimated at 19,876 GWh, giving space to the proliferation of privately owned generators. While some of these generators are located in industrial facilities or in commercial institutions, most of them are spread within neighbourhoods, supplying electricity to residential buildings and small retailers at a monthly fixed subscription fee.

To overcome the problems faced by the energy sector, the Ministry of Energy and Water (MoEW) published the Energy Policy Paper in 2010, which proposed a series of actions related to generation, transmission, and distribution of electricity including the generation of 12% of renewable energy by 2020. The Policy Paper was followed by the 2 National Energy Efficiency Action Plans NEEAP (for

2011-2015 and 2016-2020) in addition to the National Renewable Energy Action Plan NREAP for 2016-2020 setting up a series of activities to implement the targets set by the Policy Paper (MoEW/LCEC, 2011; MoEW/LCEC, 2016a; MoEW/LCEC, 2016b).

In 2015, and as part of Lebanon's Nationally Determined Contribution (NDC), sectoral targets for 2020 were set for the energy sector: 15% renewable energy and 3% reduction in demand from energy efficiency as an unconditionally target and 20% renewable energy with 10% reduction in demand as a target conditional to technical, financial and capacity building support.

In terms of renewable energy in Lebanon, its share in energy production is slowly but steadily increasing. The main contributor to the renewable energy mix is hydropower, producing between 6% and 11% of the country's total energy production depending on the precipitation levels in each year. The potential for hydroelectric power in Lebanon is significant, conditional to the rehabilitation and upgrade of existing units, the installation of new hydro units on the main rivers and streams and the development of micro-hydro potential on small streams and non-river sources.

Lebanon has an abundant solar resource with high solar irradiance levels, providing a net feasible potential energy production of 6,780 GWh/year. Photovoltaic (PV) power systems are currently being used in Lebanon mostly at the micro level and for specific applications like street lighting, small decentralised residential installations and other municipal use. In 2013, a 1 MW grid connected PV farm has been installed over Beirut River as part of the MoEW/LCEC Beirut River Solar Snake project, generating up to 1,665 MWh/year as per the initial simulations. In addition, more than 700 small-scale PV projects and 8,000 public street lighting systems are installed in Lebanon by the government, local municipalities and internationally funded projects such as the Country Energy Efficiency and Renewable Energy Demonstration Project (CEDRO) and UNDP Small Decentralized Renewable Energy Power Generation Project (DREG) projects managed by the United Nations Development Programme (UNDP) (MoEW/LCEC; 2016b).

Solar water heating technology is already a mature technology in Lebanon and its market is witnessing a steady growth. In 2013 around 400,000 m^2 of solar water heaters were installed in the country, exceeding the 190,000 m^2 target set initially by the first NEEAP 2011-2015 (MoEW/LCEC; 2016b).

The country has a significant wind potential of 12,139 GWh/year, however no wind farm has been commissioned yet in Lebanon (MoEW/LCEC, 2016b). The licensing of 3 farms with a total capacity of ca. 200 MW has started in 2017, with energy production expected by 2020.

As an incentive for increasing the share of decentralized renewable energy, net metering was launched by the Electricité du Liban to boost the development of distributed renewable energy generation. A number of private consumers are benefiting from the net metering contract. In addition, a financing mechanism known as National Energy Efficiency and Renewable Energy Action (NEEREA) has been established by the Central Bank of Lebanon and the LCEC in 2012 in which subsidized loans are given to financing new and existing energy efficiency, renewable energy and green building projects to private sector entities. NEEREA has benefited from a USD 15 million grant from the European Union in its start-up phase of 2011-2014 and has helped to fund more than 225 projects with a total amount of loans of USD 240 Million by mid-2015 (MoEW/LCEC, 2016a).

7 Transport

Land transport in Lebanon consists mainly of road-motorized vehicles, since appropriate infrastructure for non-motorized vehicles does not exist (i.e. bicycle lanes, safe storage, and convenient and affordable bike rentals) and the entire rail network is currently derelict. Road-motorized vehicles rely mainly on personal-owned passenger cars. The 2013 vehicle fleet database shows a total of 1.64 million registered vehicles, mainly constituted of passenger cars.

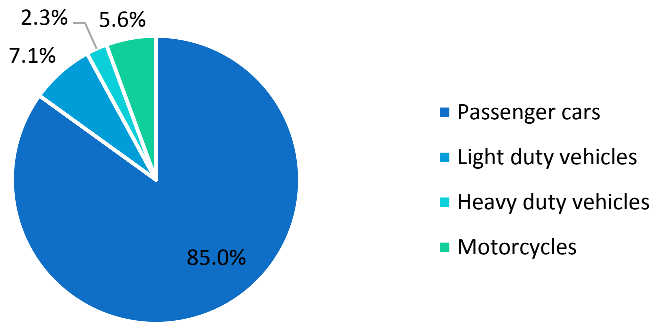

Figure 2: The 2013 vehicle fleet distribution

Mass transport consists of public and private buses, mini-vans as well as exclusive and shared-ride taxis, all operating on an ad-hoc basis without any coordination, resulting in very poor occupancy rates (MoE/URC/GEF, 2012). The mass transport market share in Lebanon is weak due to the impracticality, lack of safety and restricted reach of public transportation compared to the attractiveness of owning a private automobile, an alternative that is still promoted in Lebanon through bank loan facilities and affordable new and used car imports.

The driving patterns in Lebanon are characterized by a relatively low driving range with a high rate of congestion and frequent stops at short time intervals. It is estimated that 50% of trips have a distance lower than 5 km, 25% of stops are below 2 seconds and the total stop time per trip corresponds to more than 15% of travel time (Mansour, 2011). Moreover, observed results reflect the continuous stop-and-go driving patterns, therefore resulting in the inefficient operation of internal combustion engines, and a high rate of fuel consumption and pollutant emissions as a result.

The main road transport legislations are law 341 (6/08/2001) and decree no. 7858/2002, banning the use of private and public cars of diesel engines starting from 15/06/2002, and the use of public buses of 16 to 24 passengers of diesel engines starting from 31/10/2002. In 2014, the Ministry of Public Works and Transport (MoPWT) presented to the Council of Ministers the master plan to revitalize the land public transport for passengers. It encloses a set of actions to be implemented on the short and medium terms, shifting the passenger transport demand to mass transit systems.

In terms of aviation activities, Middle East Airlines is the national air carrier of Lebanon and Beirut International Airport is the only operational commercial airport in the country. Lebanon doesn't have any scheduled domestic flights due to the small surface area of the country.

As for maritime activities, Lebanon has five legal harbors: Beirut, Tripoli, Saida, Tyre and Jounieh. The port of Beirut hosts around 78% of the incoming ships to Lebanon and the port of Tripoli hosts around 16% (CAS, 2014). The number of yearly incoming ships and oil tankers to Beirut port ranges between 2,000 and 2,400 ships, with a total capacity around 700,000 containers Total Equivalent Unit per year (Beirut port statistics, 2014). As for Tripoli, its port hosts around 350 to 450 yearly incoming container and cargo ships, and 50 to 90 oil tankers (Tripoli port statistics, 2014).

The fisheries host a fleet of around 2,860 boats with a yearly catch of 9,000 tonnes. About 98% of the fleet is constituted of open woody boats with length less than 12 m (EastMed, 2012). The fleet is old (e.g. average age of 17 years at the port of Tyre) and spread over 44 local harbors, most of which requiring major infrastructure maintenance intervention.

8 Industry

The industrial sector in Lebanon remains an important pillar of the economy contributing to roughly 7.2% of the country's GDP in 2011 although this rate was much higher in the nineties (e.g., estimated at 12.5% in 1997). The Lebanese industrial establishments are considered as new industries, with 61.7% established between 1990 and 2007 (MoI/ALI/UNIDO, 2010).

According to the Ministry of Industry (MoI) latest census, conducted in 2007 and published in 2010, the total industrial output for 4,033 industrial establishments (establishments employing more than 5 workers) reached USD 6.8 billion. As such, the industrial sector productivity has significantly increased compared to 1998, whereby the industrial output was equivalent to USD 3.1 billion (for 5,082 industrial establishments employing more than 4 workers). This significant increase in productivity of the industrial sector is reflected by the fact that the average value of output per enterprise has increased to USD 1,686,162 in 2007 compared to USD 542,326 in 1998 (MoI/ALI/UNIDO, 2010). The industrial census has not been updated since 2007.

The key industrial sectors in Lebanon are food products and beverages, fabricated metal products and other non-metallic mineral products. These constitute 50% of the economic activity of the industries in the country. Other sectors include the chemical sector, furniture manufacturing and electrical machinery manufacturing (Figure 3) (MoI/ALI/UNIDO, 2010).

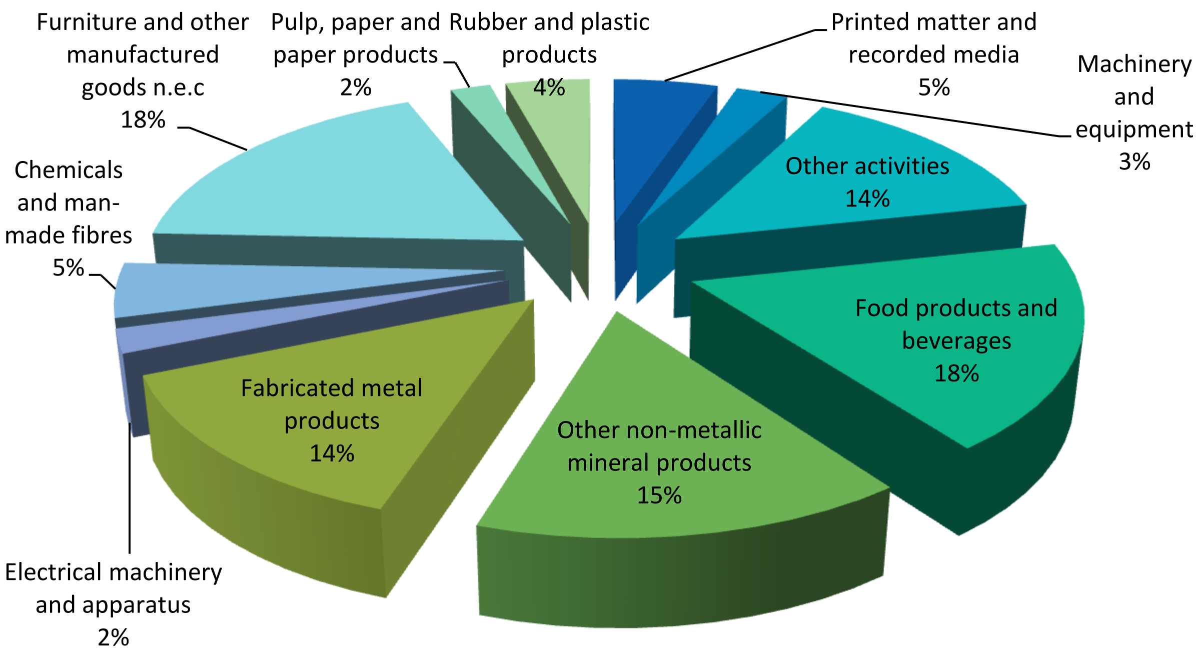

Figure 3: Distribution of industrial establishments by economic activity in 2007 in Lebanon

The industrial sector hosts large units in rural and remote areas, mainly manufacturing activities using large surface areas for their operations. The largest industrial establishments are located out of the Governorate of Beirut and Mount Lebanon, especially in North Lebanon and Bekaa.

According to the MoI, around 75% of the industries were mostly established prior to the enactment of the decree 8018/2002 "Permitting of Establishments". This issue has major consequences on the alignment of industrial enterprises with recent permitting systems, including the environmental management requirements (EFL, 2013). The MoE is responsible for the environmental compliance of industrial establishments through the implementation of the Environmental Compliance Decree 8471/2012 and its related decisions (202/1, 203/1 & 271/1 - 2013). Depending on the size and type of each industrial establishment, water and air pollution abatement measures have to be undertaken to comply with the decree.

9 Waste and wastewater

Solid waste management

Throughout the last 20 years, solid waste management in Lebanon has witnessed significant technical, legal and institutional changes, in an attempt to organize the sector. However, to date, no clear well-defined strategy has been agreed in the country. National consensus has not been reached yet on a specific solid waste management strategy despite the various attempts and efforts put in place throughout the years, especially after the waste crisis the country is witnessing since July 2015, after the closure of the main landfill of the country.

Municipal Solid Waste (MSW) generated in Lebanon is either disposed of in managed landfills (mainly in urban agglomerations) or disposed of in open dumpsites (mainly in rural areas) where open burning occurs. Hazardous waste, that are mainly produced from industrial activities is disposed of with MSW in landfills and open dumps or stored on location. In rare cases, it is exported to be treated abroad according to the Basel Convention.

It is estimated that around 17% of the waste generated is recycled or composted. Estimates for the amount recycled may understate the actual importance of recycling since this activity is conducted in part by the «informal» sector whose activities are, by definition, difficult to quantify. Informal and semi-formal private sector entities, which collect recyclable materials from municipalities, treatment facilities or directly from consumers, have created a market for recycling, providing livelihood for thousands of people. Although, the extent of this recycling activity varies according to market conditions, the draft Law on integrated solid waste management clearly aims at reducing the quantity of wastes to be disposed by promoting waste minimization, source separation, recycling and energy recovery (Sweepnet, 2014).

There are 4 main landfills in Lebanon that have been receiving since 1998 around 55% of the total generated solid waste in Lebanon. Waste sorting in dedicated facilities precede most of the landfilling activities.

The Naameh Landfill was established in 1997 as part of the emergency plan for solid waste management for the GBA and receives the majority of the waste generated in Lebanon. The Landfill received around 2,500 tonnes per day and is complemented by 2 sorting facilities and a composting facility. The landfill is equipped with a 7MW power plant with 7 containerized generating sets and is designed to generate energy for own use at the facility. After 18 years of operation and 12 million tons of waste, the site was closed on 17 July 2015, leading to a major waste crisis in the country.

The Zahle landfill was opened in 2002 in the Bekaa valley and was designed and built to receive 150 tonnes per day, serving 18 out of 33 municipalities in the Caza of Zahle. The landfill is complemented by a sorting facility since 2008 but no composting activities are taking place. Around 160 tonnes of MSW are landfilled per day. Methane generation is insignificant and is flared.

The Tripoli controlled dumpsite is located on the Tripoli seafront and serves the city of Tripoli as well as the neighboring towns with an estimated population of 400,000 inhabitants. The managed dumpsite, which receives around 380 tonnes of waste, is annexed by a sorting facility however not operational yet.

The Saida waste facility and landfill has been operational since 2013 to treat the MSW generated by the city of Saida and its surrounding areas. The facility includes a sorting facility and anaerobic digestion plant with a treatment capacity of 300 tons/day. Currently around 200 tonnes are landfilled per day and 1.6 megawatts are being produced for internal use.

A number of small and medium sized sorting and composting facilities have also been implemented at a municipal level with treatment capacity ranging from 5 to 250 tonnes/day. Funding has been secured through European Commission grants, United States Agency for International Development (USAID), as well as some Non-Governmental Organizations (NGOs) like the Young Men's Christian Association, Pontifical Mission, and Creative Associates International Inc. The execution of the facilities has been undertaken by the private sector, contracted through the concerned municipalities while the operation of these facilities is carried out by the municipalities themselves. However, the projects have known limited success due to lack of financing of the operation and maintenance services and lack of technical capabilities of the municipalities to ensure efficient solid waste management.

Table 2: OMSAR-implemented MSW Treatment Facilities (outside GBA and Mount Lebanon)

MSW treatment and disposal facility[1]	**Treatment / design capacity (t/d)**[2]	**Status**
Hbaline (Jbeil) Sorting and Composting Facility	100	Operational (based on management contract)
Khiam (South Leb.) Sorting and Composting Facility	25	
Qabrikha (South Leb.) Sorting and Composting Facility	25	
KherbitSilm (South Leb.) Sorting and Composting Facility	10	
Union of Municipalities of Tyre / Ain Baal (South Leb.) Sorting and Composting Facility	150	
Ansar / Nabatieh (South Leb.) Sorting and Composting Facility	10	
Union of Municipalities of Minieh (Akkar) Sorting and Composting Facility	70	
Michmich (Akkar) Sorting and Composting Facility	10	
Union of Municipalities of Baalbeck-Hermel Sorting and Composting Facility	200	
Tripoli (Union of Municipalities of Al Fayhaa) Sorting Facility	420	Constructed and non-operational (awaiting management contract)
ChoufSwaijani – Kahlouneyye (Chouf) Sorting and Composting Facility	30	
Union of Municipalities of Nabatieh – Chquif (Kfour) Sorting and Composting Facility	250	
Taibeh (Nabatieh) – Sorting and Composting	10	Operational
Qlaiaa (Nabatieh) – Sorting and Composting	5.0	
Kfarsir (Nabatieh) – Sorting	7.5	
Aitaroun (Bent Jbeil) – Sorting and Composting	15.0	
Chaqra (Bent Jbeil) – Sorting and Composting	5.0	
Bent Jbeil (Bent Jbeil) – Sorting and Composting	20.0	

1 Composting capacities of the facilities are estimated to be approximately 50% of their respective sorting capacities

2 Capacities for operational facilities indicate the treatment capacities. Capacities for under-construction and constructed – non-operational facilities indicate the initial design capacity.

Source| Sweepnet, 2014; MoE/UNDP/ECODIT, 2011

Open dumping and open burning of MSW are still practiced in Lebanon. Around 670 dumpsites have been reported in 2010 (MoE/UNDP/ELARD, 2011), out of which 504 are MSW dumpsites and the rest is construction and demolition dumpsites. Industrial solid waste is still dumped with MSW since no industrial waste treatment facilities exist in the country.

Incineration of MSW is not practiced in Lebanon. Only a small quantity of health care waste is being incinerated by hospitals. Currently, and after the enactment of decree 8006 in 2002 on the proper management of the health care waste in Lebanon, several hospitals started managing their waste mainly through autoclaving. However, although no license for medical waste incinerators has been issued after 2004, some hospitals are still using this practice. It is estimated that in 2013, 57 tonnes of health care waste have been incinerated. In addition, an incinerator at a university animal care facility has been incinerating an estimated 37 tonnes/year of animal carcasses since 2004 (MoE/UNEP/GEF, 2017).

Wastewater generation and management

Lebanon generates around 248 million m^3 of wastewater per year, most of which is discharged without prior treatment. Although 66% of households are estimated to be connected to a wastewater network, only 8% of wastewater is being currently treated in small scale rural waste water treatment plants (MoEW, 2010a; World Bank, 2011).

Wastewater is discharged directly in the sea and surface water bodies, in open sewers or in septic tanks that are still widely adopted in rural areas. Coastal waters receive more than 60% of the total sewage load of Lebanon, from at least 53 sewage outfalls, 16 of which lie in the Beirut area (MoE/UNDP/Ecodit,2011). Industrial wastewater is rarely treated at the industry level prior to its discharge in the environment or in the public sewer network.

The government of Lebanon, through the Ministry of Energy and Water (MoEW) developed the National Water Sector Strategy in 2012, which aims at increasing the wastewater collection, treatment and reuse rates by 2020. Due to the regulatory, institutional and financial barriers, the implementation of the plan is being delayed.

Some wastewater treatment plants were built in recent years through grants and/or loans, however only few of them are efficiently operating due to lack of financing of operation and maintenance services and lack of technical capabilities of the municipalities or water establishments to ensure proper wastewater treatment.

The heavy-flow influx of Syrian displaced to the Lebanese territories since the Syrian conflict has also had its implications on solid waste and wastewater generation and management. It has been estimated that the incremental annual waste generated by displaced is equivalent to 15.7% of the solid waste generated by Lebanese citizens prior to the crisis. In addition, national wastewater generation rates have increased between 8 and 14% with the Bekaa having the highest share of displaced population. Most of this incremental wastewater is being discharged of without treatment in the Litani River and 10% into open lands (MoE/EU/UNDP, 2014).

10 Agriculture

Agriculture is a vital part of the Lebanese economy and its social and cultural heritage. Even though the sector's share of the GDP, is relatively low (4% in 2011), agriculture employs 20-30% of the active work force and constitutes 17% of the total exports (MoA, 2010a). In rural areas, however, agriculture is reported to contribute up to 80% of the local GDP and represents the major income-earning and employment opportunity (Verner et al.; 2013). In comparison with Lebanon's neighbors, agriculture production in the country is characterized by a higher value added per square kilometer, reflecting a higher intensity of production and greater focus on higher value fruits and vegetables (FAO, 2011a). Compared to 1970 when agriculture's share of the GDP reached 9% agricultural contribution to the GDP has been steadily decreasing. There are many reasons for this decline including the post-war economic crisis, urban encroachment that changed the rural landscape of the country, government economic policies favoring other sectors, emigration of young generation of farmers and the switch from farming to higher-paid jobs, and climate change with its concomitant effect on crops, pastures, and water resources.

According to FAOSTAT (FAO, 2011a) the total agricultural area is estimated at 638,000 ha (62% of total surface area). As indicated in Figure 4, pastures and meadows constitute approximately 39% of the total area, permanent crops 12%, arable land 11%, and forests 13% of the total surface area of Lebanon.

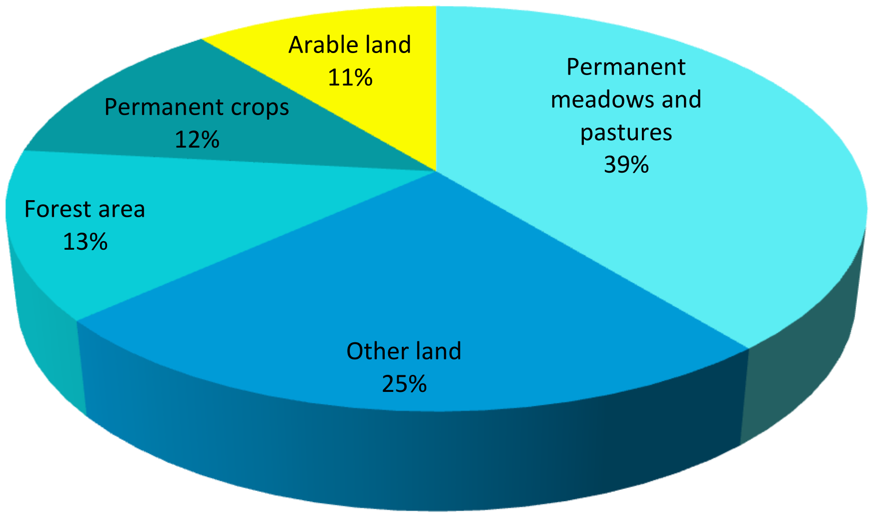

Figure 4: Agricultural land use in Lebanon (% of total agriculture area)

Source| Adapted from FAOSTAT, 2011a

According to the Ministry of Agriculture (MoA) 2010 census, the utilized agricultural area was approximately 231,000 ha, which is lower by 6% in comparison with the value from previous census in 1998. Of these, 106,272 ha were dedicated for seasonal crops (grains, vegetables, legumes, root crops, industrial crops, and forages) including 3,800 ha of greenhouse crops and 125,928 ha for permanent crops (olives, fruit trees, citrus, and grapes).

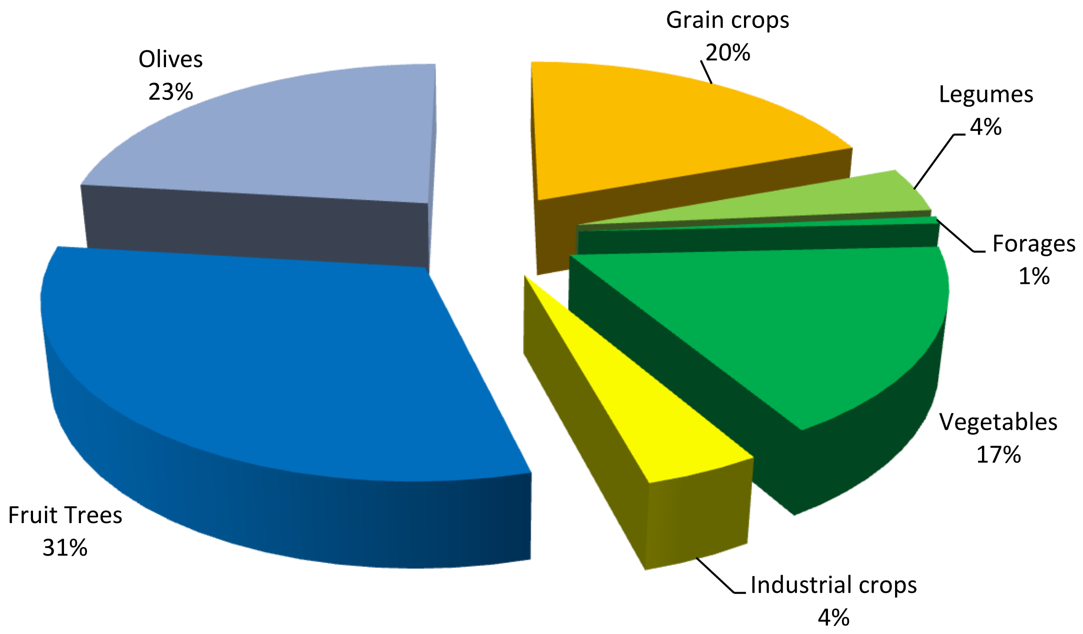

Figure 5: Agricultural production in Lebanon

Source| MoA, 2010b

Of the total utilized agricultural land, approximately half is irrigated, and increased by 8% compared to irrigated areas in 1998. Flood and furrow irrigation comprise 50% of irrigated land, while approximately 30% is through drip and 20% through sprinkler irrigation.

Agricultural production in Lebanon is diverse reflecting a Mediterranean climate with variable temperature and precipitation regimes, and distributed in the following regions of the country:

1. The Bekaa: Once regarded as the 'bread basket of the Roman Empire", the Bekaa valley is the most important production area and accounts for the highest percentage of seasonal crops (60%) as in cereals, potatoes, and vegetables, and in stone fruits, and grapevine. It also contains the highest percentage of cattle population (43%), sheep (72%), goats (51%) and poultry layers (60%).
2. The north and Akkar Plain: Olives, cereals, potatoes, vegetables, cattle and poultry broilers production.
3. South and Nabatieh: Olives, cereals, vegetables, and tobacco production.
4. Mount Lebanon: Fruits, vegetables, poultry broilers, and swine production.

In addition, the geographical coastal strip along the Mediterranean coast from the North of the country to the South is home for intensive vegetable greenhouse production, citrus fruits, and bananas.

Crop production

Lebanon's main agricultural crops are fruits, vegetables, olives, cereals, tubers, and legume crops. Pressure on the land base has led to a decline in cereal production in favor of high-value crops such as vegetables. Lebanon is self-sufficient in fruits and vegetables, although competition from open markets is leading to import of these commodities as well.

The most important cereals cultivated are wheat and barley, with some production of forage crops such as alfalfa, vetch, corn, oats, and sorghum. Most of the barley grown in the arid parts of Bekaa

(Hermel and El Qaa) is left as pasture for grazing animals. It is anticipated that forage crop production would increase after recent incentives introduced by the MoA to encourage milk and forage production by farmers with small animal holdings.

In 2010, wheat, barley, and potato production decreased due to a combination of drought and reduction in the areas planted. Although wheat and barley production recovered in 2011 and 2012, potato crop production remained at least 80% less compared with 2005, mainly due to the shrinkage in hectares planted (20,000 ha in 2005 vs. 12,000 ha in 2012). Also, imports from Saudi Arabia and Egypt rendered potato farming, once a profitable and prominent enterprise, vulnerable to open markets.

Fertilizer use

Statistics on fertilizer consumption in Lebanon are sporadic and contradictory. The Lebanese customs provide extensive data about imports but these could not be corroborated from the major agricultural importing companies. The amount of fertilizers used in Lebanon has been decreasing since 1994: approximately 122,000 tonnes of total nitrogenous fertilizers were used in 1994 (average of 31,000 tonnes of Nitrogen (N)), while in 2006 total nitrogenous fertilizers used were approximately 50,000 tonnes (average of 9,500 tonnes N). However, fertilizer consumption increased in recent years to reach 85,000 tonnes (19,000 tonnes of N) in 2013. Most of the nitrogenous fertilizers used were Nitrogen-Phosphorus-Potassium (NPK) fertilizer, (17-17-17; and 15-15-15, and other combinations), Ammonium Sulphate, Ammonium Nitrate and Urea. Application rates of nitrogen fertilizers far exceed the recommended agronomic rates (Al-Hassan, 2011). For example, potato growers apply on average 590 kg N/ha while the suggested agronomic rate is 220 kg N/ha. For vegetables, growers apply the average of 900 kg N/ha while the agronomic rate is 500 kg N/ha. Unfortunately, soil testing for soil nutrient content is not widely practiced and growers apply nitrogen rates based on experience or on the recommendation of agents from fertilizer distributors.

Animal production

The livestock sector contributes to around 30% of the total value of production (FAO, 2011a). Although animal production is considered secondary with respect to crop production, Lebanon’s poultry and dairy sectors both hold importance in terms of production and quality. The poultry sector is the only agriculture sector that satisfies domestic demand and is dominated by few companies utilizing closed systems producing quality broilers and egg products. Cattle are mainly raised for milk production with the majority of stocks raised in large farms as well as small-sized holdings (FAO, 2011b). Beef production is limited and imported live animals (in addition to imported chilled and frozen cuts) provide a major source for local consumption. The size of sheep and goat herds has fluctuated since 1994 but decreased in recent years mainly due to decrease in the number of shepherds and due to competition from imported meat from Australia, Turkey and Syria. In addition, the crisis in Syria has caused the influx of goat and sheep herders to Lebanese rangelands with their flocks but this is hard to quantify. Swine production has decreased steadily since 1994 due to a shift in consumer preferences towards poultry, mutton and beef, and due to fear from the swine flu.

11 Land use, land use change and forestry

In Lebanon, the lack of land management plans and/or inadequate urban regulations has strongly affected the natural and built environment. This has facilitated unplanned urban sprawl at the expense of natural landscapes). The construction of new roads and highways in mountain areas has also affected landforms, vegetation cover, and ecosystems.

Several initiatives have been conducted to document and map land cover attributes in Lebanon. Accordingly, the first land cover map was produced in 1961 by the Lebanese army in partnership with the French “Institut Géographique National”. Later in 2002, a land use/ land cover map of Lebanon was produced by the Ministry of Environment in cooperation with the National Center for Remote Sensing of the National Council for Scientific Research (NCSR) which involved the use of satellite remote sensing data acquired in 1998. The final map disaggregated land use and land cover into seven main categories and 23 subcategories. The NCSR is currently aiming at completing the Land Cover / Land Use map using remote sensing data acquired in 2013.

National forest resources assessments for Lebanon were conducted in 2005, 2010 and 2015 by the Ministry of Agriculture with the assistance of the Food and Agriculture Organization. The latest results showed that forests cover 13.2% of the total area of the country. In addition, 10.2% of the Lebanese territory is covered by other wooded land (MoA/FAO, 2015).

Increasingly, Lebanon's forests, which include valuable broad-leaved trees, conifer forests and evergreen trees that cover the mountains in patches, are exposed to degradation due to quarries, urbanization, pests and diseases, fires, wars, human neglect, improper management, outdated laws, and poor law enforcement. Like other Euro-Mediterranean countries, fires have been especially damaging Lebanon's forests in recent years, representing one of the most important elements that destroy Lebanon's natural resources. Moreover, the absence of a national forest management strategy and the lack of human and technical resources contribute to the degradation of Lebanon's forests.

Overall, the lack of land management in Lebanon is the cause for the over-exploitation and degradation of lands in many areas. It is estimated that 84% of the Lebanese territory still does not have adequate master plans, which has allowed for a lot of chaos when it comes to construction or any activities that change land cover and land use. It is estimated that there are about 1,278 quarries in Lebanon covering an area of 5,267 ha (MoE, 2012). Most recently, an indicative research study conducted showed that the largest area of artificialization on the coastal zone of Lebanon between 1998 and 2010 affected grasslands followed by forests and agricultural lands, consecutively (MoE/UNEP, 2013). Furthermore, it was found that wetlands decreased by 47%, grassland by 27%, and forests by 9%. Further investigation showed that most of artificialization in grassland affected moderately to highly dense vegetation, while most of the artificialization in forested lands affected shrublands.

In an attempt to tackle deforestation and to preserve what is left of natural areas, Lebanon has created until the year 2015, a total of 15 nature reserves, 3 biosphere reserves, 16 protected forests, 18 protected natural sites/landscapes, 4 Ramsar sites, 5 world heritage sites, and 15 important bird areas (MoE/UNDP/ECODIT, 2011). The MoA developed a National Forest Plan (NFP) and pursue efforts to update Lebanon's forest law to protect better the remaining forest cover and promote the increase in forest cover by 40 million trees by 2020. MoE has been involved in developing a forest fire law complementing Lebanon's National strategy for forest fire management.

In addition, a number of projects such as the GEF funded "Smart Adaptation of Forest Landscapes in Mountain Areas" project and the adaptation fund "Climate Smart Agriculture: Enhancing Adaptive Capacity of the Rural Communities in Lebanon" project are aiming at increasing forest areas in Lebanon and limit degradation losses. Also, Lebanon has set a target towards land neutrality by 2030 under the United Nations Convention to Combat Desertification.

The influx of Syrian displaced has also had impacts on land resources through the expansion of Informal Tented Settlement (ITS) and their distribution in relation to agricultural areas, environmentally sensitive areas and vulnerable towns.

II. The national GHG inventory in 2013

The inventory of greenhouse gas emissions in this report covers the year 2013, with a recalculated time series for 1994-2013. The inventory was prepared based on IPCC Guidelines and Guidance used for the Inventory preparation, the 1996 IPCC Revised Guidelines and elements from the IPCC Good Practice Guidances 2000 and 2003 (IPCC GPG 2000 and IPCC GPG-LULUCF 2003) in line with Decisions 17/CP.8 and 2/CP.17. Emissions of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) were estimated. The UNFCCC Non-Annex I greenhouse gas inventory system, version 1.3.2. was used for the computation exercise.

In 2013, Lebanon emitted 26,285 Gg CO_2eq. with the most significant greenhouse gas being carbon dioxide, primarily produced from the burning of fossil fuels. The main contributor to greenhouse gas emissions is the energy sector (including transport) with 79% of GHG emissions, followed by industrial processes (10%) and waste sector (7%). CO_2 removals from the land use, land use change and forestry category amounted to 3,518.80 Gg CO_2, bringing Lebanon's net emissions down to 22,766 Gg CO_2eq.

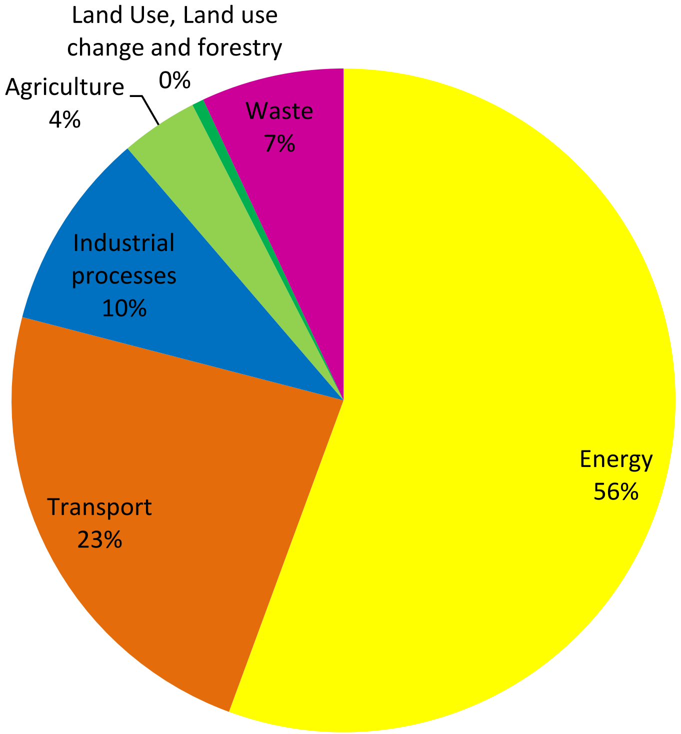

Figure 6: Lebanon's national greenhouse gas inventory by category in 2013

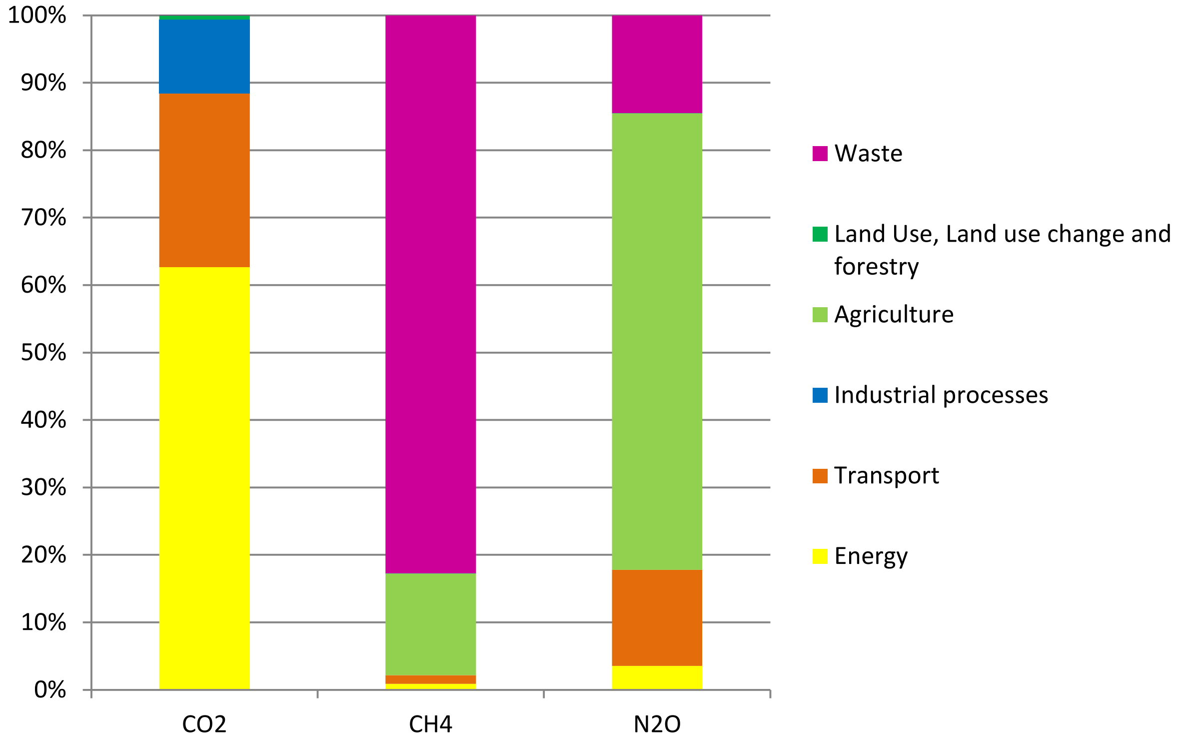

Figure 7: Lebanon's national greenhouse gas inventory by gas in 2013

Table 3: Lebanon's GHG emissions and removals for 2013 per gas and category

Greenhouse gas source and sink categories	CO_2 emissions	CO_2 removals	CH_4	CH_4	N_2O	N_2O	Total
	Gg	Gg	Gg	Gg CO_2eq.	Gg	Gg CO_2eq.	Gg CO_2eq.
Total national emissions and removals	23,246.21	-3,518.80	96.68	2,030.36	3.25	1,008.53	26,284.69
1 Energy	**20,551.07**		2.12	44.47	0.58	179.56	20,775.10
Energy industries	7,367.39		0.297	6.25	0.06	18.44	7,392.08
Manufacturing industries and construction	4,403.84		0.106	2.23	0.03	9.89	4,415.96
Transport	5,987.93		1.273	26.74	0.46	143.69	6,158.35
Other sectors	2,791.91		0.441	9.26	0.02	7.55	2,808.72
Fugitive emissions from fuels	NO		NO	NO			NO
2 Industrial processes	**2,545.42**						2,545.42
Mineral products	2,545.42						2,545.42
Chemical industry	NE		NE		NE		NE
Metal production	NO		NO		NO		NO
Other production	NA		NA		NA		NA
Production of halocarbons and sulphur							NO
Consumption of halocarbons and sulphur							NE
Other	NO		NO		NO		NO
3 Solvent and other product use	**NE**				**NE**		**NE**
4 Agriculture			14.55	305.55	2.20	682.00	987.55
Enteric fermentation			12.64	265.44			265.44
Manure management			1.91	40.11	0.55	170.50	210.61
Rice cultivation			NO	NO			
Agricultural soils					1.65	511.50	511.50
Prescribed burning of savannas			NO	NO	NO	NO	NO
Field burning of agricultural residues			NO	NO	NO	NO	NO
Other			NO	NO	NO	NO	NO
5 Land use, land use change and forestry	149.67	-3,518.80	0.01	0.23	0.0001	0.04	149.95
Changes in forest and other woody biomass stocks							
Forest and grassland conversion							
Abandonment of managed lands							
CO_2 emissions and removals from soil							
6 Waste	**0.05**		80.00	1,680.11	0.47	146.51	1,826.67
Solid waste disposal on land			60.91	1,279.14		0.00	1,279.14
Wastewater handling			19.09	400.97	0.47	146.51	547.48
Waste incineration	0.05						0.05

NA: not applicable – NE: not estimated – NO: not occurring
Numbers may reflect rounding.

To estimate the GHG emissions, tier 1 methods from the IPCC guidelines were mostly applied with default emission parameters, with activity data being derived from national sources, international organizations and other literature as identified in each sector (Table 4). Proxy data, interpolations, extrapolations and estimations based on expert judgments were used in the cases where data was unavailable.

Tier 2 methods were used to estimate emissions from cement manufacturing, road transport while approach 3 was adopted for the representation of land use areas in some subcategories of Land Use, Land Use Change and Forestry (LULUCF).

In order to allow the aggregation and total overview of national emissions, emission of CH_4 and N_2O were converted to CO_2 equivalent using the IPCC second assessment report's Global Warming Potential (GWP) values based on the effects of greenhouse gases over a 100-year time horizon (N_2O = 310, CH_4 = 21).

Table 4: Sources of activity data

Activity data	Main sources of data
Energy (including transport)	Ministry of Energy and Water Ministry of Public Works and Transport International Energy Agency Directorate General of Civil Aviation Ministry of Interior and Municipalities/Traffic, Truck and Vehicle Management Authority Fuel importers
Industrial processes	Industrial establishments Ministry of Economy and Trade Ministry of Agriculture Ministry of Energy and Water Industries' syndicates
Agriculture	Ministry of Agriculture Directorate General of Customs Food and Agriculture Organization Lebanese syndicate of cattle importers Surveys and personal communications
Land use, land use change and forestry	Ministry of Agriculture Food and Agriculture Organization Satellite imageries Scientific publications Surveys and personal communications
Waste	Ministry of Environment Central Administration of Statistics Council for Development and Reconstruction Waste contractors Scientific publications Local NGOs

1 The GHG inventory preparation process

The Ministry of Environment is the institution responsible for the preparation of the GHG inventories, as part of the BURs and National Communications. The preparation of the GHG inventory is an integral part of the BURII project, which is funded through the Global Environment Facility's (GEF) enabling activity (USD 352,000) and managed by the UNDP in Lebanon. The GoL through the MoE provides in kind support for the project (USD

50,000). The overall coordination of the project was handled by the climate change office at the MoE, which works under the Service of Environmental Technology.

The GHG inventory and report were compiled and drafted by the climate change office at the Ministry of Environment. The recruitment of local consultants was undertaken for the preparation of LULUCF and transport GHG inventories. Intensive stakeholders and key data holders consultations are conducted during the process, building on existing institutional arrangements.

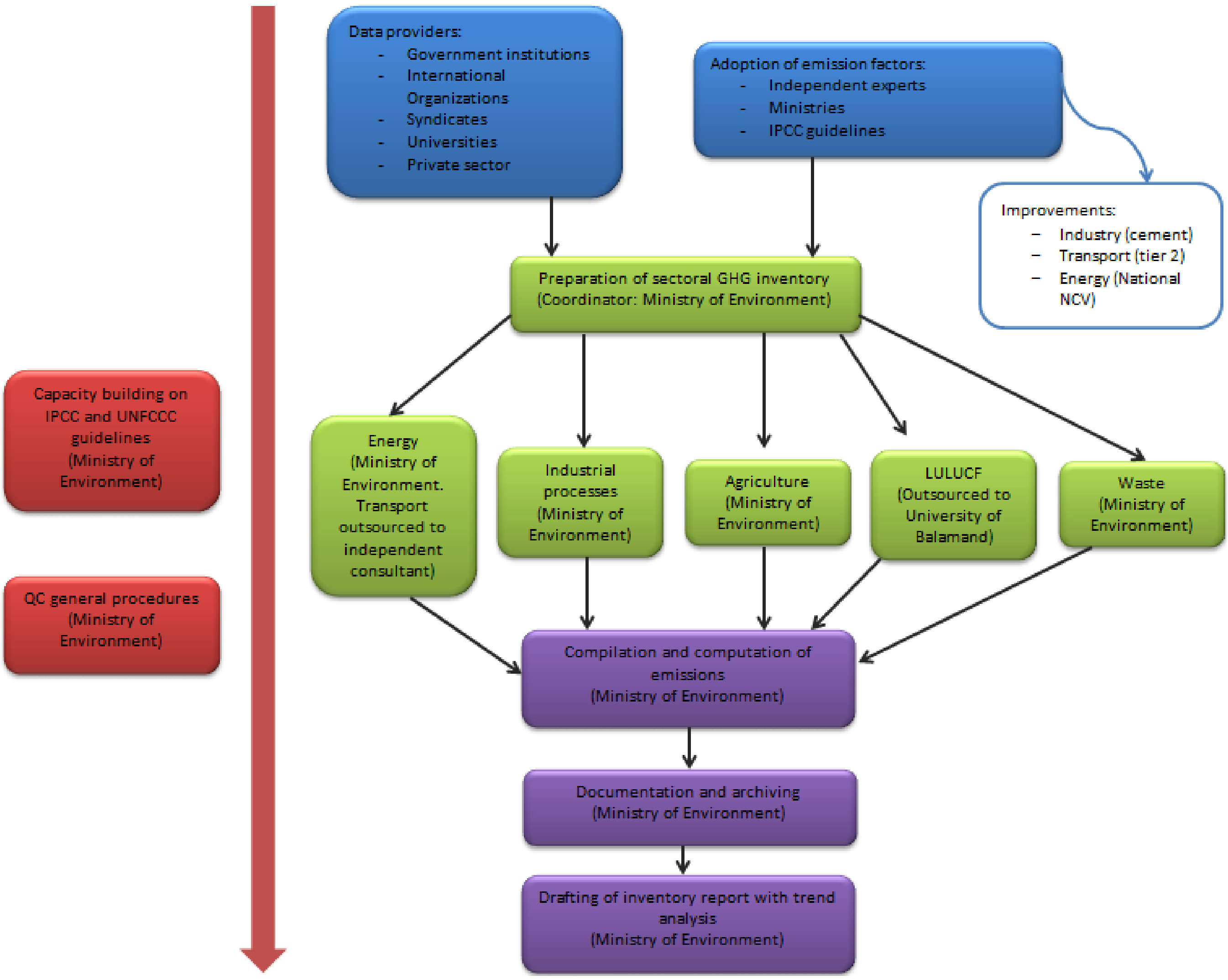

Figure 8: GHG Inventory preparation process

2 Breakdown of emissions by IPCC sector

2.1 Energy

Methodology

According to the IPCC guidelines, the source category "Energy" covers all combustion sources of CO_2, CH_4 and N_2O emissions (1A) and fugitive emissions associated with the production, transport and distribution of fossil fuels (1B). Since no oil production activities occur in the country, therefore they are reported as not occurring (NO) in the inventory reporting tables.

Fuel combustion activities (1A) are divided in two main categories, on the basis of the characteristics of the methodology applied for the calculation of emissions:

- Stationary combustion, including energy industries, manufacturing industries and construction and other sectors (agriculture, residential and commercial / institutional sectors and agriculture/forestry/fisheries) (Table 5)
- Transport, including domestic civil aviation, road transport, and domestic navigation (Table 6)

Table 5: Reporting categories under stationary combustion

Reporting categories	Description	Remarks	Methodology
Energy industries	Emissions from combustion of gas/diesel oil, heavy fuel oil and lubricants for electricity generation from the 7 power plants.	Lubricants store 50% of their carbon content and only emit the remaining 50%.	Emissions are calculated based on the tier 1 methodology and disaggregated by power plant.
Manufacturing industries and construction	Emissions from combustion of gas/diesel oil, heavy fuel oil, petroleum coke and LPG for electricity or heat generation for own use in industries.	Gas/diesel oil is considered to be used mainly for electricity production within the industrial facilities (generators). Fuel consumed by neighborhood generators is considered under this category. Petroleum coke is only used by cement industries.	Emissions are calculated based on the tier 1 methodology.
Commercial and institutional sector	Emissions from combustion of gas/diesel oil for electricity generation and space heating and LPG for cooking activities in commercial and institutional buildings.	Gas/diesel oil is considered to be used for electricity production from generators.	Emissions are calculated based on the tier 1 methodology.
Residential sector	Emissions from combustion of gas/diesel oil, LPG, and biomass fuel for space heating and cooking activities.		Emissions are calculated based on the tier 1 methodology.
Agriculture, forestry and fisheries	Emissions from combustion of diesel oil for stationary and mobile activities related to in agriculture, forestry and fishing.		Emissions are calculated based on the tier 1 methodology.

Table 6: Reporting categories under mobile combustion

Reporting categories	Description	Remarks	Methodology
Aviation	Military helicopters; civil, commercial aircrafts; and private jet- and propeller-type aircrafts.	Emissions from military aircrafts are not calculated due to the confidentiality of activity data for military case.	Civil, private and commercial aircrafts emissions are calculated based on the tier 1 methodology.
Maritime transport	Domestic navigation between local ports, and international navigation.	Emissions from military navigation are not calculated due to the unavailability of activity data for military case. Emissions from fishing are not reported under transport, but rather under the agriculture/forestry/fisheries category of the energy sector.	Emissions from international navigation are calculated based on the tier 1 methodology.
Road transport vehicles	On-road vehicle technologies rely on gasoline and gas/diesel internal combustion engines. The fleet encompasses motorcycles, passenger cars, vans, buses and trucks.	Road transport is the only mobility mean considered under land transport as the entire rail network is derelict.	Emissions are estimated using the tier 2 methodology based on the number of vehicles per category and their activity in terms of distance and/or fuel consumption.

Activity data

The country’s primary energy imports include jet kerosene, gasoline, gas/diesel oil, heavy fuel oil (also known as residual fuel oil), petroleum coke, Liquefied Petroleum Gas (LPG), Petroleum coke, bitumen, and lubricants. Biomass or logged wood is still used in fireplaces or stoves mainly for heating purposes in rural houses.

No national system has been established yet for the collection of data for the GHG inventory, particularly for the consumption of fuel by end use. Therefore, for the reference approach, the main source of data is the list of aggregated amounts of fuel imports provided by the Ministry of Energy and Water (MoEW, 2016a). For the sectoral approach, activity data has been estimated based on a survey that has been undertaken by the IPT Energy Center (IPTEC) for the Ministry of Environment on the sales of fuel from IPT stations to end users. The survey was conducted for the year 2013.

Table 7: Activity data for the energy sector

Subcategory	Data Source	Assumptions
Energy industries	Ministry of Energy and Water for fuel imports (MoEW, 2016a)	All quantities of fuel reported to be delivered to EDL are consumed within one reported calendar year.
Manufacturing industries and construction	Ministry of Energy and Water for fuel imports (MoEW, 2016a) Ministry of Environment for petroleum coke use (MoE, 2017a) IPT Energy Center (IPT, 2014)	13% of imported LPG is used in industries. 49% of the gas diesel oil consumed for private generation is used by industries and neighborhood generators (1 liter of diesel oil generates 3.65 kWh). All imported quantities of petroleum coke are consumed within one reported calendar year.
Transport	Ministry of Energy and Water (MoEW, 2016a) International Energy Agency (IEA, 2017) Ministry of Interior and Municipalities, Traffic, Trucks and Vehicles Management Authority for vehicle fleet characteristics (MoIM, 2017). Scientific publications (Waked and Afif, 2012) for number of vehicles equipped with a catalyst for emission control	Gas diesel oil is only used for Heavy Duty Vehicles (HDV), with an estimated consumption of 7.06 mpg (33.3 l of diesel/100km). Passenger cars annual mileage is 12,000 km/year. Light Duty Vehicles annual mileage is 27,250 km/year HDV annual mileage is 50,000 km/year. Motorcycles annual mileage is 5,000 km/year.
Commercial and institutional sector	IPT Energy Center (IPT, 2014)	15% of imported LPG is used in the commercial and institutional sector. 51% of the gas diesel oil consumed for private generation is used commercial institutions (1 liter of diesel oil generates 3.65 kWh).
Residential sector	Ministry of Energy and Water for fuel imports (MoEW, 2016a) Biomass from FAOSTAT (FAO, 2017) IPT Energy Center (IPT, 2014)	73% of imported LPG is used in residential sector. 52% of remaining gas diesel oil in the market is used in the residential sector.
Agriculture, forestry and fisheries	Ministry of Energy and Water for fuel imports (MoEW, 2016a) IPT Energy Center (IPT, 2014)	48% of remaining gas diesel oil in the market is used in the agriculture, forestry and fisheries.

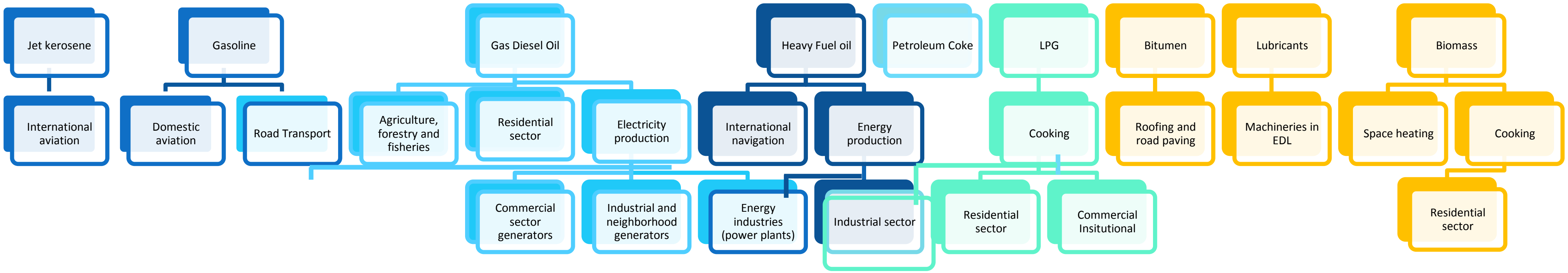

Figure 9: Distribution of fuel used in Lebanon

Table 8: Quantities of fuel imported for the period 1994-2013 (for selected years)

Fuel type (1,000 tonnes)	1994	2000	2006	2011	2013
Gasoline	1243.18	1263.757	1,224.61	1,598.42	1,596.340
Jet kerosene	145.91	124.511	103.36	223.88	258.891
Gas diesel oil	818.123	1315.64	1,596.28	2,448.07	3,075.57
Heavy fuel oil	1411.01	1507.9	1,039.72	1,347.36	1332.03
LPG	146	165.12	161.12	196.67	250.976
Bitumen	66	91.72	43.86	59.19	57.102
Lubricants	0.29	37.7	29.86	35.24	40.61
Petroleum coke	180	157.01	477.86	335.60	542.342
Biomass	9.77	10.08	9.99	9.95	9.92

Source| MoEW, 2016a and MoE; 2017

Table 9: Distribution of fuel consumption by end-use for 2013

Fuel type	Consumption (1000 tonnes)
Gas diesel oil (GDO)	
Energy industries (EDL)	1,174.53
Road transport	534.02
Private generation	1,359.15
Manufacturing industries and construction	*663.20*
Commercial and institutional sector	*695.95*
Residential sector	4.08
Agriculture/forestry/fisheries	4.28
Heavy Fuel Oil (HFO)	
Energy industries (EDL)	1,183.43
International navigation	30.00
Manufacturing industries and construction	118.6
LPG	
Residential sector	180.70
Manufacturing industries and construction	32.63
Commercial and institutional sector	37.65
Gasoline	
Domestic aviation	3.00
Road transport	1,592.95
Jet kerosene	
International aviation	258.89
Petroleum coke	
Cement industries	542.34
Lubricants	
Energy industries (EDL)	40.61

Source| MoEW, 2016a and IPTEC, 2014

Energy industries – public electricity and heat production

The fuel consumption used under the energy industries category for the estimation of GHG emissions is presented in Table 10. It includes amounts of heavy fuel oil and gas/diesel oil that are delivered by the Ministry of Energy and Water to EDL, considering that these amounts are being consumed during one calendar year.

Table 10: Activity data for fuel consumption in energy industries

Fuel type	Quantity (1,000 tonnes)				
	1994	2000	2006	2011	2013
Gas diesel oil	48.65	532.805	1,057.70	1,305.67	1174.529
Heavy fuel oil	1,124.07	1294.362	956.61	1,186.78	1,183.43
Lubricants	0.197	37.7	29.86	35.24	40.611

Source| MoEW, 2016a

Manufacturing industries and construction

This category includes GHG emissions from fuel consumption in the 2 following activities:

1- Production of electricity, steam and process heat by industries: the industrial sector is one of the major energy consuming sectors in Lebanon. However, due to the intermittent electricity supplied by EDL and the constant power shortages, most industries in Lebanon generate their own energy from in-house generators. Gas/diesel oil and fuel oil are bought either directly from the Ministry of Energy and Water or from private fuel distributors and are used in the premises. Unfortunately, no data is recoded on these quantities. Therefore, estimations have been calculated based on the IPTEC survey on the sale of fuel per end user for 2013 (IPT, 2014).

2- Production of electricity by neighbourhood generators: due to the frequent power shortages, neighbourhood generators have flourished in Lebanon, supplying electricity to households during cut-off hours (which range from 3 to 15 hours a day depending on the region). All these generators work on gas/diesel oil which is bought either directly from private fuel distributors or from gas stations. Unfortunately, no data is available on the number, capacity or quantity of fuel used for private generators in the country. Therefore, based on an intensive consultation process was put in place with the main stakeholders (Ministry of Energy, Electricité du Liban, private distributers of fuel, and owners of generators) it was agreed to assume that the gap between public electricity supply and demand (referred as Energy not Supplied ENS) is being met at 80% by private generators.

As most developing countries, Lebanon suffers from a major gap between energy demand and supply, resulting in a deficit in energy of around 23%. This energy not supplied by public utilities is being supplied by privately owned generators providing electricity to households and commerce during cut-off hours. All these generators work on gas diesel oil which is bought either directly from private fuel distributors or from gas stations. Unfortunately, no data is available on the number, capacity or quantity of fuel used for private generators in the country.

Therefore, an intensive consultation process was put in place with the main stakeholders (Ministry of Energy, Electricité du Liban, private distributers of fuel, and owners of generators) to attempt to quantify the diesel used in private generation. As a result of this process, it was agreed to assume that the gap between public electricity supply and demand (referred as Energy not Supplied ENS) is being met at 80% by private generators.

The below table presents the values that were used for the year 2011. The energy not supplied is estimated by calculating the difference between the energy produced in 2011 and the estimated demand. Then, the diesel consumption of what is equivalent to 80% of this ENS is estimated using a conversion factor of 222.98 g/KWh. Finally, GHG emissions are calculated by using a country specific NCV and default emission as per IPCC guidelines

Table 11 presents the quantities of fuel used in manufacturing industries and construction for selected years based on the following assumptions:

- The heavy fuel oil used in manufacturing industries is calculated as the difference between the total fuel oil imported to Lebanon minus the amount consumed by public utilities and the amount consumed for international navigation.
- The gas/diesel oil used in this category constitutes 49% of the total gas/diesel oil consumed for private generation (the other 51% is used by the commercial/institutional sector).
- The LPG used in this sector is estimated at 13% of the total LPG import to Lebanon.
- Petroleum coke is consumed only in cement industries and imported quantities are delivered directly to the industries' locations after receiving approval from the Ministry of Environment.

Table 11: Activity data for fuel consumption in manufacturing industries and construction

Fuel type	Quantity (1,000 tonnes)				
	1994	2000	2006	2011	2013
Gas diesel oil	424.42	292.20	153.75	361.89	663.20
Heavy fuel oil	286.94	198.54	64.11	133.59	118.60
LPG	21.06	21.47	20.95	25.57	32.63
Petroleum coke	180	157.01	477.86	335.60	542.34
Lubricants	0.102	-	-	-	-

Source| MoEW, 2016a and MoE, 2017a

Transport

Road transport covers all internal combustion vehicles used for passengers and goods mobility in Lebanon, except farm tractors and public-work vehicles. Types of vehicles investigated in this inventory are motorcycles, passenger cars, vans, buses and trucks, classified into categories in accordance with the guidelines: Passenger Cars (PC), Light-Duty Vehicles (LDV), Heavy-Duty Vehicles (HDV) and motorcycles (Table 12). After banning the use of diesel for vehicles with gross weight lower than 3,500 kg (law 341 (6/08/2001) and decree 341/2002), passenger cars, light-duty vehicles and motorcycles run only on gasoline, while heavy duty vehicles run on diesel.

Table 12: Description of the vehicles categories used in the calculation of road transport emissions

Vehicle category	Description
Passenger Cars (PC)	Private personal gasoline cars used for mobility including Sport Utility Vehicles (SUV).
Light Duty Vehicles (LDV)	Gasoline vehicles with rated gross weight less than 3,500 kg including light trucks and coaches, designed for transportation of cargo or passengers.
Heavy Duty Vehicles (HDV)	Diesel vehicles with rated gross weight exceeding 3,500 kg including heavy trucks and coaches, designed for transportation of cargo or passengers.
Motorcycles	Includes a mixture of 2-stroke and 4-stroke engines as well as mopeds having an engine less than 50cc.

The following activity data are considered:

- The numbers of registered vehicles for are provided by the Ministry of Interior and Municipalities/traffic, truck and vehicle management authority for the years 2012 and 2015

(MoIM, 2017). The database includes the number of registered vehicles by category, type of use (private or public), production date, circulation date, horsepower, and type of fuel used, as well as by emission control technologies, following the European Union (EU) classification described in the IPCC guidelines (IPCC, 1997). The number of vehicles per category for 2013 are interpolated from the 2012 and the 2015 databases.

- Table 13 summarizes the classification of the 2013 vehicle fleet per vehicle category and EU emission control technology. Note that the classification per emission control technologies takes into consideration the common practice in Lebanon of removing the emission control catalyst without any replacement. The fraction of vehicles for which the catalyst was removed is obtained from a survey conducted in Beirut on 3,000 vehicles. (Waked, 2012; Waked and Afif, 2012; Unpublished data). The results from this survey were extrapolated to the rest of the vehicle fleet.

Table 13: Classification of the 2013 vehicle fleet per category and EU emission control technologies

EU emission control technology	Passenger Cars	Light Duty Vehicles	Heavy Duty Vehicles	Motorcycles
Uncontrolled	7,220	599	298	-
Early non-catalyst control	169,027	8,081	2,991	-
Non-catalyst control	352,375	21,310	2,925	-
Oxidation catalyst	89,764	13,062	363	-
Three-way catalyst	775,306	73,370	31,973	-
<50 cc[1]	-	-	-	84,594
2-strokes[2]	-	-	-	4,811
4-strokes[3]	-	-	-	2,504
Total	1,393,692	116,422	38,550	91,910

[1] Motorcycles having 1 cylinder
[2] Motorcycles having 2 to 3 cylinders
[3] Motorcycles having 4 cylinders and above

- The annual travelled distance per vehicle category is considered. Due to field data unavailability, an assumption was made using the ForFITS (For Future Inland Transport Systems) database. ForFITS is a modeling tool intended to evaluate the transport activity, energy use and CO_2 emissions, using transport data collected from different national and international transport related agencies (UNECE, 2014). For countries with mobility characteristics similar to Lebanon, a value of 12,000 km/year is estimated for passenger cars, 27,250 km/year for light-duty vehicles, 50,000 km/year for heavy-duty vehicles and 5,000 km/year for motorcycles.
- Gas/diesel oil is only used by heavy-duty vehicles and is estimated to be 534,021 tonnes in 2013 (see Box 1 for calculation methodology). The amounts used by passenger cars (taxis in general) and LDV are considered insignificant.

Box 1: Estimation of gas/diesel oil used in road transport

HDV diesel consumption is assumed to be 7.06 mpg (33.3 l of diesel/100km), based on the data provided by IPT on their trucks fleet consumption, and double checked against the GREET Model default value (from Argonne National Laboratory) and also compared to the results study conducted by VTT Technical Research Centre of Finland. The consumption value is averaged taking into consideration the loaded and unloaded truck trips.

HDV annual mileage assumed 50,000 km/year in ForFITS, which was validated by experts in the field (Afif, 2017).

Uncertainties

- Consumption is averaged for the whole fleet without taking into consideration the age distribution effect on consumption. It is noteworthy to mention that 2% of fuel reduction is estimated every 5 years for model year trucks above 1990. However, since the HDV fleet in Lebanon is old, the considered value (33.3 l/100km) is representative of national conditions. Further refinement of this number could be done later.

- Expert judgments have validated the estimated 50,000 km/year based on survey that is currently being undertaken by the Universite Saint Joseph. However, it is unsure how representative the survey is to the HDV fleet.

- Diesel buses constitute a small share compared to HDV trucks, therefore, buses consumption was approximated to be similar to the average consumption of the diesel truck.

Conclusion

The gas/diesel oil total consumption for transport in Lebanon is 534,021 tonnes in 2013. The difference with numbers calculated in this file is related to the assumptions estimated above.

- Domestic flights consist of 5 small propeller-type aircrafts, used only for training. They operate on gasoline (AVGAS LBP 100) with an annual consumption ranging between 2 and 3 ktonnes. Which is estimated on a capita basis then weighted by the population and extrapolated to cover the 1994-2011 yearly consumption.
- Activities related to domestic navigation are limited to fishing boats, which are reported under the category agriculture/forestry/fisheries, and consequently, their emissions are not reported under transport. Emissions related to military maritime transport were not considered due to the unavailability of the activity data.

Other sectors

This category includes the greenhouse gases emitted by fuel combustion in the commercial/ institutional sector, residential sector and agriculture/ forestry/ fisheries. Different types of fuel are considered under this category and are mainly used for electricity generation, cooking, heating, navigating and use of other mobile equipment.

Emissions from burning of wood are allocated under the residential sector's, where in rural areas logged wood is still being used for cooking and heat generation. The biomass activity data is based on the volume of fuelwood logged from coniferous and non-coniferous forests (referred to as wood waste) as reported by FAOSTAT (FAO, 2017). Only emissions of non-CO_2 gases derived from biomass fuels are included, and reported, in the emissions of the energy sector and national totals of the inventory. Therefore, CO_2 emissions from biomass fuels are included only as information item because it is assumed that the consumption of biomass is similar to the volume that is regenerated. Any variation to this hypothesis is reflected and calculated in the LULUCF sector. Therefore, carbon dioxide emissions from biomass combustion are not included in national totals, but are recorded as memo item for cross-checking purposes as well as avoiding double counting.

Table **14** presents the quantities of fuel used in per category based on the following assumptions:

- The gas/diesel oil used for electricity generation in the commercial and institutional sector constitutes 51% of the total gas/diesel oil consumed for private generation (the other 49% is used by manufacturing industries sector)
- The remaining gas/diesel oil is used by the residential sector (52%) and by agriculture/forestry/fisheries (48%)
- The LPG used in the commercial and institutional sector is estimated at 13% and the amount used in the residential sector at 72% of the total LPG import to Lebanon.

Table 14: Activity data for fuel consumption in the commercial and institutional sector

Fuel type	Quantity (1,000 tonnes)					End-use
	1994	2000	2006	2011	2013	
Commercial/institutional sector						
Gas diesel oil	57.67	306.63	161.34	379.76	695.95	- Electricity generation - Space heating - Water heating
LPG	14.58	24.77	24.17	29.50	37.65	- Cooking - Space heating - Water heating
Residential sector						
Gas diesel oil	65.45		-	30.02	4.08	- Space heating - Water heating
LPG	110.36	118.89	116	141.61	180.70	- Cooking - Space heating - Water heating
Biomass	9.77	10.08	9.98	9.95	9.92	- cooking - Space heating
Agriculture/forestry/fisheries						
Gas diesel oil	179.98	-	-	19	3	Mobile equipment
	179.98	-	-	9.40	1.28	Fishing boats

Source| MoEW, 2016a

Feedstock and non-energy use of fuels

Some of the imported fuels are used as raw materials for the production of other products in chemical industry and metal production, or the use of fuels for non-energy purposes such as bitumen and lubricants (HS code used for Lebanon is HS 27.10.19.90). Since these fuels are not combusted, their carbon content is totally or partially stored in the product and is not oxidized into carbon dioxide for a certain period of time. The CO_2 released from the use or decomposition of the product is not reported under the energy sector's inventory but under the industrial sector's inventory (MoE/UNDP/GEF, 2015).

The calculation of carbon dioxide emissions from non-energy use of fuels is based on the relevant consumption by fuel type and the fraction of the carbon stored by fuel type (50% for lubricants and 100% for bitumen).

International Bunkers

International bunkers include international aviation and navigation. Emissions from these sources are not accounted in national totals and are reported as memo items in the inventory. The activity data for international civil aviation includes the jet kerosene consumption and is collected from the Ministry of Energy and Water (MoEW, 2016a). The activity data for navigation is limited to the heavy fuel oil consumption for international bunkers and it is collected from the fuel imports data by the International Energy Agency (IEA, 2017). Fuel consumption in ktonnes/year is presented in Table 15.

Table 15: Fuel consumption for marine bunkers ktonnes/year

Year	1994	2000	2006	2011	2013
Jet-kerosene	145.91	124.51	103.36	223.88	258.89
Marine bunkers	-	15	19	27	30

Emission factors and other parameters

Due to the lack of country specific emission factors and emissions measurements, tier 1 methodologies are adopted for the calculation of all greenhouse gases emissions from stationary combustion. CO_2, CH_4 and N_2O emission factors and other parameters used in the calculation are based on default values of the Revised 1996 IPCC Guidelines and the IPCC Good Practice Guidance. CH_4 and N_2O emission factors are differentiated by technology and fuel, while CO_2 emission factors are differentiated only by fuel. Information on the Net Calorific Value (NCV) per imported fuel for 2013 is provided by the Ministry of Energy and Water.

Table 16: Carbon content, net calorific value and other parameters by fuel type

Fuel type	Net calorific value (TJ/ktonnes)	Carbon content (tonnes C/TJ)	Oxidation factor (%)	Fraction of carbon stored[1]
Gasoline	43.50	18.9	0.99	0
Jet kerosene	42.80	19.5	0.99	0
Diesel oil	41.60	20.2	0.99	0
Heavy fuel oil	41.10	21.1	0.99	0
LPG	47.31	17.2	0.99	0
Lubricants	40.19	20.0	0.99	0.5
Bitumen	40.19	22.0	0.99	1
Petroleum coke	35.30	27.5	0.99	0
Natural gas	48.00	15.3	0.995	0
Biomass	15.00	29.9	0.98	0

[1] Assumption is made that no carbon is stored, except for bitumen and 50% of lubricants, as per the IPCC default values.

Table 17: CH_4 and N_2O emission factors

		CH_4 emission factor (kg/TJ)		N_2O emission factor(kg/TJ)		NOx emission factor (kg/TJ)		CO emission factor (kg/TJ)		NMVOC emission factor (kg/TJ)	
		Oil	Biomass	Oil	Biomass	Oil	Biomass	Oil	Biomass	Oil	Biomass
Energy industries		3		0.6		200		15		5	
Manufacturing industries and construction		2		0.6		200		10		5	
Transport	Gasoline	20		0.6		600		8,000		1500	
	Diesel	5		0.6		800		1,000		200	
Commercial/institutional		10	300	0.6	4	100		20		5	
Residential		10	300	0.6	4	100	100	20	5000	5	600
Agriculture/forestry/ fisheries		10	300	0.6	4	100		20		5	

For mobile combustion, GHG emissions from road transport have been calculated using tier 2 emission factors, which depend on the production date of vehicles, the vehicle category and the type of fuel used. Therefore, besides the classification per category, the vehicles are also categorized by model year of production. Since no national emission factors are available and most of the Lebanese vehicle fleet is constituted of European vehicles, default EU emission factors are used. Emissions from other categories under mobile combustion are calculated with default emission factors available in the 1996 IPCC guidelines (IPCC, 1997).

Table 18: Default EU emission factors for gasoline passenger cars under the tier 2 methodology

Estimated emission factors for EU gasoline passenger cars (g/km)						
	NO_X	CH_4	NMVOCs	CO	N_2O	CO_2
Three-way catalyst: assumed fuel economy 11.8 km/l (8.5 l/100 km)						
	0.5	0.02	0.5	2.9	0.05	205
Oxidation catalyst: assumed fuel economy 12.3 km/l (8.1 l/100 km)						
	1.4	0.07	1.4	7.5	0.005	190
Non-catalyst controls: assumed fuel economy 12.0 km/l (8.3 l/100 km)						
	2.3	0.07	4.5	19	0.005	200
Early non-catalyst controls: assumed fuel economy 10.6 km/l (9.4 l/100 km)						
	2.0	0.08	5.2	29	0.005	225
Uncontrolled: assumed fuel economy 8.9 km/l (11.2 l/100 km)						
	2.2	0.07	5.3	46	0.005	270

Table 19: Default EU emission factors for gasoline light-duty vehicles under the tier 2 methodology

Estimated emission factors for EU LDV gasoline cars (g/km)						
	NO_X	CH_4	NMVOCs	CO	N_2O	CO_2
Moderate control: assumed fuel economy 7.4 km/l (13.6 l/100 km)						
	2.9	0.08	6.1	37	0.006	325

Table 20: Default EU emission factors for diesel heavy-duty vehicles under the tier 2 methodology

Estimated emission factors for EU HDV diesel cars (g/km)						
	NO_X	CH_4	NMVOCs	CO	N_2O	CO_2
Moderate control: assumed fuel economy 3.3 km/l (29.9 l/100 km)						
	10	0.06	1.9	9	0.03	770

Table 21: Default EU emission factors for motorcycles under the tier 2 methodology

Estimated emission factors for motorcycles (g/km)						
	NO_X	CH_4	NMVOCs	CO	N_2O	CO_2
Motorcycles < 50 cc Uncontrolled: assumed fuel economy 41.7 km/l (2.4 l/100 km)						
	0.05	0.1	6.5	10	0.001	57
Motorcycles > 50 CC 2 stroke Uncontrolled: assumed fuel economy 25.0 km/l (4.0 l/100 km)						
	0.08	0.15	16	22	0.002	95
Motorcycles > 50 cc 4 stroke Uncontrolled: assumed fuel economy 19.6 km/l (5.1 l/100 km)						
	0.3	0.2	3.9	20	0.002	120

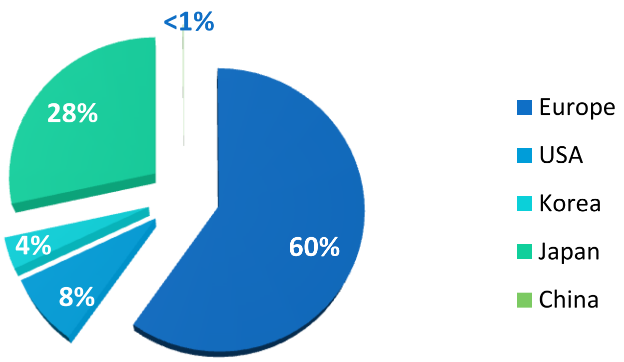

Figure 10: Classification per country of origin of the 2010 Lebanese vehicle fleet

Results

In 2013, the energy sector's GHG emissions were estimated at 20,775 Gg CO_2eq. (20.7 million tonnes CO_2eq.), representing 79% of the total greenhouse gas emissions in Lebanon. Energy is mainly responsible for carbon dioxide emissions (99.63%), while it also contributes to methane and nitrous oxide emissions with 0.12% and 0.28% respectively. The contribution of each subcategory to the total of the energy sector is presented in Table **22** and Figure 11.

Table 22: GHG emissions from energy by source category and gas for 2013

Categories	Emissions					
	CO_2 (Gg)	CH_4 (Gg)	CH_4 (Gg CO_2eq.)	N_2O (Gg)	N_2O (Gg CO_2eq.)	Total (Gg CO_2eq.)
Total energy	20,551.07	2.12	44.47	0.58	179.56	20,775.10
Energy industries	7,367.39	0.29	6.25	0.06	18.44	7,392.08
Manufacturing energy and construction	4,403.84	0.11	2.23	0.03	9.89	4,415.96
Transport	5,987.93	1.27	26.74	0.46	143.69	6,158.35
Other sectors	2,791.91	0.44	9.26	0.02	7.55	2,808.72
Commercial/Institutional	*2,234.11*	*0.307*	*6.447*	*0.018*	*5.580*	*2,246.14*
Residential	*546.21*	*0.132*	*2.772*	*0.006*	*1.806*	*550.84*
Agriculture/Fishing/Forestry	*11.59*	*0.002*	*0.042*	*0.000*	*0.000*	*11.63*

A Global Warning Potential of 1 was used for CO_2, 21 for CH_4 and 310 for N_2O,
Numbers may reflect rounding.

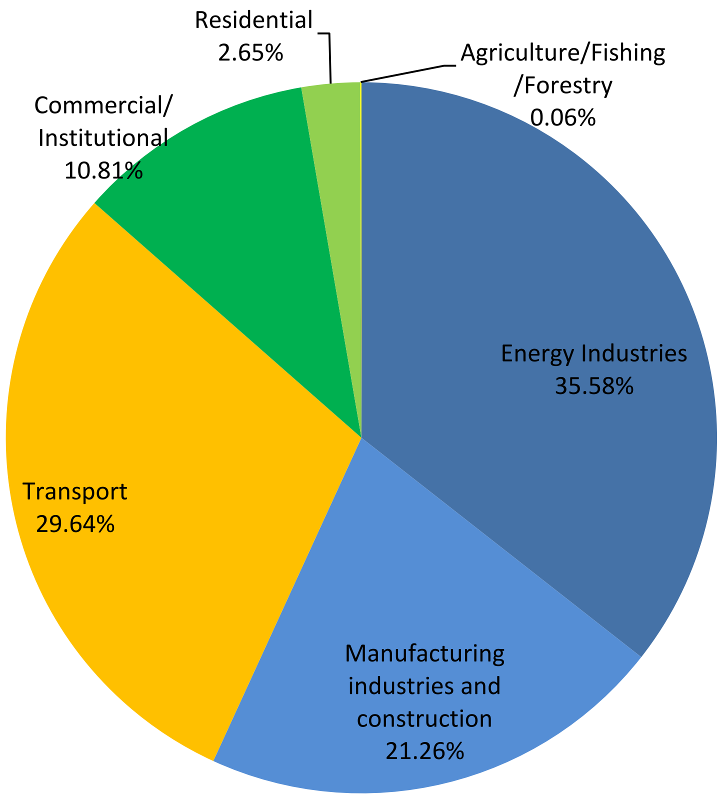

Figure 11: Contribution of energy emission sources to the sector's total for 2013

Energy industries

The energy sector in Lebanon relies on fossil fuel combustion for meeting the bulk of energy requirements in the country. The final energy consumption in 2013 amounted to approximately 287,465 TJ. Since electricity generation from public power plants (energy industries) is the main fuel consumer, it is responsible for 35.58% of the sector's emissions followed by transport (29.64%) and manufacturing industries (21.26%) as illustrated in Figure 11.

Indeed, public electricity generation is the largest contributor to the sector's emission due to the fact that more than 88% of imported fuel oil and 38% of imported gas diesel oil are used in thermal power plants for public electricity generation (Figure 12).

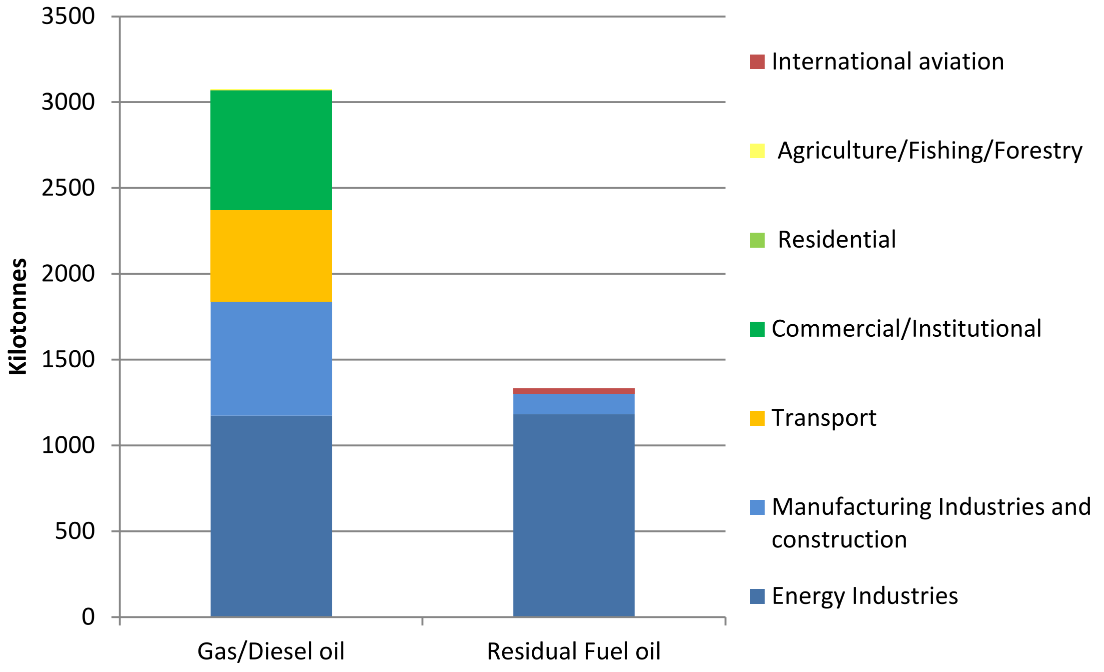

Figure 12: Amount of gas diesel oil and fuel oil consumed per subcategory

Transport

In 2013, GHG emissions from transport are estimated at 6,158.35 Gg CO_2eq. Carbon dioxide, methane, and nitrous oxide contribute to 97.2%, 0.43%, and 2.3% of total CO_2eq. respectively.

Table 23: Transport sector GHG emissions for 2013

	CO_2eq.	CO_2	CH_4	N_2O
Emissions (Gg)	6,158	5,988	1.27	0.46
Contribution		***97.2%***	***0.43%***	***2.3%***

As for the contribution of the different vehicle categories, passenger cars have the highest share of the 2013 emissions with 58.1% of the total road transport GHG emissions (CO_2eq.), while LDV, HDV, and motorcycles account for 17%, 24.5%, and 0.5% respectively.

Manufacturing industries and construction and commercial/institutional sectors

Other high-emitting subcategories in the energy sector are manufacturing industries and construction and the commercial/institutional sector since they cover all combustion activities related to the private generation of electricity. Due to high difference between electricity supply and demand, private generation in industries, commercial institutions and at neighbourhood levels consume considerable amounts of Gas/Diesel (GDO). In 2013, it is estimated that private generators supplied 6,095 GWh of electricity, calculated as 80% of the Energy-Not-Supplied (ENS), i.e. the difference between supply[1] (12,257 GWh) and demand (19,987 GWh) in 2013. Assuming a rate of consumption of 222.98 g/kWh of GDO, it is estimated that 1,359,149 tonnes of gas diesel have been used for private electricity generation in 2013, exceeding the amount of GDO used in EDL power plants and constituting 44% of total import of gas diesel oil.

Manufacturing industries and construction and commercial/institutional sectors also emit GHG emissions from their consumption of Liquefied Petroleum Gas (LPG) for heating and cooking, heavy fuel oil for heat generation in industries and petroleum coke for cement production (Table 24).

Table 24: CO_2 emissions from manufacturing industries and the commercial/institutional sector in 2013

	Manufacturing industries (including neighbourhood generators)	**Commercial/institutional sector**
Fuel Type	**Emissions in 2013 (Gg CO_2)**	
Gas/Diesel oi for private generation	2,023.00	2,122.90
Heavy fuel oil	373.35	-
LPG use	96.38	111.21
Petroleum coke	1,911.11	-
Total	4,403.84	2,234.11

Compared to the results reported in Lebanon's first BUR, the emissions from manufacturing industries and the commercial/institutional sector in 2013 seems to be twice as much as the emissions in 2011 (4,592.03 Gg CO_2eq.). This is mainly driven by the increased reliance on private generation resulting from the growing gap between the electricity supplied by EDL and electricity demand.

Table 25: Difference in GHG emissions from manufacturing industries and the commercial/institutional sector

	2011	**2013**
Emissions (Gg CO_2eq.)	4,592.03	7,224.68
DO for private generation (ktonnes)	741	1,359
Energy-not Supplied	4,158	7,619
EDL Supply (GWh)	12,406	12,257
Electricity demand (GWh)	16,564	19,876

Residential sector

In the residential sector, LPG is estimated to be the main source of GHG emissions (537.095 Gg CO_2eq.), followed by gas diesel oil that is used for space and water heating in households. Emissions from the use of private generators in residential buildings are not allocated in this category to avoid double counting from private generation under the manufacturing industries and construction category.

[1] Electricity supply takes into account electricity production and purchase for any given year

Comparison between the sectoral approach and the reference approach

According to the IPCC guidelines, carbon dioxide emissions from the energy sector should be calculated using both the reference and the sectoral approach. The reference approach is based on detailed data on primary energy consumption, which leads to the calculation of apparent consumption of fuel and to the consequent calculation of emissions, while the sectoral approach is based on a detailed disaggregation of energy consumption by sector and fuel for the calculation of CO_2 emissions. The application of the reference approach can be considered as a quality control procedure, as the deviation of estimations should not be significant (deviations in the order of ±2%) or else explanations should be provided.

In Lebanon, carbon dioxide emissions for the energy sector are calculated according to the two methodologies. In the reference approach, it was considered stock change was not taken into consideration due lack of data, and it was assumed that all fuel imported are consumed within the same calendar year.

As shown in Table 26, the difference between the 2 approaches is 2.48%, which is slightly above the threshold defined by the IPCC guidelines. The existing difference results mainly from statistical differences in fuel consumption and the use of tier 2 methodology in the transport sector.

Table 26: Difference between the reference and sectoral approach for 2013

	CO_2 emissions (Gg)	**Difference**
Reference approach	21,072.72	2.48%
Sectoral approach	20,551.07	

International bunkers

For international bunkers, the total direct GHG emissions from aviation and marine amounted to 879.77 Gg of CO_2eq. in 2013, with 90% of these direct GHG emissions originating from international aviation.

2.2 Industrial processes

Methodology

The GHG inventory of industrial processes in Lebanon is carried out based on calculation methodologies of the Revised 1996 IPCC Guidelines for national greenhouse gas inventories and the IPCC Good Practice Guidance. Further descriptions of the methodologies used and gases covered for each source of emissions identified by the guidelines are detailed in Table 27.

Table 27: Reporting categories investigated in the inventory of the Lebanese industrial processes sector

Reporting categories	**Emitted gases**	**Methodology, description and remarks**
Cement production	CO_2	All cement industries in Lebanon are covered in this calculation. Cement manufacturing is a key category in Lebanon. Tier 2 is adopted to calculate emissions from this category.
Lime production	CO_2	The only lime production plant in Lebanon is covered in this calculation. Lime is also produced in cement manufacturing; however it is already accounted for in clinker produced in cement industries.

Limestone use	CO_2	Limestone is mainly used in Lebanon in cement, glass and lime industries. Therefore emissions from limestone are already accounted for in each of these categories.
Soda ash production and use	CO_2	There is no soda ash production in Lebanon. Therefore all soda ash used is imported. Percentages of soda ash used for each type of industry (glass manufacturing, soap and detergents, water treatment etc.) are not available.
Production and use of miscellaneous mineral products	NMVOCs CO SO_2	**Asphalt use and production** Bitumen used for asphalt road paving in Lebanon is imported. It is assumed that all asphalt used for non-paving applications is produced by blowing process (IPCC, 1997). Therefore, the amount of asphalt blown was derived by subtracting cement asphalt for road paving from total bitumen imports. **Glass production** Glass production does occur in Lebanon; however, production data could not be accessed. Therefore emissions from glass production are not estimated. **Concrete pumice stone production** There is no concrete pumice stone production in Lebanon. Therefore emissions are not occurring.
Ammonia production	CO_2 NMVOCs CO SO_2	There is no ammonia production in Lebanon. Therefore emissions are not occurring.
Nitric acid production	N_2O NO_x	There is no nitric acid production in Lebanon. Therefore emissions are not occurring.
Adipic acid production	N_2O NO_x NMVOCs CO	There is no adipic acid production in Lebanon. Therefore emissions are not occurring.
Carbide production	CO_2 CH_4	There is no carbide production in Lebanon. Therefore emissions are not occurring.
Production of other chemicals	CH_4 NO_x NMVOCs CO SO_2	Phosphate fertilizers are reported to be produced in Lebanon. However, data from producing companies is inaccessible to any government agency. Therefore, emissions from this category are not estimated.
Metal production	CO_2 NO_x NMVOCs CO SO_2	There is no metal production in Lebanon. Production of Iron and Steel from the years 2000 to 2002. Then the only metal producing company in Lebanon closed. Besides emissions from this period, none have occurred for this category.
Pulp and paper industries	NO_x CO SO_2 NMVOCs	In Lebanon, there is no pulp production in any of the paper industries. Pulp is imported. Therefore emissions are not occurring.

Food and drink	NMVOCs	Categories included in this module are: wine production, beer production, meat, fish and poultry production. Estimations were also made for bread and cake and biscuits production based on quantities of imported as well as locally produced wheat. Data on coffee, animal feeds and Arak (locally produced spirit) production could not be obtained, therefore emissions from these subcategories were not estimated.
Production of halocarbons and sulphur hexafluoride	HFCs PFCs	Halocarbons are not produced in Lebanon. Therefore, emissions from production are not occurring.
Consumption of halocarbons and sulphur hexafluoride	HFCs PFCs	There is no data available on consumption of fluorinated gases. Lebanon's national ozone office is in the process of finalizing a survey to estimate the amount of ODS, mainly HFC, in the country.

Activity data

Table 28 below summarizes the data sources used for the calculation of CO_2 emissions industrial processes in Lebanon's second BUR. Details of the calculation of activity data are presented in Annex II.

Table 28: Summary of data sources used in the GHG inventory for the industrial processes sector

Reporting category	Activity data needed	Reference
Cement production	Quantity of cement produced Quantity of clinker produced	The three cement industries in Lebanon
Lime production	Quantity of lime produced	The only lime producing company in Lebanon
Soda ash use	Soda ash used	Lebanese customs through Ministry of Economy and Trade (except for the year 2013 for which data was retrieved directly from the customs website). HS code: 28.36.30.00

Data for the present inventory was collected for the time series 1994 – 2013. Table 29 present some of the activity data collected for the source categories for the industrial sector for selected years.

Table 29: Activity data for industrial processes in Lebanon for selected years

Year	1994	2000	2006	2011	2013
Quantity of clinker produced (tonnes)	298,000	3,135,084	3,868,051	4,955,079	4,881,844
Quantity of cement produced (tonnes)	298,000	2,790,336	4,043,357	5,771,074	5,905,811
Quantity of lime produced (tonnes)	15,000	2,500	2,503	2,722	1,901
Quantity of soda ash used (t)	12,072.6	9,555	14,601	9,122.62	10,564

Emission factors

The emission factors used in the calculation of emissions from industrial processes are based on default values provided by the IPCC 1996 revised guidelines except for cement industries for which a national emission factor has been calculated.

Table 30: Emission factors and other parameters for industrial processes

Reporting categories	Emission factor and other parameters	Source of emission factor
Cement production	0.51 t CO_2/t clinker produced	Nationally developed emission factor, SNC (MoE/UNDP/GEF, 2011)
	Correction factor for cement kiln dust (CKD): 1.02	IPCC Good Practice Guidance and Uncertainty Management, p.3.12
	0.3 kg SO_2/t cement produced	Revised 1996 IPCC guidelines, reference manual, p.2.7
Lime production	0.79 t CO_2/t quicklime produced	Revised 1996 IPCC guidelines, reference manual, p.2.9
Soda ash use	415 kg CO_2/t soda ash used	Revised 1996 IPCC guidelines, reference manual, p.2.13
	320 kg NMVOCs/t road paving material used	Revised 1996 IPCC guidelines, reference manual, p.2.14
Production and use of miscellaneous mineral products	2.4 kg NMVOCs/t asphalt roofing produced	Revised 1996 IPCC guidelines, reporting instructions, p.2.9
	0.095 kg CO/t asphalt roofing produced	Revised 1996 IPCC guidelines, reference manual, p.2.13
	0.035 kg NMVOCs/hl beer produced	Revised 1996 IPCC guidelines, reference manual, p.2.41
	0.3 kg NMVOCs/t fish processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t meat processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t poultry processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	8 kg NMVOCs/t bread processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	8 kg NMVOCs/t bread processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	1 kg NMVOCs/t cakes and biscuits processed	Revised 1996 IPCC guidelines, reference manual, p.2.42

Box 2: Calculation of national emission factor for clinker and a correction factor for cement kiln dust

According to the IPCC Good Practice Guidance and Uncertainty Management, data on calcium oxide (CaO) content of the clinker ($CaO\_{Clinker}$) is needed in order to generate a national emission factor for tier 2 method as per equation 3.3 p.3.12:

$EF_{clinker} = 0.785 \times CaO\_{Clinker}$

0.785 is the molecular weight ratio of CO_2 to CaO in the raw material mineral calcite ($CaCO_3$) from which most or all the CaO in clinker is derived.

The value obtained from the three plants producing cement in Lebanon for CaO content of clinker is: 65%.

Therefore,

$EF_{clinker} = 0.785 \times 0.65 = 0.51$ t CO_2/t clinker

Cement Kiln Dust (CKD) is a mix of raw material and clinker that is produced by cement furnaces. It may be partly recycled to the furnace. Good practice is to correct for the CO_2 contained in the non-recycled, therefore lost calcined CKD because this CO_2 will not be accounted for by the clinker produced. The default CKD correction factor is 1.02 (i.e. add 2% to the CO_2 calculated for clinker).

Therefore, the emissions from the cement industries from clinker production as per the tier 2 method will be:

Emissions = clinker production x $EF_{clinker}$ x CKD correction factor

Results

In 2013, total emissions from industrial processes in Lebanon amounted to 2,545.42 Gg of CO_2. Greenhouse gas emissions primary entail the CO_2 gas from the cement and lime production sectors, with the largest contributor being cement production. Lime production and soda ash use have a very minimal contribution to CO_2 emissions in the sector. CH_4 and N_2O are not emitted from industrial processes.

Table 31: CO_2 emissions from industrial processes in Lebanon for selected years

Year	Total Emissions CO_2 (Gg)	Emissions from cement production (Gg)	Emission from lime production (Gg)	Emissions from use of soda ash (Gg)
1994	171.88	155.02	11.85	5.01
2000	1,765	1,631	2	4
2006	2,020	2,012	2	6
2011	2,584	2,578	2	4
2013	2,545	2,539	1.50	4.38

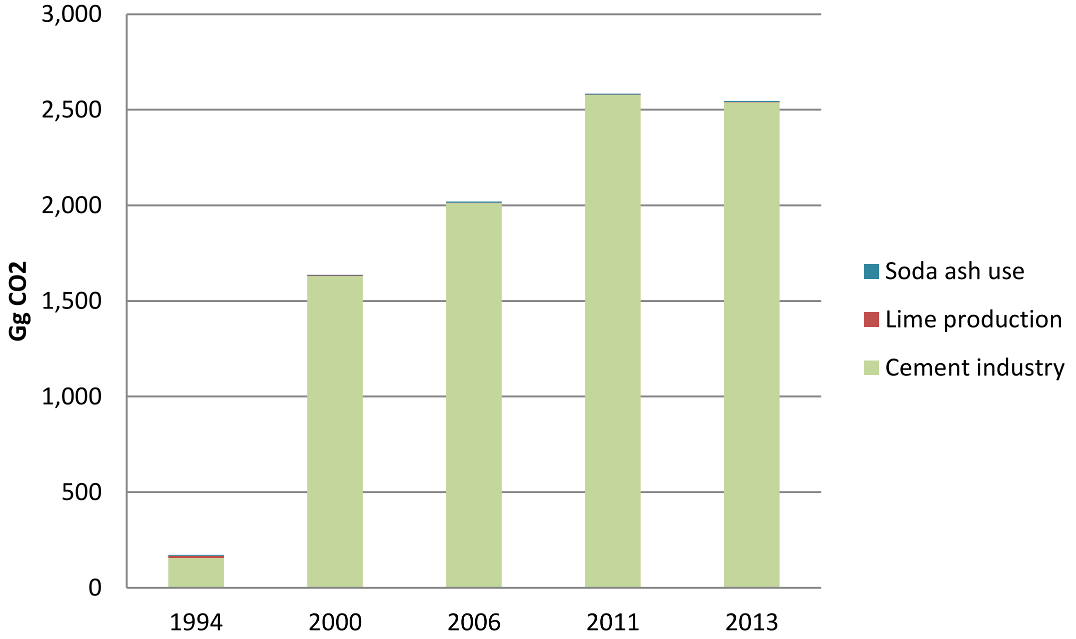

Figure 13: CO_2 emissions from industrial processes in Lebanon per category

While emissions from some categories were not estimated due to the absence of activity data (namely glass production and phosphate fertilizers), it is assumed that these will not highly impact overall GHG emissions from the sector, as the quantity produced is believed to be very minimal compared to the highest emitter, i.e., the cement sector. However, emissions from the consumption of halocarbons and SF_6, having a high global warming potential, may significantly affect the overall emissions from the sector in terms of CO_2 equivalent, even with small quantities.

2.3 Agriculture

Methodology

The IPCC guidelines for national GHG inventories identified six sources of GHG emissions in agriculture as follows:

- Enteric fermentation
- Manure management
- Agricultural soils
- Rice cultivation
- Prescribed burning of savannahs
- Field burning of agricultural residues

Agricultural GHG emissions in Lebanon consist mainly of emissions from enteric fermentation (CH_4 emissions), manure management (CH_4 and N_2O emissions) and agricultural soils (N_2O emissions). The other IPCC subcategories – rice cultivation, prescribed burning of savannas, and field burning of agricultural residues do not occur in Lebanon and are thus reported as Not Occurring (NO).
The tier 1 approach was employed in the calculation of emissions, using the Revised 1996 IPCC Guidelines and the GPG 2000. There are no available data to adopt a Tier 2 methodology.
For the GHG inventory of the agricultural sector, the UNFCCC software version 1.3.2 (Non - Annex 1 National GHG Inventory Software) was used. All sheets presented in the software were filled as in the module 4 (agriculture) of the software, except for sheet (4-5s1) used for the calculation of F_{BN} (nitrous oxide emission from agricultural soils). F_{BN} was calculated manually and the values entered in the sheet. The calculations are presented in Annex III.

Activity data

In BUR I, activity data of the agriculture sector was mainly derived from the FAO database (FAO Stat), which was the most complete database, with additions from the Lebanese Ministry of Agriculture, the Lebanese Customs, and the Lebanese syndicate of cattle importers. Imported beef had not been included in any national greenhouse inventory before the first BUR, which was considered an improvement in the methodology.

Based on lessons learned from the BURI and recommendations from the technical review under the ICA process to: (1) rely on national primary sources rather than secondary sources, (2) enhance sustainable institutional arrangements for data exchange between ministries, and (3) decrease reliance on independent consultants to improve institutional memory and build capacities within national institutions, a different approach for data collection has been adopted for the second BUR. The new approach consists of adopting data available at the MoA, even if incomplete or based on assumptions, and work on the establishment of institutional arrangements for continuous data exchange, which would save significant amounts of resources and time. The data missing from the Ministry of Agriculture was completed by secondary sources or extrapolation. In addition, the MoE and the MoA have initiated a long-term dialogue to understand each other's needs in terms of data collection and segregation level, in addition to participation in trainings on GHG inventories.
Table 32 below summarizes the data sources used for the GHG inventory of the agriculture sector in the second BUR.

Table 32: Summary of data sources used in the GHG inventory for the agricultural sector

Reporting category and activity data needed		Source used in BUR I	Source used in BUR II
Livestock population	Dairy Cattle	FAOSTAT under the domain production\Livestock primary\Milk, whole fresh cow\producing animals	Ministry of Agriculture
	Non-Dairy Cattle Non-Dairy Cattle Population = Total Cattle population minus Dairy Cattle population.	Total Cattle is the summation of two sources: 1) Total Cattle: Obtained from FAOSTAT under the domain production\Live animals\Cattle\Stock. 2) Imported beef: Local data obtained from Syndicate of Cattle Importers (1997-2012). Values for 1994-1996 were extrapolated.	Ministry of Agriculture – Imported beef was not included due to: 1) lack of records and archives from BUR I on the source and contacts to obtain data on imported beef 2) the exclusion of imported beef from the MoA statistics. Future institutional arrangements will explore the possibility of gathering this data on a sustainable basis.
	Sheep, Goats.	FAOSTAT under the domain production\live animals\(name of the species)\stock	Ministry of Agriculture
	Swine, Camels, Horses, Mules, Asses	FAOSTAT under the domain production\live animals\(name of the species)\stock	FAOSTAT under the domain production\live animals\(name of the species)\stock
	Poultry (Laying Hens, Broilers and traditional chicken)	For laying hens and broilers: FAOSTAT under the domain production\livestock primary\"meat poultry > (list)" and "eggs primary >	All data obtained from the Ministry of Agriculture, and broilers were adjusted to 60 days alive using the following

		(list)\producing animals. Broilers were adjusted to 60 days alive. For traditional chicken, data was obtained from Lebanese MOA. However population were missing for 1994-1996, 2006-2007 and 2011-2012. These were obtained through extrapolation and interpolation.	equation: ***Population = Days alive x (NAPA/365)*** Where: Days alive= Average number of days for the animal before it is slaughtered NAPA = Number of Animals Produced Annually Detailed calculation of poultry population is presented in Annex III.
Nitrogen Fertilizer Consumption		Consumption data was taken from local imports. Data obtained from The Lebanese Customs. Values for 1994-1996 were extrapolated.	2013 data obtained by extrapolation from the available data series from the previous inventory. Data available at the Lebanese customs did not match the data series gathered for the first BUR and no explanation could be obtained. Data not available at the Ministry of Agriculture.
Crop Production	Dry beans, green beans, broad beans, horse beans, chickpeas, lentils, lupins, dry peas, green peas, vetches, barley, maize, oats, sorghum, wheat, carrots and turnips, garlic, onions, potatoes.	FAOSTAT under the domain Production\crops\(name of crop)\production quantity.	FAOSTAT under the domain Production\crops\(name of crop)\production quantity. Data available at the Ministry of Agriculture only until 2009. Crop production values should be reported on dry matter (DM) basis. Therefore all crop production values were multiplied by the appropriate DM fractions.
	Alfalfa.	Alfalfa production was obtained by multiplying the area harvested by the yield. Area harvested was obtained from FAOSTAT. Yield (40 tonnes Fresh Weight/ha) was obtained from expert judgment.	Alfalfa production was obtained by multiplying the area harvested by the yield. Area harvested was obtained from FAOSTAT, except for the year 2013, estimation was provided by Ministry of Agriculture. Yield (40 tonnes Fresh Weight/ha) was adopted from expert judgment during BUR I.
Manure Management systems		Data was obtained though expert judgment and survey of selected dairy, poultry and swine farms (Liban Lait, Dairy Khoury, Hariri Farms, Hawa Chicken, Tanmia, Wilco, Porkys).	Data was adopted from BUR I.

Table 33 to Table 37 present some of the activity data collected for livestock population, fertilizer consumption, crop production and manure management for selected years.

Table 33: Activity Data for livestock population in Lebanon for selected years

	Number of animals (heads)				
	1994	2000	2006	2011	2013
Dairy Cows	51,620	38,900	43,900	55,000	67,118
Other Cattle	43,480	38,100	33,100	15,000	13,382
Sheep	242,980	354,000	370,400	450,000	450,000
Goats	418,980	417,000	484,400	550,000	550,000
Camels	530	450	440	200	200
Horses	6,810	3,580	3,580	2,634	4,000**
Mules and asses	26,500	19,780	19,780	20,000	20,000
Swine	52,800	26,000	10,000	7,650	5,300*
Poultry	11,790,260	14,491,781	16,972,603	13,363,014	12,705,479

*extrapolation
**estimation

Table 34: Fraction of Manure Nitrogen per Manure Management System (MMS) in Lebanon based on expert judgement

	Dairy Cows	Other Cattle	Sheep	Goats	Camels	Horses	Mules	Swine	Poultry
Anaerobic Lagoons	0.01								
Liquid systems	0.005								
Solid storage and drylot	0.955	1	0.33	0.33				0.9	
Daily spread	0.01							0.1	
Pasture range and paddock	0.02		0.67	0.67	1	1	1		0.04
Poultry manure without bedding									0.19
Poultry manure with bedding									0.77

Table 35: Amount of synthetic fertilizer applied to soil in Lebanon for selected years

	1994	2000	2006	2011	2013
Synthetic Fertilizer Applied to Soil N_{FERT} (Kg N/yr)	31,016,000	25,354,000	9,535,000	18,359,000	18,269,111*

*extrapolation

Table 36: Amount of pulses produced in Lebanon for selected years, reported in tonnes on a dry matter basis

Production of pulses (dry) (tonnes)	Dry matter	1994	2000	2006	2011	2013
Dry beans	1 (a)	4,726	100	200	743	426
Green beans	0.85 (b)	25,500	39,015	10,795	21,250	20,773
Broad beans, horse beans	1 (a)	1,950	300	300	126	150
Chick peas	1 (a)	9,700	2,200	1,200	3,547	2,435
Alfalfa	0.5 (c)	13,600	15,000	15,000	15,000	10,000

Lentils	1 [a]	13,000	800	600	1,893	1,471
Lupins	1 [a]	1,170	1,150	450	132	115
Dry peas	1 [a]	1,986	2,450	2,400	2,500	2,495
Green peas	0.85 [b]	10,880	3,740	2,465	3,715	3,476
Vetches	0.9 [d]	4,500	4,725	2,835	648	742.5
Total (dry basis)		87,012	69,480	36,245	49,554.35	42,084.15

(a) Pulses data from FAO are on DM basis; (b) 2000 GPG; Table 4.16; (c) WSU, 2016; (d) 2006 IPCC GL, Table 11.2; (N-Fixing Forages)

Table 37: Amount of non-N fixing crop produced in Lebanon for selected years, reported in tonnes on a dry matter basis

Production (dry) (tonnes)	DM	1994	2000	2006	2011	2013
Barley	0.88 [e]	17,762.8	8,272	27,984	26,400	30,800
Maize	0.88 [e]	3,595.68	3,080	2,728	2,640	2,640
Oats	0.88 [e]	448.8	352	211.2	161.04	128.48
Sorghum	0.88 [e]	1,454.64	1,232	756.8	396	440
Wheat	0.88 [e]	46,354	95,128	134,992	110,000	123,200
Carrots and turnips	0.12 [c]	3,914.4	984	696	612.72	456.96
Garlic	0.35 [f]	12,250	3,850	1,085	992.95	668.85
Onions	0.14 [f]	9,910.46	22,064	6300	12,131.98	10,701.18
Potatoes	0.45 [g]	144,795.2	123,750	179,100	123,750	185,400
Total (dry basis)		240485.9	258712	353853	277084.7	354435.5

(c) WSU, 2016; (e) 2006 IPCC GL -Table 11.2; (f) Slovenian NIR; (g) 1996 IPCC GL - reference Manual Table 4.17

Emission factors

Enteric fermentation

Emission factors used for calculation of methane emissions from enteric fermentation are default values from 1996 IPCC GL and reported in Table 38 below. Total CH_4 emissions is then the sum of emissions from all animal categories, except poultry as per the guidelines (enteric fermentation in poultry is insignificant).

Table 38: Methane emission factors for enteric fermentation.

Species	CH_4 Emission factor	Source
Sheep	5	1996 IPCC GL, reference manual, Table 4.3
Goats	5	
Camels	46	
Horses	18	
Mules and asses	10	
Swine	1	
Dairy cows	100	1996 IPCC GL, reference manual Table 4.4. Milk production data are

Other cattle	48	used in estimating an emission factor for enteric fermentation using the Tier 1 method. Average annual milk production for dairy cows in Lebanon is 4,200 kg/head/yr (comparable to Western Europe).

Manure management

- Methane (CH_4)

Table 39 below shows the emission factors used for calculating methane emission from manure management. In addition to the livestock populations used for calculating methane emission from enteric fermentation, poultry populations were also included for estimating methane emissions from manure management. For cattle and swine, emission factors suitable for Eastern Europe were chosen as they better reflect the conditions for manure management in Lebanon (i.e. solid based systems are used for the majority of manure). For the other species shown in Table 39, emission factors for temperate regions were chosen from the default factors proposed by the 1996 IPCC guidelines. Indeed, in the Reference Manual, Table 4-1, three climate regions are defined in terms of annual average temperature: cool (<15°C), temperate (15°C - 25°C), and warm (>25°C). Livestock population in Lebanon all fall within the temperate region.

Table 39: Methane emission factors for manure management.

Species	EF (kg/head/year)	Source
Sheep	0.16	1996 IPCC GL, reference manual, Table 4-5 (Temperate regions)
Goats	0.17	
Camels	1.9	
Horses	1.6	
Mules and asses	0.9	
Poultry	0.018	
Dairy cattle	19	1996 IPCC GL, reference manual, Table 4-5 (Eastern Europe)
Other cattle	13	
Swine	7	

- Nitrous Oxide (N_2O)

The amount of N_2O emitted from manure management is estimated using the IPCC Tier 1 approach where the total amount of Nitrogen excretion (from all livestock species/categories) in each type of Manure Management System (MMS) is multiplied by an emission factor for that type of MMS. In the absence of country-specific emission factors, the IPCC default nitrogen excretion rates (N_{ex}) and emission factors were used. Table 40 and Table 41 provide the nitrogen excretion rates for animal species N_{ex} and emission factors used for each type of MMS. Fraction of manure managed in each MMS was determined using surveys of major dairy, non-dairy, swine, and poultry farms as well as expert judgment from academic experts.

Table 40: Nitrogen excretion rate for animal species and fraction of manure managed in each manure management system in Lebanon

	Dairy Cows	Other Cattle	Buffalo	Sheep	Goats	Camels	Horses	Mules	Swine	Poultry	Source
Fraction of Manure Nitrogen per MMS											
Anaerobic Lagoons	0.01										*Expert judgement*
Liquid systems	0.005										
Solid storage and drylot	0.955	1		0.33	0.33				0.9		
Daily spread	0.01								0.1		
Pasture range and paddock	0.02			0.67	0.67	1	1	1		0.04	
Poultry manure without bedding										0.19	
Poultry manure with bedding										0.77	
Nitrogen Excretion (kg/head/yr)											
	70	50		12	12	40	40	40	16	0.6	*1996 IPCC GL, RM, Table 4-20.*

Table 41: Emission factors for Nitrous Oxide emission for each utilized manure management system.

MMS	Emission Factor (kg N_2O-N/kg N excreted)	Source
Anaerobic lagoons	0.001	GPG 2000, Table 4.12 and Table 4.13
Liquid systems	0.001	
Solid storage & drylot	0.02	
Poultry with bedding	0.02	
Poultry without bedding	0.005	
Daily spread	0.00	

* As per the 1996 IPCC guidelines, emissions from pasture range and paddock are not reported under manure management, but rather under agricultural soils, which is why this table does not contain an emission factor for this type of MMS.

Agricultural soils

Emissions of N_2O from agricultural soils result from anthropogenic N inputs through both a direct and an indirect pathway. Direct pathway occurs via two mechanisms (a) intentional additions of N directly to soils through synthetic fertilizers, nitrogen fixation by N-fixing crops, animal manure, and crop residues and (b) unintentional additions of N through animals grazing on pasture, ranges, and paddocks (PRP). Indirect N_2O emissions occur through two pathways – volatilization from applied fertilizer and manure as NH_3 and NO_x and subsequent deposition, and through leaching and runoff of applied fertilizer and animal manure.

- Direct Nitrous Oxide emissions

F_{SN}: Nitrogen from Synthetic Fertilizer

F_{SN} is annual amount of synthetic fertilizer nitrogen added to soil, adjusted for NH_3 and NO_x volatilization.

Table 42: Factors used for the calculation of nitrogen from synthetic fertilizer

Fraction of Synthetic Fertilizer Applied Emitted as NO_x and NH_3 $Frac_{GASF}$	0.1	*1996 IPCC GL, Reference Manual, Table 4-24*
Emission factor for direct emissions (kg N_2O-N/kg N)	0.0125	*1996 IPCC GL, Reference Manual, Table 4 -18*

F_{AW}: Nitrogen from Animal Manure

F_{AW} is annual amount of animal manure nitrogen adjusted for (a) NH_3 and NO_x volatilization, (b) for manure dropped on soil from animal grazing (PRP), and (c) for fraction of manure N burned (i.e. used as fuel, assumed zero).

In order to avoid double counting, N-inputs from animals on pasture, range, and paddock (PRP) is subtracted from nitrogen additions from animal manure (F_{AW}) and added separately as direct N_2O emissions from Pasture, Range, and Paddock.

Table 43: Factors used for the calculation of nitrogen from animal manure

Fraction of Nitrogen excreted during grazing ($Frac_{PRP}$)	0.2-0.34	*$Frac_{PRP}$ was calculated as the ratio of the amount of nitrogen excreted during grazing (PRP) to the total nitrogen excreted from all MMS.* *Appropriate cells on worksheet:* *4-1s2 A24/ 4-1s2 A27*
Fraction of Nitrogen excreted emitted as NO_x and NH_3	0.2	*1996 IPCC GL, Reference Manual, Table 4-19*
Emission factor for direct emissions (kg N_2O-N/kg N)	0.0125	*1996 IPCC GL, Reference Manual, Table 4 -18*
Emission Factor for AWMS (kg N_2O – N/kg N)	0.02	*GPG 2000, Table 4.12*

F_{BN}: N fixed by Crops

F_{BN} is the annual amount of nitrogen added to soil through the process of nitrogen fixation by N-fixing crops cultivated annually. Nitrogen fixing crops include pulses (dry beans, broad beans, peas, chickpeas, and lentils), leguminous crops (green peas and green beans) and N fixing forages (alfalfa and vetch). F_{BN} is manually calculated using Tier 1a method (Equation 4.25; 2000 GPG):

$$F_{BN} = 2 \times Crop_{BF} \times Frac_{NCRBF}$$

Where

$Crop_{BF}$ = Yield of Pulses and leguminous vegetables (kg dry Matter/year, refer to Table **36**)

$Frac_{NCRBF}$ = Fraction of biomass that is nitrogen (0.03, default value: 1996 IPCC GL, Reference Manual, Table 4.19)

As per IPCC recommendations, crop production values for N-fixing crops are all reported on dry matter (DM) basis. Therefore, all crop production values were multiplied by the appropriate DM fractions (see AnnexI V for detailed calculations of F_{BN}).
The factor 2 converts the edible portion of the crop (which is reflected in the production data) to total crop biomass.
The emission factor for direct emissions (0.0125 kg N_2O-N/kg N) also applies for the calculation of nitrogen fixed by crops.

F_{CR}: Nitrogen from crop residues
Nitrogen returned to soil from crop residues left to decompose in the field.

Table 44: Factors used for the calculation of nitrogen from crop residues

Fraction of nitrogen in N fixing crops	0.03	*1996 IPCC GL, Reference Manual, Table 4.19*
Fraction of nitrogen in non N fixing crops	0.010	
Fraction of crop residue burned $Frac_{BURN}$	0	*Experts judgement*
Average of fraction of residue removed from field for N fixing and non N fixing crops $Frac_R$	0.66	*Experts judgement (LARI) for $Frac_R$ of each crop. We calculated the average*
Emission factor for direct emissions (kg N_2O-N/kg N)	0.0125	*1996 IPCC GL, Reference Manual, Table 4 -18*

- Indirect Nitrous Oxide emissions

Indirect N_2O emission from nitrogen added to agricultural soils are based on two sources. These are: volatilization and subsequent atmospheric deposition of NH_3 and NO_x from the application of fertilizers and animal manure, and leaching and runoff of the nitrogen that is applied to or deposited on soils.
Note: Emissions of N_2O produced from the discharge of human sewage into rivers are reported under the waste sector.

Table 45: Fractions and emission factors used for calculating indirect emissions from agricultural soils

Fraction of total manure N excreted that volatizes $Frac_{GASM}$ kg NH_3-N + NO_x -N volatilized/kg of N excreted by livestock	0.2	*1996 IPCC GL, Reference Manual, Table 4-19*
Fraction of synthetic fertilizer N applied that volatizes $Frac_{GASF}$ kg NH_3-N + NO_x -N volatilized/ kg of fertilizer N applied	0.1	*1996 IPCC GL, Reference Manual, Table 4-24*
Fraction of N that leaches $Frac_{LEACH}$ kg N leached /kg of fertilizer or manure N applied	0.3	*1996 IPCC GL, Reference Manual, Table 4-24*
Emission Factor for atmospheric deposition of NH_3 and NO_x (EF_4) (kg N_2O – N/kg N)	0.01	*1996 IPCC GL, Reference Manual, Table 4-23*
Emission factor for leaching (EF_5) (kg N_2O – N/kg N)	0.025	*1996 IPCC GL, Reference Manual, Table 4-23*

Results

In 2013, total GHG emissions from the agricultural sector were 987.55 Gg CO_2eq, constituting 4% of total national emissions. Nitrous oxide (N_2O) emissions from agricultural soils (511.5 Gg CO_2eq.) represented over half of emissions from agriculture, CH_4 emissions from enteric fermentation were 265.61 Gg CO_2eq., and N_2O and CH_4 emissions from manure management 210.4 Gg CO_2eq. Most of the emissions from manure management were due to N_2O emissions as opposed to CH_4.

The summary of methane (CH_4) emissions from enteric fermentation and manure management and nitrous oxide (N_2O) emissions from manure management and agricultural soils are presented in Table 46 below.

Table 46: GHG emissions for the agriculture sector for selected years

Year	1994	2000	2006	2011	2013
Enteric fermentation (Gg CH_4)	11.02	9.88	10.55	11.48	12.64
Enteric fermentation (Gg CO_2eq.)	231.42	207.48	221.55	241.06	265.44
Manure management (Gg CH_4)	2.27	1.83	1.80	1.72	1.91
Manure management (Gg CO_2eq.)	47.67	38.43	37.80	36.20	40.11
Total Gg CH_4	13.29	11.71	12.35	13.21	14.55
Manure management (Gg N_2O)	0.46	0.47	0.52	0.53	0.55
Manure management (Gg CO_2eq.)	141.05	145.70	161.20	164.3	170.50
Agricultural soils (Gg N_2O)	1.99	1.75	1.29	1.62	1.65
Agricultural soils (Gg CO_2eq.)	615.35	542.50	399.90	502.20	511.50
Total Gg N_2O	2.44	2.22	1.81	2.15	2.20
Total emissions from agriculture (Gg CO_2eq.)	1,035.49	934.11	820.45	943.87	987.55

The main source of emissions across the years is N_2O from agricultural soils, which constitute over half of total agricultural emissions, while the remaining sources of emissions are almost equally from enteric fermentation (CH_4) and from manure management (CH_4 and N_2O) (Figure 14).

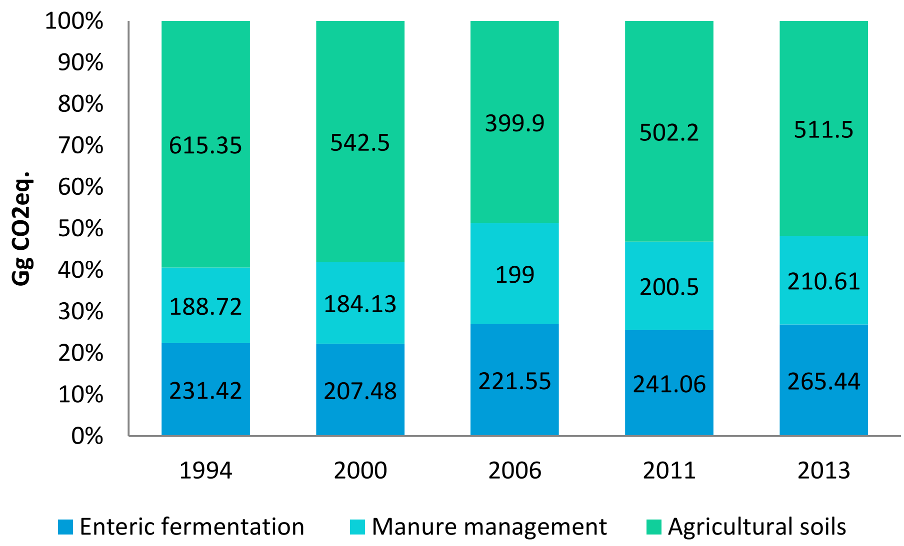

Figure 14: GHG emissions by agricultural source (Gg) and contribution (% of total from agriculture)

Enteric fermentation

Enteric fermentation is a major source of emissions within the agricultural sector. In 2013, it constituted 265.44 Gg CO_2eq., compared to 241.16 Gg CO_2eq. in 2011 and 221.55 Gg CO_2eq. in 2006. Dairy cattle are the main methane emission source for enteric fermentation, followed by sheep and goats (Table 47).

Table 47: Methane emissions from enteric fermentation for selected years

Species	1994	2000	2006	2011	2013
Dairy Cattle CH_4 (Gg)	5.16	3.89	4.39	5.50	6.71
Non-Dairy Cattle CH_4 (Gg)	2.08	1.82	1.58	0.72	0.64
Sheep CH_4 (Gg)	1.21	1.77	1.85	2.25	2.25
Goats CH_4 (Gg)	2.09	2.08	2.42	2.75	2.75
Camels CH_4 (Gg)	0.024	0.02	0.020	0.0092	0.0092
Horses CH_4 (Gg)	0.12	0.064	0.064	0.0047	0.072
Mules and Asses CH_4 (Gg)	0.26	0.197	0.197	0.20	0.2
Swine CH_4 (Gg)	0.052	0.026	0.010	0.0076	0.0053
Poultry CH_4 (Gg)	0.00	0.00	0.00	0.00	0.00
Total CH_4 (Gg)	11.02	9.88	10.55	11.48	12.64
Total CO_2eq. (Gg)	231.42	207.48	221.55	241.16	265.44

Manure management

In 2013, dairy cattle were also the largest contributor to CH_4 emissions from manure management (67%). They are followed by non-dairy cattle (9%) and poultry (12%) (Figure 15).

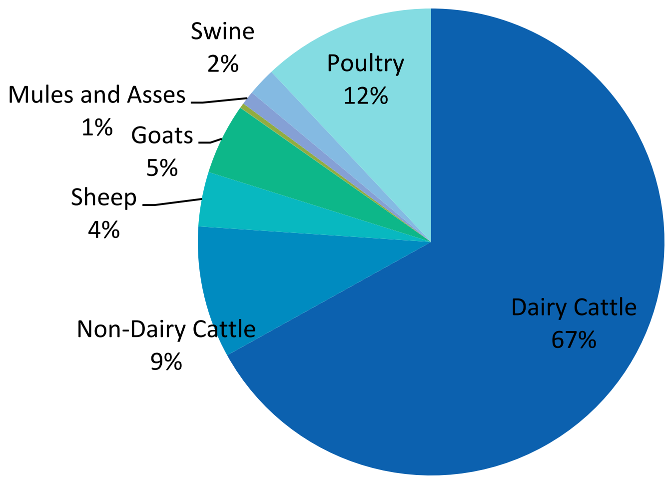

Figure 15: Distribution of methane emissions from manure management per selected species in 2013.

Nitrous oxide emission from manure management depends on how manure for each animal species is distributed between different Manure Management Systems (MMS). MMS utilized in Lebanon for different animal species and the fraction of manure nitrogen per species per MMS are presented in Table 34. Mainly, cattle manure is largely managed in solid storage and drylot, whereas sheep and goats are distributed between Pasture, Range and Paddock (PRP) and solid storage and drylot. Poultry manure is mainly managed with bedding and to a lesser extent without bedding (traditional chicken manure is included under PRP).

Nitrous oxide emissions from major MMS are presented in Table 48 below. Manure managed under solid storage and drylot, and poultry manure managed with bedding represent the largest sources of emissions (almost equally), since nitrogen excretions from manure managed in those two systems are the highest (Figure 16). Note that emissions from daily spread and from pasture, range and paddock are considered under emissions from agricultural soils and therefore not included in the calculations of N_2O emissions from manure management.

Table 48: Nitrous oxide emissions from major manure management systems utilized in Lebanon for selected years

	1994	2000	2006	2011	2013
Anaerobic lagoons N_2O (Gg)	0	0.00	0.00	0	0.00
Liquid systems N_2O (Gg)	0	0.00	0.00	0	0.00
Daily spread					
Solid storage & drylot N_2O (Gg)	0.28	0.24	0.26	0.27	0.29
Pasture range and paddock					
Poultry manure without bedding N_2O (Gg)	0.01	0.01	0.02	0.01	0.01
Poultry manure with bedding N_2O (Gg)	0.25	0.22	0.25	0.25	0.25
Total N_2O (Gg)	0.46	0.47	0.52	0.53	0.55
Total CO_2eq.	141.05	147.70	160.20	164.3	170.50

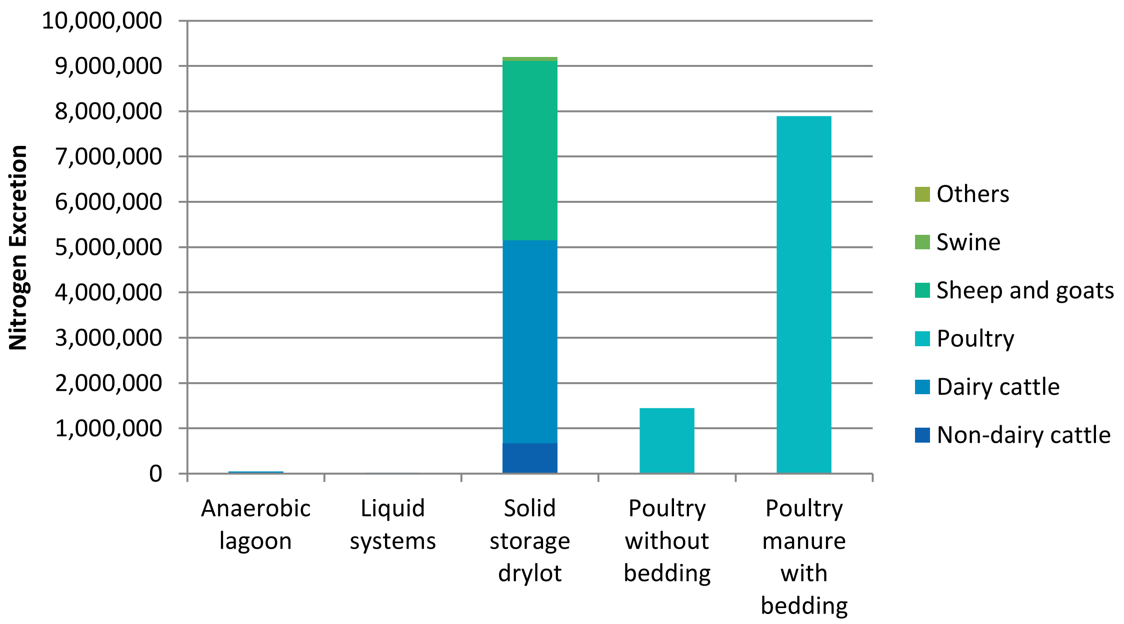

Figure 16: Amount of nitrogen (kg N/year) excreted from animals in different manure management systems in Lebanon in 2013

Agricultural soils

In 2013, 40% of total N_2O emissions from soils were due to indirect emissions, while direct emissions were 42%, and emissions from grazing (PRP) were 18%. Shares of subcategories from agricultural soils emissions remain fairly stable over the years as shown in Table 49. Figure 17 further disaggregates direct and indirect emissions into their subcategories for the year 2013. Leaching constitutes a much larger fraction (90%) than atmospheric deposition (10%). Leached nitrogen enters the groundwater, riparian areas, and rivers where it enhances biogenic production of N_2O. Emissions from this category are therefore directly linked to the use of N fertilizers, and they will vary accordingly. On the other hand, fertilizer use and animal waste are the main sources of direct emissions.

Table 49: Total emissions from agricultural soils and its subcategories in Lebanon for selected years

Year	Total direct emissions		Total indirect emissions		Emissions from animal grazing		Total N_2O emissions from soils	Total N_2O emissions from soils
	Gg N_2O	% total	Gg N_2O	% total	Gg N_2O	% total	Gg N_2O	Gg CO_{2eq}
1994	0.98	49	0.79	40	0.22	11	1.99	615.35
2000	0.81	46	0.70	40	0.24	14	1.75	542.50
2006	0.51	40	0.52	40	0.26	20	1.29	399.90
2011	0.68	42	0.65	40	0.29	18	1.62	502.20
2013	0.69	42	0.66	40	0.30	18	1.65	511.50

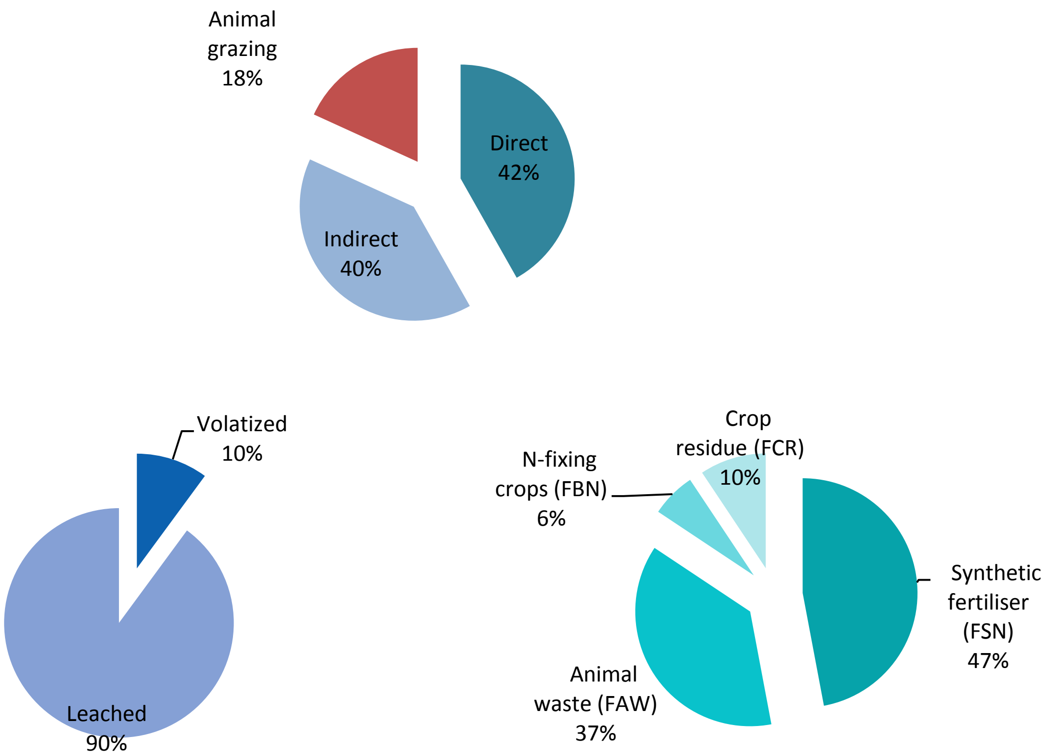

Figure 17: Contribution of subcategories to direct and indirect emissions from agricultural soils in 2013

2.4 Land use, land use change and forestry

Methodology and activity data

Selection of the appropriate tier level for the land categories and subcategories, non-CO_2 gases and carbon pools, was mostly based on the resources available for the inventory process. The representation of most land-use areas and land conversions was done following the Approach 3 which is a Tier 3 level methodology used in the selection of activity data. The top-level land categories which were considered in the change detection mapping were forest land, cropland, grassland, wetlands, settlements and other land. The definitions for these categories according to the National classification system based on the Land Cover / Land Use map of 1998 are listed in Annex IV.

Initial collection and calculation of the activity data (Annex IV**)** was conducted following three methodologies depending on the availability and type of country-specific data:

- Approach 3 within Intergovernmental Panel Climate Change Good Practice Guidance
- Surveys and personal communications
- Interpolations and extrapolation

The abbreviations FF, GG, CC, WW, SS, OO denoted land-use categories undergoing no conversions; and the abbreviations LF, LG, LC, LW, LS, LO denoted land conversions to these land-use categories (Annex IV). Overall, land categories and subcategories were accounted for in the inventory estimation depending on data availability.

Table 50: Land use categories and subcategories, carbon pools and non-CO_2 gases accounted for in the inventory estimation of the LULUCF sector in Lebanon

Land use categories	Subcategories	Estimations calculated[1]	Not Estimated (NE)/No activity data available	Assumptions
Forest land	Forest land remaining forest land	Estimated	-	-
	Land converted to Forest land	Other land converted to Forest land through afforestation/ plantations	Grassland and Cropland converted to Forest land	No Settlements converted to Forest land
Cropland	Cropland remaining Cropland	Estimated		
	Land converted to cropland	-	Forest land, Grassland and Other land converted to Cropland	No Settlements converted to Cropland
Grassland	Grassland remaining Grassland	Estimated	-	-
	Land converted to Grassland		Cropland, Forest land and Other land converted to	No Settlements converted to Grassland

Land use categories	Subcategories	Estimations calculated[1]	Not Estimated (NE)/No activity data available	Assumptions
			Grassland	
Wetland	Wetland remaining Wetland	-	-	Estimations not required for calculation[2]
	Land converted to Wetland	Grassland converted to Wetland	-	No Cropland, Forest land, Settlements or Other lands that are converted to Wetlands
Settlement	Settlements remaining Settlement			Estimations not required for calculation[2]
	Land converted to Settlements	Forest land, Grassland and Cropland converted to Settlements	Other land converted to Settlements	-
Other land	Other land remaining Other land	-	-	Typically unmanaged in reference to GPG (IPCC, 2003-p.3.145)
	Land converted to Other land	-	Forest land, Grassland and Cropland converted to Other land	No Settlements converted to Other land

[1] Estimations are calculated for the following carbon pools and non-CO_2 gases depending on data availability: AGB, BGB, DOM, litter and soil carbon; CH_4, N_2O, CO and NO_x
[2] Lebanon is considered as non-Annex I Party in the UNFCCC convention.

GHG emissions and removals reported from the LULUCF sector in Lebanon are respectively caused by biomass losses and increments and by variation in soil carbon stocks from the different land use and land use change categories which were taken into consideration in this work (**Table 51**).

Table 51: Causes of GHG emissions and removals reported for the LULUCF sector in Lebanon

Biomass losses	Biomass increments	Increase in soil carbon stocks and litter
Forest converted to settlement	Growth of forest lands	Afforestation
Grassland converted to settlement		
Cropland converted to settlement	Growth of croplands (Perennial crops)	
Burned forest lands		
Burned croplands (perennial crops)		
Burned grasslands	Growth of lands converted to forests or plantations (Afforestation)	
Fuelwood gathering from forests		

Almost all burned areas in Lebanon have resulted from human-caused fires. It is not easily possible to have natural causes of fires such as lightning due to the coincidence of lightning with the start of the wet season.

Emission factors and other parameters

Collection of the Emission/Removal (E/R) factors was done following two methodologies according to the availability and type of data:

- Tier 1: IPCC GPG default data or assumptions
- Tier 2: Country-specific data from global databases, literature or surveys, and personal communications

A complete list of the E/R factors investigated and reported in reporting tables for the calculation of GHG emissions and removals from 1994-2013 is provided in Annex IV. E/R factors were collected or calculated (by averages and extrapolations) for each category depending on the disaggregation level required by the GHG emission/removal calculation method and depending on the data availability. Detailed calculations, values and sources of all the E/R factors are reported and documented in the UNFCCC reporting tables.

Results

In 2013, LULUCF acted as a greenhouse gas sink in Lebanon, with net removals equal to -3,368.86Gg CO_2 (Table 52). Indeed, Lebanon's wide forest cover still represents a significant CO_2 sink, although a downward trend in sink capacities have been observed in recent years due to deforestation, forest fires and most importantly, urbanization.

Table 52: Lebanon's GHG emissions/removals summary from the LULUCF sector for 2013

	CO_2 emissions Gg	CO_2 removals Gg	CH_4 emissions Gg	N_2O emissions Gg	Total emissions Gg CO_2 eq.
Land use, land use change and forestry	149.67	-3,518.80	0.01094	0.00014	**-3,368.86**
A. Forest land	0.00	-2,296.94	0.01066	0.00013	**-2,296.67**
1. Forest land remaining forest land		-2,210.73			-2210.73
2. land converted to forest land		-86.21			-86.21
B. Cropland	**0.00**	**-1,221.86**	**0.00**	**0.00**	**-1,221.86**
1. Cropland remaining cropland		-1,221.86			-1,221.86
2. Land converted to cropland					0.00
C. Grassland	**0.00**	**0.00028**	**0.00001**	**0.00**	**0.01**
1. Grassland remaining grassland		0.00028	0.00001		0.00
2. Land converted to grassland					0.00
D. Wetlands	**0.04**	**0.00**	**0.00**	**0.00**	0.04
1. Wetlands remaining wetlands					0.00
2. Land converted to wetlands	0.04				0.01
E. Settlements	**149.63**	**0.00**	**0.00**	**0.00**	**149.63**
1. Settlements remaining settlements					
2. Land converted to settlements	149.63				149.63
F. Other land	**0.00**	**0.00**	**0.00**	**0.00**	0.00
1. Other land remaining other land					
2. Land converted to other land					

Results reflect calculations of emissions from LULUCF based on 2003 GPG for LULUCF.

Numbers may reflect rounding.

The main categories that are contributing significantly to the emissions/removals in LULUCF are the conversion from forest land, crop land and grassland to settlements. These are mainly driven by the following factors:

- Unregulated urban sprawl
- Active market of the real estate sector
- Absence of clear zoning
- Expansion and improvement of the road networks in rural areas
- Improvement of public and private services in rural areas
- Lack of interest of owners of cropland, forest land and grassland in keeping such type of lands due to increase in land prices and increase demand for commercial and residential development projects
- High costs of labors to maintain croplands
- Lack of a market for the agricultural products
- Degrading financial situation of citizens (selling agricultural lands and grasslands which are eventually converted to urbanized areas)

It is important to note, however, that the reported numbers of annual conversion to settlement accounted only for the annual sum of any conversion that is above 90 to 100 m^2. This was mainly due to the spatial resolution of the employed satellite imagery. Counting the changes that are below 90 m^2 can slightly increase the total areas of conversion to settlement.

Table 53: Changes in emissions/removals in 2013

Type of change		Change in area (ha)	CO_2 emissions/removals (Gg)
Forest to settlements	Coniferous	48.62	+11.94
	Broadleaf	258.75	+57.87
	Mixed	49.56	+11.63
Cropland to settlements	Perennial	265.25	+61.27
	Annual	329.37	+6.04
Grassland to settlements		296.687	+0.87
Fuelwood gathering (m^3)		18,769 m^3	+26.8
Forest land remaining forest land (difference between 2012 and 2013)		-356.94	+3.15
Afforestation (Cumulative)		3,597.56	-86.20

Further observations showed that broadleaf forests were the most affected by land conversion to settlements. This was mainly the result of the relatively large extent of broadleaf forests in the country and the fact that urbanization most likely occurs more on shrubland (mostly broadleaf vegetation) than on forested areas.

Conversions to settlements have also affected croplands and grasslands. It is easier, however, to convert annual crops than removing perennial crops (mainly comprising fruit trees and orchards). Conversions of cropland and grassland to settlements might be related to the lack of interest of owners in keeping such type of lands (e.g. increase in land prices related to an increasing number of population, increasing demand for development projects), high costs of labors and lack of a market for the agricultural products, and degrading financial situation of citizens (selling agricultural lands and grasslands which were eventually converted to urbanized areas). This has been at least confirmed for artificialized cropland on the Lebanese coast.

The total estimate for fuelwood gathering in 2013 was 18,769 m^3, a quite constant number over the inventory time period resulting in an average CO_2 emission of about 27 Gg/yr. Moreover, a decrease of 0.14% in forest lands from 2012 was shown in 2013, which is was mainly attributed to urbanization resulting in a decrease in CO_2 removals from forest areas by 12.1 Gg. Afforestation activities in 2013 covered a total area of 302.62 ha of forests leading to a cumulative increase in CO_2 removal of 86.20 Gg in 2013.

The main source of GHG emissions in 2013 was wildfires affecting forest land, cropland and grassland, with forest lands being the main target of these fires (Table 54).

Table 54: Emissions from burned areas in 2013

Type		Burned areas (ha)	CO_2 emissions (Gg)	CH_4 emissions (Gg)	N_2O emissions (Gg)
Forest	Coniferous	4.75	+0.68	+0.01066	+0.00013
	Broadleaf	44.25	+5.79		
	Mixed	78.56	+10.78		
Cropland[1]	Annual	NE	NE	NE	NE
	Perennial	9.56	+2.20	NE	NE
Grassland[2]		37.88	NE	+0.00028	+0.00001

[1] CH_4 and N_2O emissions from croplands are not accounted for in the GPG for LULUCF since the source of these types of emissions are mainly agricultural activities (fertilization, livestock, burning, etc.). These are included in the agricultural sector.

[2] CO_2 emissions from burned grasslands are not accounted for in Tier 1 of the IPCC GPG for LULUCF, since it is assumed that there is a balance in biomass stocks of grasslands. Burned lands are only calculated for perennial crops.

In 2013, forests followed by croplands had the largest contribution to CO_2 emissions/removals in the LULUCF sector in Lebanon (Figure 18).

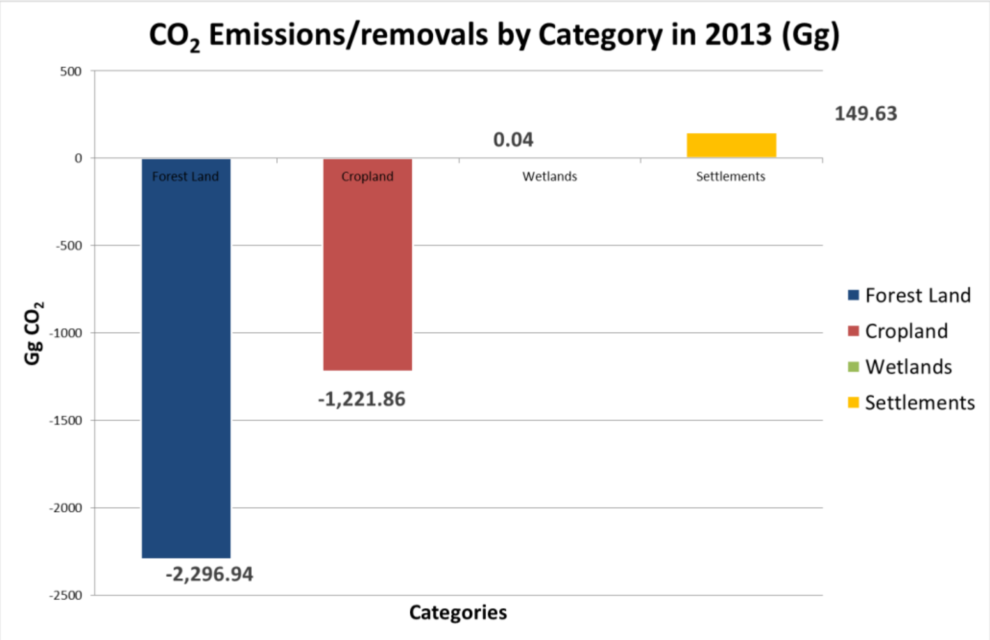

Figure 18: CO_2 emissions/removals by category in 2013.

Table 55 shows for selected years a summary of the total CO_2 and non-CO_2 emissions/removals in Gg CO_2 equivalent from the LULUCF sector.

Table 55: Lebanon's GHG emissions/removals summary from the LULUCF sector for the period 1994-2013 (for selected years)

GHG emissions/removals of the LULUCF sector	1994*	2000	2005	2010	2013
CO_2 (Gg)	-3450.84	-3221.29	-3303.30	-3218.00	-3369.12
CH_4 (Gg)	NE	0.03	0.04	0.04	0.01094
CH_4 (Gg CO_2 eq.)	NE	0.57	0.74	0.81	0.22974
N_2O (Gg)	NE	0.00	0.00	0.00	0.00014
N_2O (Gg CO_2 eq.)	NE	0.11	0.14	0.16	0.0434
NO_x (Gg)	NE	0.00	0.00	0.01	0.00149
CO (Gg)	NE	0.41	0.52	0.59	0.16316
Total emissions (Gg CO_2 eq.)	NE	0.68	0.88	0.97	0.2731
Total removals (Gg CO_2)	-3450.84	-3221.29	-3303.30	-3218.00	-3369.12
Net GHG removals (Gg CO_2 eq.)	-3450.84	-3220.61	-3302.42	-3217.03	-3368.85

*NE: Not Estimated. No activity data about burned areas from 1994-1998 resulting in no data about total emissions during this period.

2.5 Waste and wastewater

Methodology

According to the IPCC guidelines, the source category "waste" covers emission from disposal and discharge of both solid waste and wastewater, while differentiating between the various management options. The fundamental basis for the inventory methodology rests upon three assumptions:

1. The flux of methane (CH_4) to the atmosphere is assumed to be equal to the sum of emissions from solid waste disposal sites and wastewater treatment, and emissions from waste incineration (considered to be negligible).
2. The flux of nitrous oxide (N_2O) to the atmosphere is assumed to be equal to the sum of emissions from wastewater treatment and emissions from waste incineration.
3. Carbon dioxide (CO_2) can be estimated by first establishing the rates of organic content in waste incinerated.

Based on the availability and level of aggregation of the information on waste and wastewater characteristics in Lebanon, the tier 1 method was adopted for the emissions calculations.

Activity data –Solid waste

Data on solid waste generation is not readily available and where available, information is disaggregated (by site, operator, local authority, etc.), decentralized and often reported in hard copy reports making any manipulation and analysis time consuming and difficult. Furthermore, solid waste amounts are generally estimated based on population and generation rate per capita estimations and not on direct weighing and monitoring of collected solid waste from households and institutions. Surveys and assessment conducted for the years 1994 (El Fadel and Sbayti, 2000), 2006 (CDR, 2006), and 2010 (MoE, 2010) produced generation rates for these respective years. Due to the increased migration from rural to urban areas and major cities during the past 20 years, a significant increase in the quantity of waste in Beirut and Mount Lebanon (excluding Jbeil Caza which is served by a private waste collection operator) took place over the last years. The estimated quantities of municipal solid waste generated within the Greater Beirut Area and Mount Lebanon in year 2013 was estimated to be 2,850 tonnes/day, compared to 2000 tons/day back in year 1999 (SWEEP-net, 2014).

The data collection for this GHG inventory (was conducted using several references and studies that helped retrieving basic information to start building up the model. This information was mainly based on population statistics, waste statistics, review of literature made available through national reports and publications and personal communication. In addition, expert consultation meetings were held in order to validate assumptions and findings. Extrapolations and interpolations were used when data was unavailable.

Table 56: Activity data for solid waste emissions calculations

Population	Population includes: - Lebanese residents in 2013 was extrapolated from published surveys from CAS for the years 1997, 2004 and 2010 - Foreign workers (Approx. 840,000 in 2013) as per CAS - Palestinian refugees (calculated as 441,000 in 2013) as per the United Nations Relief and Works Agency - Syrian displaced starting 2012 were retrieved from official yearly publicationsby the UNHCR (UNHCR, 2013) Interpolation and extrapolation were performed using a growth rate of 1.65% as commonly used in studies for World Bank (World Bank, 2011; SWEEP-Net, 2010).
Per capita waste generation rate	The generation rate for the Lebanese population, including foreign workers and Palestinian refugees, was extrapolated based on publications issued for the years 1994 (El Fadel and Sbayti, 2000), 2006 (CDR, 2006), and 2010 (MoE, 2010). For other years, rates were calculated by extrapolation and interpolation. The generation rate used for Syrian displaced was adapted from Lebanon Environmental Assessment of the Syrian Conflict. The waste generation rate for the Lebanese population (including foreign workers and Palestinian refugees) is 1.05. The rate for Syrian displaced varies between 0.47 for the bekaa region, 0.5 for the south, 0.51 for the north and 0.53 for Beirut and Mount Lebanon (MoE/EU/UNDP, 2014).
Municipal solid waste generation	Waste generation for the years 1994 through 2013 was calculated based on the "per capita waste generation rate" (tonnes/capita/year) and the population (capita and refugees) for each year respectively.
Municipal solid waste disposed in Solid Waste Disposal Sites (SWDS)	4 "managed" Solid Waste Disposal Sites (SWDS) are considered in Lebanon: Naameh ,Zahle ,Tripoli and as of 2013, Saida. 3 other landfills in Minieh, Nabatieh and Baalbeck have partially received waste during 2013, 2014 and 2015. Information on the waste quantities landfilled/dumped in these sites was retrieved from the managing entities of these landfills: LACECO reports for the Naameh Landfill, Moores for the Zahle landfill, BATCO for Tripoli landfill, Sidon Environmental for Saida and OMSAR for Minieh, Baalbeck and Nabatieh. Waste quantities generated by Syrian displaced were adapted from Lebanon Environmental Assessment of the Syrian Conflict (MoE/EU/UNDP, 2014).
Open dumpsites	In 2011, a detailed survey was conducted on dumpsites in Lebanon (MoE, UNDP, ELARD,

	2011). The study was used as a basis for analysis on the status of dumpsites in Lebanon and for emission factors estimations in 2013.
Percentage of treatment (composted, recycled, reused)	The information provided by personal communications with the MoE on the operational solid waste treatment facility was the base for calculating the percentage of waste composted, recycled and reused (MoE, 2017c).
Health care waste (HCW)	The portion of HCW incinerated was retrieved from MoE and extrapolated for the period 1994-2013. Autoclaving conducted by Arcenciel and specifically operations as of the year 2003 significantly reduced the amount of waste incinerated. It should be highlighted however that incineration is still conducted at various medical establishments without permits or monitoring.
Quantity of recovered gas	The information of recovered gas in the operational landfills was provided from the supervising consultants' reports for each of the landfills through MoE. Only methane recovered from the Naameh landfill have been considered in this inventory.
Exported quantities	Quantities of waste exported are minimal and are mainly composed of hazardous material. These amounts have not been taken into account in the calculation of CH_4 emissions from waste disposal mainly due to their composition.

Table 57: Main data collected and computed for solid waste

Year	Population	Waste generation rate (kg/cap/d)	Total waste generated (Gg/yr)	Quantity of recovered CH_4 (Gg)	% deposited in SWDS	% recycled reused composted
1994	3,863,542	0.83	1,170.46	0	96%	4%
2000	4,262,161	0.90	1,400.12	0	89%	11%
2006	4,701,909	1.00	1,716.20	10.94	87%	13%
2011	5,102,830	1.05	1,955.66	16.11	85%	15%
2013	6,131,254[1]	0.47-1.05	2,177.72	18.14	83%	17%

[1] This includes 5,272,613 as Lebanese population and 858,641 as Syrian displaced

Table 58: Solid waste generation and disposal considered for Syrian Displaced for the year 2013

Mohafaza	Registered Syrian Displaced[1]	Solid waste Generation rate (kg/refugee/day)	Solid waste generation (kg/year)	Solid waste disposal (tonnes/year)	
Beirut ML	223,249	0.53	43,187,519	43,187.52	Naameh landfill
North	250,128	0.51	46,561,327	12,571.56	Tripoli landfill[2]
				33,989.77	Open dumps
Bekaa	280,110	0.47	48,052,871	24,026.44	Zahleh landfill[3]
			-	24,026.44	Open dumps
South	105,154	0.5	19,190,605	19,190.61	Open dumps
Total	**858,641**		**156,992,322**		

[1] Including Syrian displaced, Palestine Refugees from Syrian and returning Lebanese

2 Tripoli landfill receives 27% of the waste generated in North Lebanon. The remaining quantities are disposed of in open dumps

3 Zahleh Landfill receives 50% of the waste generated in the Bekaa. The remaining quantities are disposed of in open dumps.

Source| adapted from MoE/EU/UNDP, 2014

The calculation of methane generated from solid waste disposal sites based on the use of the Methane Correction Factor (MCF) available by the IPCC (IPCC, 2007) taking into account the different SWDS categories. Naameh, Tripoli, Zahleh and Saida landfills are categorized as Managed, with an MCF of 1. The 504 unmanaged dumpsites are classified between deep and shallow, as per the data available by MoE/UNDP/ELARD (2011). It is worth noting that some dumpsites were classified as shallow in this study despite having a depth of ≥ 5 m since they were reported to be regularly on fire, thus losing potential methane generation. Total amounts of waste received by the different managed and unmanaged classes are presented in Table **59** and Table 60.

Table 59: Description of SWDS categories

SWDS Category	MCF	Description
Managed	1	- Sufficient depth - High compaction with suitable equipment - Properly designed and well-operated leachate and storm water systems - Proper site management with no scavenging at the operational area - Control of incoming waste types and quantities and environmental monitoring schemes established - Frequent surface covering - Prevention of landfill fires, litter and scavenging animals - Gas control and extraction/recovery
Unmanaged – deep (≥ 5 m waste)	0.8	- Sufficient depth - High compaction - Anaerobic degradation conditions in substantial or all parts of the sites - Poor and light operational equipment - Scavenging by people and animals
Unmanaged – shallow (< 5 m waste)	0.4	- Poor and light operational equipment - Scavenging by people and animals - Aerobic degradation conditions in substantial or all parts of the sites, - Frequent fires, often used deliberately and systematically mainly to reduce volumes and to "get rid of" the SW

Source| IPCC, 2007

Table 60: Proportion of waste received by each category of unmanaged sites

	Proportion of waste (by weight) for each type of SWDSs [1]		
Year	Managed	Unmanaged – deep (≥5 m waste)	Unmanaged – shallow (< 5 m waste or >=5 m with open burning)
1994	0.00	0.31	0.69
2000	0.54	0.14	0.31
2006	0.56	0.14	0.30
2011	0.65	0.11	0.24
2013	0.65	0.11	0.24

[1] it is considered that 31% of open dumpsites are unmanaged-deep and 69% are unmanaged-shallow (by weight) (MoE/UNDP/ELARD, 2011).

As for health care waste, a new sectoral assessment on industrial and unintentionally released POPs was prepared by the Ministry of Environment in 2017. The inventory updated the amount of health care waste being incinerated since 2004 based on a field survey with hospitals, which necessitated the recalculation of CO_2 emissions from waste incineration to preserve a time-series consistency.

Table 61: Quantities of medical waste being incinerated

	2004	2006	2009	2011	2013
Medical waste (tonnes/year)	330	284	219	216	57

Source | MoE/UNEP/GEF, 2017

Activity data -Wastewater

Limited information is available in Lebanon with regards to wastewater generation rates, treatment percentages and discharge media. Therefore, all of the activity data relies on assumptions and estimation that are either made for this inventory or adopted from other publications.

Table 62: Activity data and assumptions made for wastewater emissions calculations

Wastewater quantities	Wastewater quantities are estimated based on the degradable organic content (kg BOD/1000 persons) of the Lebanese population. Calculations take into account Syrian displaced located in Lebanon, where it is assumed that the same wastewater discharge practices are adopted.
Wastewater management	There is no large-size wastewater treatment plan (WWTP) that is currently operational in Lebanon. Some small size rural WWTPs are reported to be partially operational and/or their efficiency questioned. These are therefore not considered in this inventory.
Wastewater discharge	The discharge media of wastewater considers only three options: river discharge, septic tank and sea. Discharge percentages were computed based on the percentage of households' sewerage connections onto the networks vs. connections to septic tanks as published by CAS in 2009. This was complemented by overlaying GIS layers showing population data in various regions in Lebanon to calculate the percentage of the wastewater discharged in the different media. It is assumed that the inside regions in Lebanon (Bekaa) discharge into rivers and/or septic tanks and coastal zones discharge into sea and/or septic tanks.
Industrial Wastewater	In Lebanon, quantities of industrial wastewater generated from the industrial sector are not available. Relevant studies estimate it as 20% of municipal wastewater generation, which is also the assumption made for this inventory (MoEW, 2010a) Industrial wastewater is generally discharged either in sewers that release wastewater directly in the sea without treatment or directly in rivers. Therefore, and based on the geographic distribution of industries between coastal and inland area, it is considered in this inventory that 85% of industrial wastewater is discharged in the sea and 15% in rivers (MoInd, 2015) Since there is limited information on the wastewater generation per type of industry, its Chemical Organic Demand content could not be determined. Therefore, the degradable organic component of municipal wastewater is used.

Table 63: Specific data for wastewater

Year	Population	Degradable Organic Component (kg BOD/1000 Pers)	Total Organic Wastewater generated (kg BOD/yr))	Wastewater generation incl. industrial [3] (kg BOD/yr)	Discharge in Rivers (%)	Discharge in septic tanks (%)	Discharge in sea (%)
1994	3,863,542	23700	91,565,935	109,879,122	0.15	0.26	0.59
2000	4,262,161	23700	101,013,224	121,215,869	0.15	0.26	0.59
2006	4,701,909	23700	111,435,234	133,722,281	0.15	0.26	0.59
2011	5,102,830	23700	120,937,071	145,124,485	0.09	0.28	0.63
2013	6,131,254[1]	23700[2]	145,310,711	174,372,853	0.09	0.28	0.63

[1] This includes 5,272,613 as Lebanese population and 858,641 as Syrian displaced (UNHCR, 2013)
[2] considered to be the same for Lebanese population and Syrian displaced
[3] industrial wastewater adds a load of 20% on the domestic wastewater

Emission factors

For the calculation of GHG emissions from solid waste, the following tables show the parameters and the methane correction factor used for each type of disposal site. The main source of information for the SWDS parameters and MCF used is the IPCC (2000) considering the unavailability of country specific and site-specific data.

Expert judgment was used to estimate some of the parameters in the cases where ranges were provided in the guidelines or in the cases where no clear provision is taken in the guidelines. These parameters were discussed and validated during the expert consultation meeting.

Based on the recommendations of the inventory review of the first BUR, the fraction of degradable organic carbon (DOC) which actually degrades (DOCf) used for Lebanon was estimated inconsistent with the IPCC Good Practice Guidance. It was suggested use the value 0.5 instead of 0.77 and revise estimates. The fraction of DOC which actually degrades has been changed accordingly.

Table 64: Parameters adopted for methane generation from MSW

Parameters	Values
Fraction of DOC in MSW (%)	17
Fraction of DOC which actually degrades (%)	50
Fraction of carbon released as CH_4 (%)	50
CH_4 oxidation correction factor (%)	0

Source | IPCC, 2000

Table 65: Methane correction factor from SWDS

Type of site	CH_4 correction factor
Managed	1.0
Unmanaged – deep (>= 5 m waste)	0.8
Unmanaged – shallow (< 5 m waste)	0.4

Source | IPCC, 2000

Table 66: Incineration default values considered for HCW and municipal waste

Incineration default values			Source
	MSW	HCW	
Carbon content of waste (%)	40	60	(IPCC, 2000)
Fossil carbon as % of total carbon	40	40	(IPCC, 2000)
Efficiency of combustion	95	95	(IPCC, 2000)
CH_4 Emission Factor (EF) (%)	0	0	
N_2O emission factor (kg N_2O/Gg waste (dry))	400	0	(CDR, Ramboll, 2012)

Table 67: Wastewater parameters and conversion factors

Parameters	Value	Source
Degradable organic component (kg Biological Oxygen Demand (BOD)/1000pr/yr)	23,700	Expert judgment
Fraction of degradable organic component removed as sludge (%)	0	Expert judgment
CH_4 conversion factor for river discharge (0 to 1)	0.1	Expert judgment
CH_4 conversion factor for septic tank (0 to 1)	0.3	Expert judgment
CH_4 conversion factor for sea (0 to 1)	0.2	Expert judgment

Maximum CH_4 producing capacity (kg CH_4/kg BOD)	0.6	(IPCC, 2007)
EF (kg CH_4 / kg BOD) for treatment system	-	(No treatment considered)
CH_4 recovered or flared (%)	0	
Organic content loading kg BOD/1000pr/yr)[1]	23,700	

[1] This was used as the degradable organic component of the wastewater, equivalent to around 65 g of BOD per liter of wastewater based on the design of treatment plants in Lebanon.

Table 68: Wastewater methane emission factor for commercial and domestic wastewater

Wastewater Handling System	**Fraction of Wastewater Treated by the Handling**	**Methane Conversion Factor for the Handling**	**Product**	**Maximum Methane Producing Capacity**	**Emission Factor for Domestic/Commercial Wastewater**
	System	System		(kg CH_4/kg BOD)	(kg CH_4/kg BOD)
River Discharge	0.09	0.1	0.01		
Septic Tank	0.28	0.3	0.08		
Sea	0.63	0.2	0.13		
		Aggregate MCF:	0.22	0.6	0.13

Table 69: Wastewater methane emission factor for commercial and domestic wastewater

Wastewater Handling System	**Fraction of Wastewater Treated by the Handling**	**Methane Conversion Factor for the Handling**	**Product**	**Maximum Methane Producing Capacity**	**Emission Factor for Domestic/Commercial Wastewater**
	System	System		(kg CH_4/kg BOD)	(kg CH_4/kg BOD)
River Discharge	0.15	0.1	0.02		
Sea	0.85	0.2	0.17		
		Aggregate MCF:	0.19	0.6	0.11

Table 70: Parameters used for N_2O emissions calculation

Parameters	**Values**	**Source**
Per capita protein consumption (protein in kg/person/yr)	25 to 30	Food and Agriculture Organization (FAO) reports for the years 1990-2007
Fraction of nitrogen in protein (kg nitrogen (N)/kg protein)	0.16	(IPCC, 1997)
Amount of sewage N applied to soils as sewage sludge (kg N/yr)	0	
EF (kg N_2O-N/kg sewage-N produced)	0.005	(IPCC, 1997)

Results

In 2013, activities related to the generation and treatment of solid waste and wastewater emitted 1,826.7 Gg CO_2eq., thus contributing to 7% of Lebanon's total GHG emissions. CH_4 emissions are mainly generated from solid waste disposal, N_2O emissions from the discharge of wastewater effluents into aquatic environments, while CO_2 gases are mainly emitted from the health care waste incineration.

Table 71: Greenhouse gas emissions from solid waste and wastewater per gas in 2013

	CO_2	CH_4		N_2O		Total CO_2eq.
	Gg	Gg	Gg CO_2eq.	Gg	Gg CO_2eq.	Gg CO_2eq.
Solid waste*	0.05	60.91	1,279.14			1,279.14
Wastewater	0.00	19.09	400.97	0.47	146.51	547.47
Total	0.05	80.00	1,680.11	0.47	146.51	1,826.67

*including waste incineration

The results of the inventory show that GHG emissions are highly dependent on emissions from solid waste generation and management activities, constituting more that 80% of the sector's emissions. CH_4 is the main greenhouse gas emitted by these activities due to high proportion of waste being disposed in dumpsites coupled to low methane recovery rates. As for the CO_2 emissions from incineration, they are insignificant compared to emissions from other disposal methods since autoclaving has become the most used method for treating health care waste in Lebanon. Emissions of N_2O are mainly linked to wastewater generation and disposal, whether it is discharged in rivers, sea or septic tanks.

3 Key category analysis

Key category analysis is performed in accordance with GPG 2000 and GPG-LULUCF 2003 guidelines. Key categories under the guidelines are sectors whose emissions when summed in descending order of magnitude, add up to 95% of total greenhouse gas emissions. 8 categories have been identified as key in the analysis, with CO_2 being the main gas and the energy sector being the main key category. Key categories have remained the same throughout the 1994- 2013 period. The results of key category analysis are shown in Table 72.

Table 72: Key category analysis for 2013

Sector	Source categories	GHG	Emission estimate (Gg CO_2eq.)	Level assessment (%)	Cumulative total (%)
Energy	CO_2 mobile combustion: energy industries	CO_2	7,367.39	28.05%	28.05%
Energy	CO_2 mobile combustion: road vehicles	CO_2	5,977.51	22.76%	50.80%
Energy	CO_2 emissions from manufacturing industries and construction	CO_2	4,403.84	16.76%	67.57%
Industrial processes	CO_2 emissions from cement production	CO_2	2,539.54	9.67%	77.23%
Energy	Other sectors: commercial CO_2	CO_2	2,234.11	8.50%	85.74%
Waste	CH_4 emissions from solid waste disposal sites	CH_4	1,279.14	4.87%	90.61%
Energy	Other sectors: residential CO_2	CO_2	5,46.20	2.08%	92.69%
Agriculture	N_2O (direct and indirect) emissions from agricultural soils	N_2O	511.50	1.95%	94.63%

4 Trend analysis

Lebanon has already prepared national GHG inventories as part of national communication and biennial update report processes and has produced and updated its numbers since 1994. In light of new activity data, improved methodologies and revised emission factors, the inventory has gone through 2 recalculation exercises: one for the Third National Communication (TNC) which resulted in changes in the transport, agriculture, and waste sectors and one for this second BUR which mainly affected the results of the waste sector's emissions. The GHG emissions for the period 1994-2013 have therefore changed twice, reducing emissions by 3% to 5.5% across period, hence modifying Lebanon's business-as-usual emission trajectory. Table 73 and Table 74 present the changes in emissions caused by recalculations and Annex V provides additional details on sectoral recalculations.

Table 73: Changes in national emissions after recalculation

Year	Emissions reported in TNC (Gg CO_2 eq.)	Emissions reported in BURII (Gg CO_2 eq.)	Percent change
1994	13,947	13,185	-5.46%
2000	17,062	16,288	-4.54%
2006	18,790	17,890	-4.79%
2011	24,653	23,743	-3.69%
2012	26,333	25,550	-2.97%

Table 74: Changes in emissions of the year 1994 after recalculations

Emissions (Gg CO_2eq.)	1994	1994 recalculated in BURI	1994 recalculated in BUR II	Reasons for recalculation
Energy	7,743	7,743	7,833	Change fuel type from coking coal to petroleum coke
Transport	3,991	1,571	1,577	Change from tier 1 to tier 2 methodology Addition of GHG emissions from domestic aviation
Industrial processes	1,924	1,924	1,924	
Agriculture	1,130	1,037	1,035	Change in activity data
LULUCF	210	210 -3,450	54 -3,450	Change from approach 1 to approach 3 methodology
Waste	902	1462	762.36	Change in activity data in solid waste and health care waste quantities Change in fraction of DOC which actually degrades
Total	15,900	13,947	13,186	

Table 75: Trend of emissions during the period 1994-2013

	Total GHG emissions (Gg CO_2eq.)	Energy (Gg CO_2eq.)	Transport (Gg CO_2eq.)	Industry (Gg CO_2eq.)	Agriculture (Gg CO_2eq.)	Land Use and Forestry (Gg CO_2eq.)	Waste (Gg CO_2eq.)
1994	13,186	7,833	1,577	1,924	1,035	-3,450	762
2013	26,285	14,617	6,158	2,545	987	-3,519	1,827
% change 1994-2013	99%	87%	291%	32%	-5%	-2%	140%

Average % change/year	5.23%	4.56%	15.30%	1.70%	-0.24%	-0.13%	7.35%

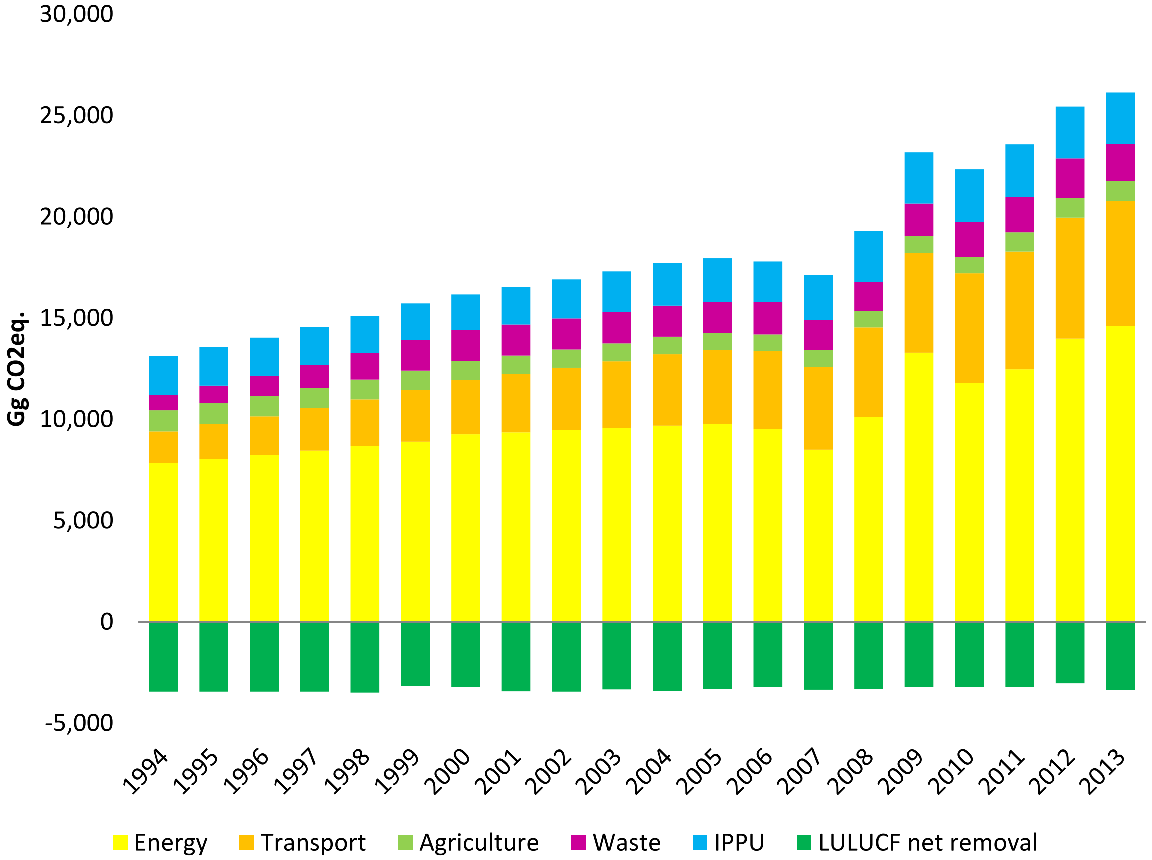

Figure 19: Trend in GHG emissions 1994-2013

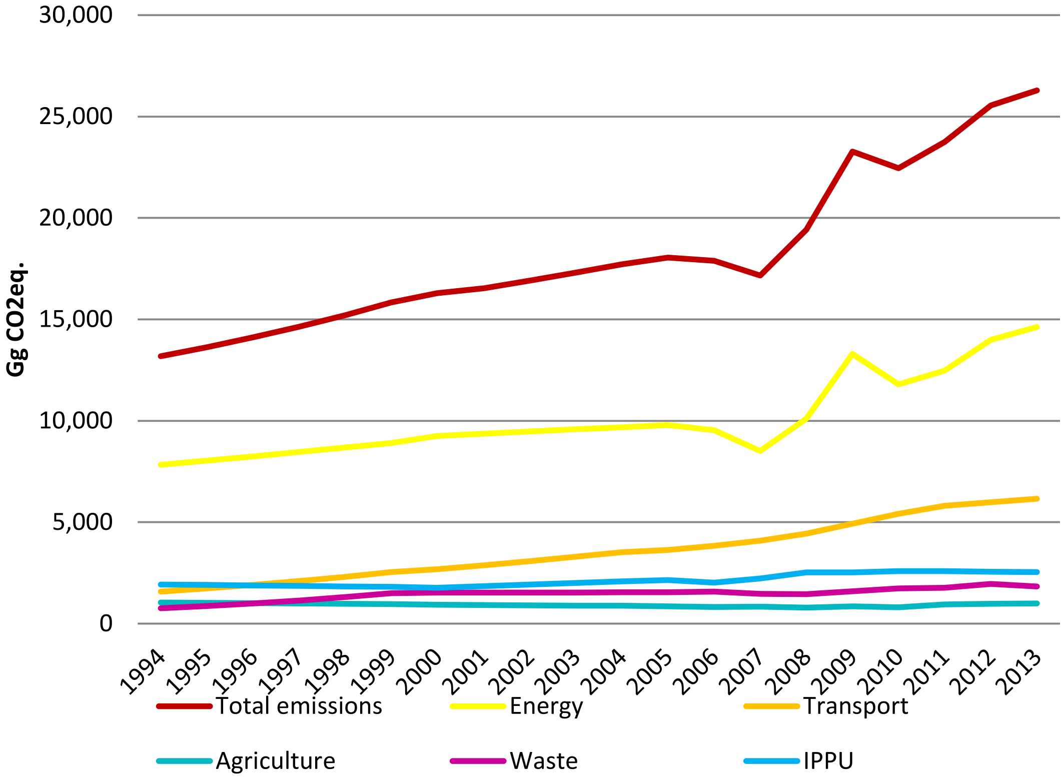

Figure 20: Trend of GHG emissions 1994-2013

Lebanon's GHG emissions are increasing at an average rate of 3.4% every year, which lead to a doubling of emissions since 1994. As shown in Figure 20, the trend of increase in total GHG emissions closely follows the trend of emissions from the energy sector, which constituted 53% to 59% of total emissions during this period. This significant growth in emissions reflects the growing demand for electricity, due in part to the changing socio-economic conditions and to the expansion of the national grid. In fact, the sharp increase noticed between the 1994 and 2000 emissions is due to the increase in gas/diesel oil consumption that accompanied the installation and operation of the Baalbeck, Tyre, Beddawi and Zahrani diesel power plants during this period.

However, emission growth did not follow a stable trend, as it witnessed 2 detectable drops in 2007 and 2010 in addition to one significant increase in 2009. The drop in the emission trend in 2007, mainly driven by a similar drop in gas diesel oil import is an indirect result of the July 2006 war where significant damage to the road network and electricity infrastructure was inflicted. Indeed, due to the impairment of the electricity distribution network, it was impossible to distribute all the electricity produced and consequently thermal power plants were operating at partial load during the year 2007. The rehabilitation of the infrastructure extended over 2 years, and it was not until 2009 that power plants started to run on full capacity again, hence explaining the peak in GHG emissions in 2009. As for the decrease in emissions observed in 2010 which is proportional to the decrease in gas/diesel oil import, it is mainly caused by 1) the use of natural gas in the Deir Aamar plant in 2010 thus consuming 40% less gas/diesel oil, 2) the increase in hydropower production by 34% from 2009 to 2010 and 3) the decrease in production of the Tyre plant (consuming 30% less gas diesel oil).

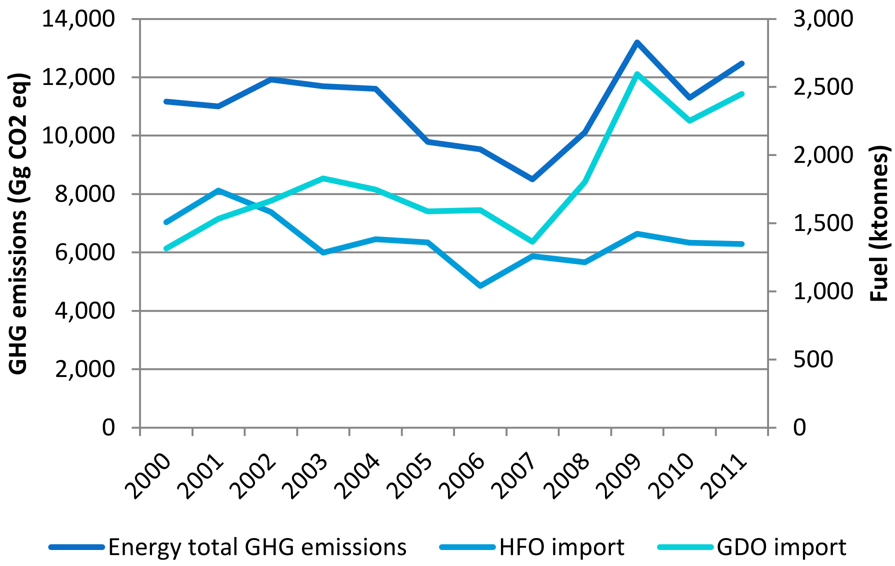

Figure 21: Fuel import and GHG emissions trends of the energy sector

The sector with the most significant change in emissions is still the transport sector with emissions increasing by a factor of 3.9 reaching 6.1 million tonnes CO_2eq. in 2013. Nitrous oxide has increased by a significant factor of 11.5 due to the fact that vehicles equipped with technologies for emission control are suspected to emit higher amounts of nitrous oxide.

This increase is mostly related to the upturn of the number of registered vehicles in Lebanon from 500,000 in 1994 to 1,640,000 in 2013. Among the main reasons for this significant increase is the inefficient and unreliable management of the mass transport sector, preventing the modernization and growth of the system and allowing the market to be controlled by private operators with an ad-hoc evolution strategy; consequently, encouraging passengers to rely on their private cars for their daily trips, along with the lack of policy enforcement for encouraging deployment of new fuel efficient vehicle technologies.

It is worth mentioning that the decrease in the yearly emission rates of the different greenhouse gases between 1994 – 2000 and 2000 – 2005 is a natural consequence to the advancements in reduction of consumption and emissions of new vehicles with emission control technologies. However, this technology advancement in emissions savings did not reduce the fleet average emissions over the period 2005 – 2013 as shown in Table 76, and the upturn that took place is explained by the 8.62% yearly increase in the number of registered vehicles over the same period, and more likely in the increase in the yearly average distance travelled.

Table 76: Trends of road transport emissions in Gg/year and in % during the period 1994-2013

	Number of vehicles	**CO_2 (Gg)**	**CH_4 (Gg)**	**N_2O (Gg)**
1994	479,120	1,548.18	0.46	0.04
2000	756,885	2,629.29	0.71	0.10
2005	970,803	3,540.62	0.85	0.20
2013	1,640,574	5,977.51	1.27	0.46
Yearly increase (%) 1994-2000	9.66%	11.64%	9.06%	25.00%
Yearly increase (%) 2000-2005	5.65%	6.93%	3.94%	20.00%
Yearly increase (%) 2005-2013	8.62%	8.60%	6.22%	16.45%

The waste sector also witnessed a significant increase in emissions, increasing by a factor of 2.4 from 1994. With an increase in population, in waste generation and in percent of waste deposited in landfills, methane emissions from solid waste disposal on land have increased by 93% during this period. A significant increase in emissions is detected in 1997 coinciding with the start of operations of the Naameh landfill and a small decrease in emissions may be attributed the 2006 war. Following the evacuation of a part of the population to abroad and the displacement of the residents of the southern suburbs of Beirut, less waste was generated and disposal methods were altered during this period. In fact, waste displacement occurred from areas served by managed landfills (Beirut) in the direction of areas served by unmanaged solid waste disposal sites (mainly in the South of Lebanon) thus impacting the generation of methane and total GHG emissions.

The increasing emission trend is also caused by the development of the industrial sector. The shy increase is mainly due to the cement and lime production that increased from 2006 to 2013. The sector witnessed a decrease of emissions from 1994 to 2002 due to decrease in soda ash use and lime production. Industrial activity picked up starting 2003 with a yearly increase in emissions of 3.9%, except in 2006, where a significant drop of cement production was caused by the July 2006 war. This was compensated by the booming of reconstruction activities after the war, resulting in an increase in emissions again.

The agriculture sector is still showing a decrease in emissions with a reduction of -5% from the 1994 levels. This is mainly due to the decrease in emissions from agricultural soils and to a lesser extent from enteric fermentation. These are in turn caused by the decrease in the use of nitrogen fertilizers and in crop residues added to soils in addition to the decline in dairy, sheep, and swine populations during the period 1994-2013.

As for Land Use, Land Use and Forestry, forests are still constituting important sinks of greenhouse gases. However, changes in forest and vegetation covers due to wildfires and mainly urbanization resulted in a net decrease of 2.37% in CO_2 emissions. Indeed, the peak of land converted to settlement recorded in 2013 coincides with a peak in the amount of cement deliveries (a total of

5,905,811 tonnes) in the same year 2013, which explains the high rate of urbanization on the expense on forested or planted areas.

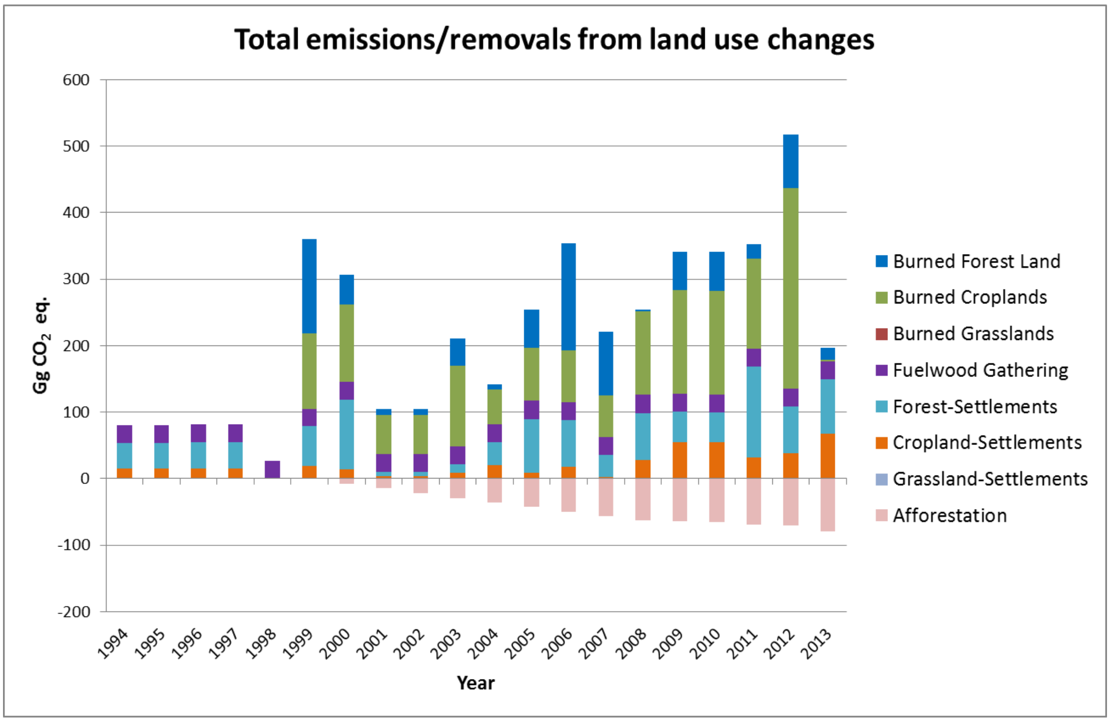

Figure 22: CO_2 emissions/removals from the changes in the LULUCF sector

Overall, the comparison of emissions and removals shows that emissions from land conversions, burning of biomass and fuelwood gathering are higher than the removals caused by the growth of new plantations (afforestation). Although net emissions/removals proved that LULUCF is a major sink, emissions from changes in land use and land cover were still high and couldn't be compensated by the afforestation activities.

Reforestation activities have played an important role in increasing removals during the last decade, especially after the Ministry of Environment signed in 2010 around 41 reforestation agreements covering 185 ha. and the five-year Lebanon Reforestation Initiative (LRI) was launched by the United States Forest Service in 2010.

5 Indirect GHG emissions

The role of carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane organic volatile compounds (NMVOCs) is important for climate change as these gases act as precursors of tropospheric ozone. In this way, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. Sulphur dioxide (SO_2) also has an indirect impact on climate, as it increases the level of aerosols with a subsequent cooling effect. Therefore, emissions of these gases should be taken into account in national inventories.

Emissions of non-CO_2 gases are calculated based on tier 1 methodology by applying emission factors which are organized by sector. In reality, emissions depend on the fuel type used, energy combustion technology, operating conditions, control technology and on maintenance and age of the equipment. However, since such detailed data is unavailable in Lebanon, the use of more detailed methodologies was not possible.

In Lebanon, the transport sector is the major source of indirect greenhouses, being responsible for 61% of NO_x emissions, 99% of CO emissions and 65% of NMVOCs. Fuel combustion for energy production is the main emitter of SO_2 with 94% of emissions, mainly caused by the sulphur content in burnt fuel. As for industrial processes, they mainly emit NMVOCs, being responsible for 34% of these emissions.

Table 77: Indirect GHG emissions and SO_2 emissions in 2013

	Emissions (Gg)			
	NO_x	CO	NMVOCs	SO_2
Energy	34.43	3.55	1.05	111.66
Transport	54.23	371.06	75.83	5.58
Industrial processes			40.31	1.77
Agriculture	0.00	0.00	0.00	0.00
LULUCF	0.01	0.16	0.00	0.00
Waste	0.00	0.00	0.00	0.00
Total	88.67	374.77	117.19	119.01

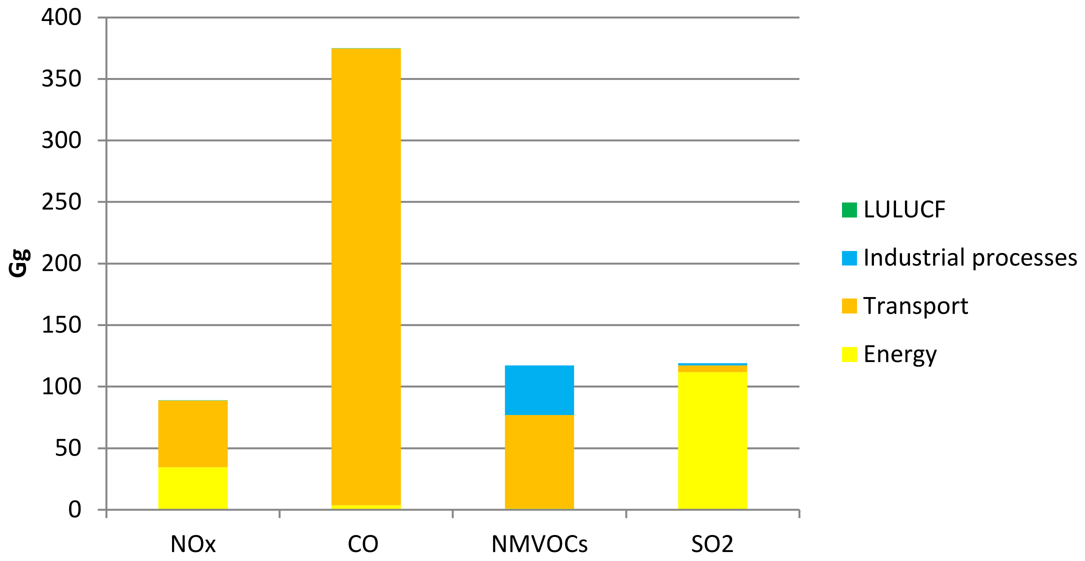

Figure 23: Indirect GHG emissions and SO_2 emissions in 2013

For the transport sector, indirect GHG emissions are dominated by passenger cars, with a significant HDV contribution to SO_2 emissions since HDV uses diesel fuel with higher sulphur content compared to gasoline in passenger cars (**Table 78**)

Table 78: Indirect GHG emissions for the transport sector in Gg in 2013

Category	CO_2eq.	NO_x	CO	NMVOCs	SO_2
PC	3,571.95	25.69	231.32	49.63	2.07
LDV	1,042.29	9.20	117.38	19.35	0.63

HDV	1,504.52	19.27	17.35	3.66	2.87
Motorcycles	29.07	0.03	5.01	3.18	0.02
Total	6,147.83	54.19	371.06	75.83	5.58

Industrial processes emit SO_2 and NMVOC mainly from use of asphalt for road surface, food and beverage production and cement production.

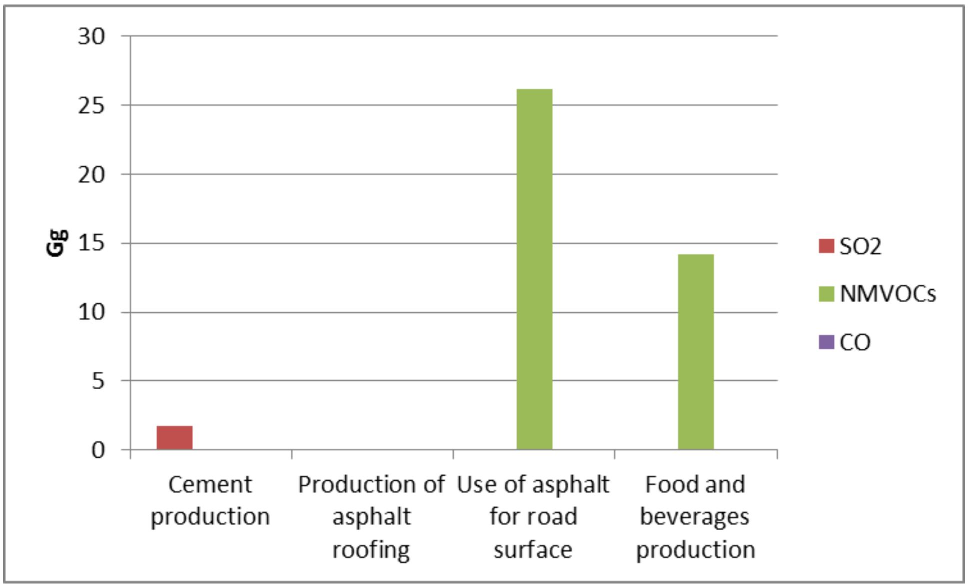

Figure 24: Emissions of indirect greenhouse gases from industrial processes for the year 2013

6 Quality assurance/ quality control procedures

6.1 Quality control

The inventory compilation team performed some quality control procedures intended to ensure transparency and quality of the GHG inventory. The implemented measures that have been monitored and documented are mainly focused on the general level related to the processing, handling, documenting, archiving and reporting procedures that are common to all the inventory source categories. Source category specific quality control procedures were also implemented, but these were not comprehensively documented by the respective coordinators of the various national inventory chapters. By adopting this approach, the inventory compilation team intended to bring significant improvement on both the implementation and reporting of QC procedures, while balancing quality control requirements, improved accuracy and reduced uncertainty against requirements for timeliness and cost effectiveness. It is the aim of the inventory team of experts to maintain this balance in subsequent inventories and enable continuous improvement of Transparency, Accuracy, Completeness, Comparability and Consistency of inventory estimates.

Below is a list of the general QC performed measures:

- Ensured that the description of activity data and emission factors match information on source categories described in IPCC guidelines and that they are properly recorded.
- Confirmed that bibliographical data references are properly cited in the BUR report and in internal documentation.

- Double checked a sample of activity data, emission factors and other parameters from each source category for transcription errors in the UNFCCC model, the BUR report and the internal documentation sheets.
- Checked that emissions are calculated correctly through performing recalculation of emissions from selected sources and years.
- Checked that units of numbers entered in UNFCCC calculation sheets correspond to the unit mentioned in labels.
- Searched for outlier emission figures and double check accuracy of reported emissions.
- Identified activity data and other parameters that are common to multiple source categories and confirmed that there is consistency in the values used for these parameters in the emissions calculations.
- Ensured that qualifications of individuals providing expert judgement for estimates are appropriate.
- Ensured that assumptions and expert judgements are properly recorded.
- Checked that inventory data, supporting data, and inventory records are saved and stored to facilitate review and provision of needed clarifications in the ICA process.
- Identified methodological and data changes resulting from recalculations and analyze how they affect the overall estimations of national emissions. Make sure these are reported in the final report.
- Performed a completeness check through confirming that estimates are reported for all source categories and for all reported years.
- Checked that data gaps that result in incomplete estimations of source category emissions are documented.
- For each source category, compared current inventory estimates to previous estimates in previous models for years that have already been reported in previous national inventories. If there are changes or departures from expected trends, estimates were rechecked.

6.2 Quality assurance

The GHG inventory methodologies, activity data, results and reporting tables of the BURI have been reviewed by an independent international inventory reviewer and the resulting recommendations have been taken into account in the preparation of the current inventory.

In the BURII project, UNDP Global Support Programme provided support for reviewing the GHG inventory. Recommendations included some immediate improvements, which have been incorporated in this report, and other suggestions for future improvements, which will be tackled in subsequent inventories.

Box 3: Quality Assurance through external review undertaken for BURI

- Performed initial checks to determine the completeness of data in the CRF

- Examined procedures and methodologies used from the collection of data to the reported emission estimates (double counting, completeness of years and sources/sinks, key category analysis, QC procedures, assumptions, units, recalculations, etc.).

- Assessed the quality and reliability of the methodology in accordance to established guidelines.

- Detected anomalies/mistakes in activity data.

- Assessed reliability of emission factors used.

- Validated time series consistency and compared with data from previous submissions.

- Identified areas for further improvement and noted possible ways for improving the estimation and the reporting of inventory information.

6.3 Uncertainty analysis

The QA/QC procedure that Lebanon adopted for its GHG inventory in the second BUR did not include uncertainty assessment due to the lack of relevant information to facilitate the uncertainty estimation. Lebanon is trying to improve its transparency in reporting and is aiming to collect required information to complete its uncertainty analysis in subsequent reports.

III. Mitigation policies and actions

As a party to the UNFCCC, Lebanon has made efforts to implement activities that lead to emission reduction based on its capabilities and taking into account its national circumstances. This chapter outlines Lebanon's commitment to address the challenges of climate change in the context of sustainable development and provides information on actions undertaken till 2013 to mitigate anthropogenic emissions by sources and removals by sinks. Information on these mitigation actions and their effects has been documented, to the extent possible, following the guidelines on BUR, including the associated methodologies and assumptions. Wherever possible, information on emissions reductions has been calculated.

Mitigation measures are mainly achieved in the power and forestry sectors. Unfortunately, emission reduction initiatives in the industrial, transport, agriculture and waste sectors are few and not well documented. Therefore, the list of measures reported in this section is not exhaustive, which underestimates the emission reduction that Lebanon is undertaken to combat climate change. Lebanon is committed to improve data collection and management and to formalize institutional arrangements that support the long-term collection, analysis and reporting of information on mitigation actions and efforts to explore co-benefits in more details.

Currently Lebanon has no specific methodology for monitoring the progress of actions described. Consultations with project proponents and main stakeholders helped identify the extent to which each mitigation action was implemented and accordingly, percentages of completion were used to calculate emission reductions achieved. Consequently, capacity building is much needed on the national level to improve monitoring and reporting of sectoral mitigation activities.

The methodology adopted for the calculation of emission reduction of the identified mitigation actions was based on the 1996 IPCC revised guidelines, IPCC good practice guidance and 2003 IPCC guidelines for the LULUCF sector, as already adopted in the preparation of the inventory. Consequently, and similar to how emissions are aggregated in national inventories, emissions reduction levels were also aggregated by sector.

Table 79 and Table 82 present the progress of these measures as per end of 2013. A detailed description of the measures developed and implemented in Lebanon until 2013 including information on objectives and goals, coverage, budget, and GHG reduction potential, is provided in tabular format as per decision 2/CP.17 in Annex VI and Annex VII.

1 Energy

As reported in the national GHG inventory, the majority of Lebanon's emissions are from the energy sector. Energy is a strategic resource for Lebanon as the country is almost completely reliant on the import of oil for energy needs. Therefore, climate mitigation in this sector plays an important role in achieving positive environmental, economic, and social impact through demand side management and cleaner energy production. In 2013, mitigation measures implemented in the energy sector contributed in reducing emissions by 513,063 tonnes CO_2 eq., with the expansion of the solar water heaters and the replacement of incandescent lamps inducing the most significant emission reductions.

Although renewable energy has not taken yet its proper share in energy production due to physical and regulatory barriers, the government is nonetheless continuing to invest actively in the research, development, and demonstration of clean energy technologies in Lebanon.

Energy mitigation actions are classified into 11 major categories, covering both energy efficiency and renewable energy, as presented in Table 79.

Table 79: Types of energy mitigation measures

Category	Description
Decentralized Solar PV Installations	Solar PV installations in residences, commercial institutions, and industrial facilities for power generation
Solar-Powered Water Pumping	Solar PV installations for agricultural applications and water pumping
Solar-Powered Public Street Lighting	Solar PV for public streetlights. Includes addition of new poles and replacement of existing poles
Energy-Efficient Public Street Lighting	Replacement of existing HPS and LPS street lamps with LED street lamps and the use of photocells and timers
Solar Water Heating	Solar water heating systems in residential, commercial, industrial, and public institutions
Certified Green Buildings	Certified green buildings under the BREEAM and LEED schemes
Energy Conservation Measures	Implemented energy conservation measures by energy audit companies and ESCOS, including measures related to lighting, cooling, heating, etc.
Biomass Space Heating	Biomass and pellet stoves for space heating
Other Renewables	Other renewable technologies including wind, hydro, geothermal, and others
Other Energy Efficiency	Energy efficiency measures undertaken by the public and private sector including energy efficient lighting, equipment, and others
Energy efficiency in power plants	Implemented measures such as upgrades and increase capacity in thermal power plant to increase efficiency of production.

Based on the data collected from the Ministry of Energy and Water, private entities, donor agencies and international organizations, a significant number of initiatives are being undertaken in the energy sector. For the purpose of the BURII, A detailed and comprehensive database was designed by the Ministry of Environment to report all the energy-related mitigation actions in Lebanon. The database includes information on implementing body, funding source, budget, timeframe, energy savings and emission reductions for each initiative, which have all been aggregated and compiled in

Table **80** and in reporting tables presented in Annex VI. The database structure and related data collection process have served in further developing the Management and Information System for Climate Action (MISCA) platform that was developed under the UNDP LECB project in partnership with the Ministry of Energy and Water and the EU-funded ClimaSouth. Indeed, MISCA contains a section on collecting information and calculating emission reductions from the implementation of mitigation actions in the energy sector.

Table 80: Summary of mitigation activities in Lebanon in 2013

Activity	Achieved outcome by 2013	Cumulative reduction of GHG emissions up to 2013* (tonnes CO_2 eq.)
Decentralized solar PV installations	Cumulative energy savings: 3,897,784 kWh	2,811
Solar-powered water pumping	Cumulative energy savings: 91,433 kWh	62
Solar powered public street lighting	Cumulative energy savings: 550,971 kWh	339
Energy-efficient public street lighting	Cumulative energy savings: 245,714 kWh	164
Installation of Solar Water Heaters (SWH)	Cumulative energy savings: 358,650,466 kWh	246,269
Certified green building	Cumulative energy avoided: 1,326,310 kWh	905
Energy conservation measures	Cumulative energy savings: 240,000 kWh	166
Biomass Space heating	Cumulative energy savings: 2,029,000 kWh	1,384
Other renewables	Cumulative energy savings: 28,823 kWh	20
Other Energy Efficiency measures	Cumulative energy savings: 382,579,313 kWh	260,943
Energy efficiency in power plants	-	-
Total known GHG emissions reduced by 2013		513,063

*calculated as the sum of yearly emission reductions achieved through the date of implementation of the action up to 2013 (including 2013)

As presented in Table 80, solar water heaters, which are by far the most developed renewable energy technology in Lebanon, represent 48% of the estimated emissions have been reduced during the reporting period. Indeed in 2013, more than 400,000 m^2 of solar collector area were installed in the country, further expanding the market of solar water heaters. Other initiative with a high emission reduction is the "3 million Lamp" initiative launched in 2011 by the Ministry of Energy and Water to distribute 3 million CFLs to 1.5 million residential households across the country to replace incandescent lamps. This is estimated to have saved 382 million kWh and 260, 943 tonnes of CO_2eq., representing 51% of reported emission reductions by 2013.

Other activities such as the installations of decentralized PV and wind power, solar water pumping, public street lighting, biomass space heating and other renewable energy activities are being implemented on a pilot and demonstration scales mainly by international organizations with the close coordination and guidance of the Ministry of Energy and Water. This is translated by their relative low emission reduction potential reported in 2013. The respective implementing agencies are however planning to scale-up these initiatives for more significant energy savings and emission reductions.

The government led activities are mainly related to increasing efficiency in thermal power plants as guided by the Policy Paper of the Electricity Sector and introducing renewable energy in public power production. Most of these activities have started in 2013, resulting in no emission reductions to be reported for 2013. However, it is estimated that these measures can result in a yearly reduction of 1,312,996 tonnes of CO_2 emissions.

Table 81: Increasing energy efficiency and introducing E in public power production

Activity	Description	Expected GHG reduction/yr (tonnes CO_2eq.)
Zouk ICE 194 MW (HFO)	Construction of new power plants in Zouk and Jiyeh which utilizes the energy in the exhaust gases and the hot cooling water from the engines in order to improve the efficiency of the plant by installation.	250,032
Jiyeh ICE 78.2 MW (HFO)		100,788
DACCPP II 539.2 MW (HFO)	Construction of an indoor gas turbine plant at Deir Ammar site with Nox control system a mini Hydro unit at the condenser outlet to improve efficiency.	597,849
ZCCPP 33.5MW Upgrade (DO)	Upgrade of design, material and coatings of Zahrani and Deir Amar power plants, which leads to improvement in turbine performance, and increases the overall power output and efficiency of the gas turbine.	177,315
DACCPP I 29.5MW Upgrade (DO)		156,143
HFO Conditioning Zouk Power Plant	Improvement of quality of HFO before boiler furnace combustion, which reduces emissions and increases the combustion efficiency.	29,895
PV Beirut River Snake Project	1 MWp solar PV farm built on the top of a river to generate an estimated 1,665 MWh/year.	974
Total		1,312,996

2 Transport

In 2014, the Ministry of Public Works and Transport (MoPWT) presented to the Council of Ministers the master plan to revitalize the land public transport for passengers. It encloses a set of actions to be implemented on the short and medium terms, shifting the passenger transport demand to mass transit systems. The main actions with direct impact on reducing GHG emissions are:

On the short term:

- Implementation of phase 1 of the rail transportation plan, namely the lane connecting port of Tripoli to the Syrian border.
- Revitalization and restructuring of the operation of public buses inside cities.
- Continuing the development project of traffic management in GBA.
- Improvement of the pedestrian infrastructure.

On the long term:

- Deployment of a Bus Rapid Transit (BRT) on Beirut north and south gates, commuting Jounieh to Jiyeh.

- Development of a mass transit system covering territories all over Lebanon and commuting cities.
- Restructuring the freight transport.

The full implementation of the master plan would eventually induce significant emission reductions. However to date, since no concrete action has been taken yet towards the implementation of the masterplan, no emissions reduction could be quantified and reported in this BUR.

3 Land-Use, Land Use Change and Forestry

In the identification of climate mitigation measures related to Land Use, Land-Use Change and Forestry that have the potential to significantly contribute to emission reduction or sink enhancing, the following main categories are considered:

- Protecting existing carbon reservoirs from losses associated with deforestation, forest and land degradation, urbanization, and other land management practices.
- Enhancing carbon sequestration and expanding carbon stores in forests, other biomass, soils, and wood products (including through reforestation, afforestation, and forest management efforts).
- Reducing emissions of other greenhouse gases, primarily CH_4 and N_2O, from land use interventions on from fire management

This section reviews and updates the mitigation actions published in the first Biennial Update Report in the LULUCF sector (i.e., covering the period 2005 and 2011 as in Table 82) by adding the progress achieved and any new initiative launched in 2012 and 2013 (Table 83). Table 82 reports activities that have been implemented prior to 2012 but whose emission reductions still happen on a yearly basis even after project completion.

Table 83 reports projects are still ongoing for 2012 and 2013 inducing more emission removals or that started in 2012/2013. The methodology adopted for the calculation of CO_2 removals and emission reductions in these projects is described in Annex VII.

Table 82: Summary of annual GHG removals per type of mitigation project (2005-2011)

Title of mitigation action	Annual GHG removals and emission reductions (Gg CO_2 eq.)	Type of project
The 40 million forest trees Initiative of the Ministry of Agriculture	N.A.	Reforestation/afforestation
National Physical Master Plan of the Lebanese Territory	N.A.	Forest management and landcover/land use planning
Alleviating barriers for quarries rehabilitation	N.A.	Land restoration
Reforestation on degraded lands	0.49	Reforestation/afforestation

Title of mitigation action	Annual GHG removals and emission reductions (Gg CO_2 eq.)	Type of project
Regaining ecological integrity of forest	0.05	Reforestation/afforestation
Restoration and conservation of sensitive forest areas in Lebanon	0.66	Reforestation/afforestation
Support the national early recovery efforts in restoring a part of the burned Lebanese Forests	0.266	Reforestation/afforestation
Forest for peace project	0.269	Reforestation/afforestation
Reforestation: development of a community forest	0.093	Reforestation/afforestation
Management and sustainable development of forest areas	0.133	Reforestation/afforestation
Reforestation within an integrated forest fire management	1.332	Reforestation/afforestation
Developing Lebanon's National Strategy for forest fire management	N.A.	Fire prevention
Strengthening Lebanese capabilities in forest fire control operations	N.A.	Fire prevention
RISICO system for forest fire forecasting	N.A.	Fire prevention
Total	3.293	

* based on assumptions

In 2012 and 2013, afforestation and reforestation activities were sustained and increased by the Ministry of Agriculture and leader organizations in the country such as the Association for Forest Development and Conservation and Jouzour Loubnan, increasing the total amount of GHG emissions that has been removed from mitigation actions in LULUCF to 18.996 Gg CO_2eq. in 2013 as presented in Table 83 and Annex VII.

Table 83: Summary of achieved removals as per 2013

Title of mitigation action	Cumulative GHG removals and emission reductions by 2013 (Gg CO_2 eq.)	Type of project
Development and implementation of pilot landscape restoration plans	0.646	Reforestation/afforestation
AFDC afforestation/reforestation projects	0.213	Reforestation/afforestation
The Reforestation Initiative of the Ministry of Environment of Lebanon	9.72	Reforestation/afforestation
Reforestation and afforestation activities conducted by Jouzour Loubnan	2.117	Reforestation/afforestation
Lebanon Reforestation Initiative by USAID	6.3	Reforestation/afforestation
Total GHG removal and emission reductions achieved by 2013	18.996	

4 Preparation of Nationally Appropriate Mitigation Actions (NAMAs)

In 2013, the Ministry of Environment was appointed by the CoM as the official national coordinator for NAMAs in Lebanon and in 2014, it has established and officiated a mechanism for approving and submitting NAMAs to the UNFCCC NAMA registry.

Following a series of workshops and consultation meetings with stakeholders, 3 NAMA proposals were prioritized in the energy, waste and forestry sectors. The UNDP Low Emission Capacity Building (LECB) Project has supported the Ministry of Environment to develop one proposal on waste management with a waste-to-energy scheme and another on the promotion of fuel efficient and hybrid vehicles in Lebanon. Both have been submitted to the Council of Ministers for approval prior to their submissions to the NAMA registry.

In addition, the Ministry of Environment through the LECB project has engaged with the Ministry of Agriculture to develop a forestry NAMA for the implementation of the 40 million trees programme of the Government. Capacity building sessions and technical support have been provided through the EU Climasouth project to the MoA team and the NAMA is in its final stages of development.

These NAMAs represent an opportunity for sustainable development for Lebanon, and at the same time an opportunity to reduce GHG emissions. Indeed, they provide a prospect to provide access to appropriate and affordable transport modes, to provide sustainable solutions to the country's waste and energy crisis and to preserve and increase Lebanon's green cover. The NAMAs will also provide the conditions for income generation, new business opportunities and enhanced private sector involvement.

5 Information on international market mechanisms

The Ministry of Environment has been appointed Designated National Authority for CDM projects in 2006 and 7 projects have been approved by the CDM Executive Board with the total potential of CER generation of 91,721 CERs every year. The table below provides details on these projects.

Table 84: CDM project in Lebanon

Project name	Project proponent	Potential CO_2 savings per year
Thermal Solar Plant Project at Zeenni Trading Agency; Bsarma El Koura, Lebanon	Zeenni Trading Agency	1,685 tonnes CO_2eq
The Lebanese CFL Replacement CDM Project – Mount Lebanon	Ministry of Energy and Water (MEW) Lebanese Center for Energy Conservation (LCEC)	20,091 tonnes CO_2eq
The Lebanese CFL Replacement CDM Project – South Lebanon	Ministry of Energy and Water (MEW) Lebanese Center for Energy Conservation (LCEC)	14,435 tonnes CO_2eq
The Lebanese CFL Replacement CDM Project - North and Bekaa	Ministry of Energy and Water (MEW) Lebanese Center for Energy Conservation (LCEC)	21,281 tonnes CO_2eq
The Lebanese CFL Replacement CDM Project – in and around Beirut Central, Northern and Eastern Suburbs	Ministry of Energy and Water (MEW) Lebanese Center for Energy Conservation (LCEC)	20,091 tonnes CO_2eq
The Lebanese CFL Replacement CDM Project – in and around Beirut Southern Suburbs	Ministry of Energy and Water (MEW) Lebanese Center for Energy Conservation (LCEC)	14,138 tonnes CO_2eq
Programme for Grid Connected Renewable Energy in the Mediterranean Region	Renewable Energy for the Mediterranean (R.E.M.)	Not determined yet
Total potential CO_2 savings per year		**91,721 tCO_2eq**

IV. Lebanon's transparency framework, institutional arrangements and MRV system

The requirements of the Paris Agreement's article 13 on transparency, which call for a considerable improvement of Parties' Measurement, Reporting and Verification (MRV) systems to reach a mechanism that ensures the periodic flow of needed information while ensuring the transparency, accuracy, completeness, consistency and comparability in all of its components, currently represents a challenge for Lebanon.

As part of enhancing climate information sharing and outreach, several initiatives are being undertaken as described below. Some gaps and challenges still exist to coordinate the initiatives and to enforce their efficient implementation. Lebanon will continue to raise awareness and build capabilities to sustain and gradually improve the implementation of these efforts while addressing specific barriers using incentives or regulatory measures where appropriate.

Minister of Environment decision 99/1

The Minister of Environment's decision 99/1, which was established in April 2013 under the UNDP LECB project, provides an incentive to the private sector (commercial, institutional and industrial enterprises) to report on a voluntary basis their GHG emissions and related activity data to the Ministry of Environment using a MS Excel-based simple tool. As a quality assurance measure, the reported data is verified and certified by an auditor or accountant (from the submitter's side) prior to its submission and is further checked for completeness and consistency by the Ministry of Environment.

This scheme is designed with an awareness raising approach in instigating a reporting culture (GHG emission reporting) by the private sector and to provide a self-tracking tool to be used by participating companies to monitor their GHG emission growth/reduction.

The Ministry of Environment is planning to undertake a systematic and objective assessment of Decision 99/1 to determine its relevance and scalability for better informing climate change policy in Lebanon.

Cooperation between Ministries of Environment, Industry and of Finance

In an attempt to institutionalize data sharing between ministries, the Ministry of Environment has established 2 cooperation mechanisms under the UNDP LECB project:

1. Collection of information from the Ministry of Industry by requesting that basic activity data be included as part of the standard procedures followed for industries to acquire their business licenses. To date, information for the years 2015 and 2016 have been collected in hard-copy format by the Ministry of Industry. While this initiative was successful in guaranteeing activity data collection by the Ministry of Industry in a systematic manner, the data needs to be digitalized in order to facilitate its analysis and use for inventory preparation.

2. Collection of information from the Ministry of Finance on energy and raw material consumption from commercial, institutional and industrial companies. Requested data have been included in the online tax declaration template of the Ministry of Finance and a first round of data collection will be launched starting 2018 for the companies registered at the Large Taxpayer Office of the Ministry of Finance.

The Lebanon Climate Act initiative: reporting of climate change mitigation and adaptation projects

The Lebanon Climate Act (LCA) is an initiative that has been launched in 2016 by the Green Mind NGO in cooperation with the UNDP LECB project, the Central Bank of Lebanon, the Federation of

Chamber of Commerce, Industries and Agriculture and the Ministry of Environment to engage the private sector and non-state actors in climate action. A series of trainings labelled as Business Knowledge Platforms have been conducted in cooperation with the EU ClimaSouth project to support companies in determining their level of engagement, identifying potential partners from civil society and municipalities, and developing implementation, monitoring and reporting plan for their climate actions. To date, around 100 companies and non-state actors have joined this initiate with different level of engagements. In 2017, 10 champion companies have been selected from the LCA members and rewarded for their engagement in a high-level ceremony organized in Beirut.

Transparency law – access to public information

Lebanon's Parliament ratified an access to information law in January 2017 that prescribes that virtually all government entities publish online key documents showing performance indicators such as annual reports, orders and decisions, and office expenditures. The full enactment of the law is pending the issuance of other legislative documents as the establishment of an anti-corruption commission to enforce the law. Nevertheless, the law is a positive step towards improving transparency and public accountability, and work for climate change transparency will benefit from this initiative.

Management and Information System for Climate Action (MISCA)

The Ministry of Environment with the support of the UNDP LECB project liaised with the EU-funded ClimaSouth project to design and develop an online information system to facilitate the exchange of data between Ministries. It is intended to track progress of implementation of Lebanon's Nationally Determined Contribution. The system targets the energy sector as priority sector for the first phase to enhance data sharing between the Ministry of Environment and the Ministry of Energy and Water, and improve the preparation of the energy sector's GHG emission inventory and mitigation action reporting. MISCA is also designed to help the ministry to track its own progress and automatically calculate resulting CO_2 reductions. Quality of data entered in the system is ensured throughout the data entry cycle, by the strict separation of functions associated with the entry, verification and release of data. The management of potentially sensitive or confidential data is also supported. The success of the system lies in the engagement and commitment of the Ministry of Energy and Water, which in turn serves towards meeting the energy sector's emission reduction targets, the country's most significant target of its

The Ministry of Environment aims at expanding the MISCA initiative to include other ministries such as the Ministry of Agriculture and the Ministry of Public Works and Transport in the future, based on the experience and lessons-learned from the first phase. This would be an important move towards enhancing the effectiveness and transparency of Lebanon's Monitoring Reporting and Verification (MRV) of data on climate action.

V. Constraints and gaps, and related financial, technical and capacity needs, including a description of support needed and received

1 Gaps, constraints and needs

Numerous constraints and gaps still exist for Lebanon to report to the required standards and frequency to the UNFCCC. Constraint removal and filling of gaps will be possible in the medium and longer term with continuous national efforts and sustained support from bilateral and multilateral partners and donor agencies.

The main challenge related to the preparation of the BUR is the absence of sustainability of the team responsible for the climate reporting processes at the Ministry of Environment. Therefore, the main need is the provision of permanent financial and administrative support to the Ministry of Environment in order to guarantee the sustainability, continuity and integrity of the information reported in the BUR. This can be ensured through the establishment of the MRV Unit which will be responsible not only for tracking climate change activities and collecting relevant data, but also in identifying needs to strengthen climate reporting processes in Lebanon.

Other significant challenges relate to the preparation of national inventories. Although some progress has been achieved so far in order to create databases, institutionalize data generation and sharing, and develop national emission factors, some challenges surpass the mandate of the BUR project and require significant financial, technical and institutional support to be surmounted. Concrete examples include the empowerment of the Central Administration of Statistics to centralize and manage data, the development of measurement campaigns to better characterize Lebanon's energy systems and vehicle fleet, or even the undertaking of an official census on the population in Lebanon.

In addition, with BUR preparation, new challenges have emerged from the collection and consolidation of information related to existing mitigation actions. These challenges are mainly related to limited availability of data, weak coordination between institutions working in climate change and the difficulty in quantifying emission reductions achieved.

1.1 Gaps and constraints in the BUR preparation process

Lebanon has already submitted 3 national communications to the UNFCCC (1999, 2011 and 2016) and two BURs including the present one. In the wake of the increasing reporting requirements under the UNFCCC (1/CP.16, 2.CP/17), Lebanon's capacities in producing national communications and BURs have been enhanced, relying more on in-house expertise and less on outsourced services. However, the Ministry of Environment is aware that these reporting requirements for developing countries will soon be enhanced with the adoption of the 2018 Rulebook as per the Paris Agreement work programme, and therefore wishes to take the necessary steps to enable readiness for optimized compliance with upcoming guidelines.

Technically, the Ministry of Environment, with the support of UNDP, is able to compile a BUR or a National Communication without setting up a reporting management system. However, such a system will optimize resources invested in the process. The challenges faced in the preparation of Lebanon's second BUR and previous UNFCCC reports are listed in Table 85, along with corresponding capacity building needs. Many of the below-listed challenges have also been identified by the technical team of expert of the BURI ICA process. They have been further formulated to better structure the development of a UNFCCC reporting management system.

Table 85: Challenges and needs for the preparation and communication of BURs

Challenge	Description	Needs
Human resources	Currently, the BUR process is being led by the Ministry of Environment, with the involvement of independent sectoral expert on an ad-hoc basis. Little technical involvement is provided by other ministries, where their role is limited to consultations and validation of information.	Engage more ministries in the technical preparation of BURs. Build technical capacities of public servants Retain competent experts Establish a reporting management system that allocates clear responsibilities between ministries and departments
Funding cycles	The Ministry of Environment fully relies on GEF's enabling activities funding window for the preparation of national communications and BURs, and therefore is dependent on the funding cycles made available by GEF. This paralyses the planning stages of BUR preparation.	Ensure a continuous and sustainable fund for the preparation of BUR Integrate the preparation of BURs in ministries existing workplans
Institutional arrangements	The current institutional structure relies on informal mutual agreements for data collection with relevant institutions. However, there is no protocols or institutional arrangements that guarantee the sustainability of data collection that often requires heavy administrative processes.	Formalize processes and protocols to institutionalize collection, compilation and verification of activity data and required information Design and implement a complete national GHG inventory system for activity data and proxy data
IPCC Guidelines	Shifting to 2006 IPCC Guidelines requires additional data collection, recalculation, and technical expertise that may be cumbersome for the inventory team, given the time and fund restrictions of the GEF projects.	Establish procedures to shift to the 2006 IPCC Guidelines in future GHG inventory procedures including adjustment of historical data Improve technical skills of inventory team to adopt adopt the 2006 IPCC Guidelines Establish a reporting management system that includes documentation and archiving procedures, QA/QC protocols, and uncertainty management procedures
Enhancing national ownership of reports	The BUR has a limited role in informing national climate policy, as it is still being considered as a reporting requirement instead of policy tracking tool.	Develop a communication plan to policy makers to facilitate integration of BUR and national communication results in national policy making Develop a communication plan to the general public to raise awareness on climate change.
Identification of capacity building needs	No methodology or systematic approach is adopted to identify capacity building needs, training, equipment and other resources needed for the preparation of the BUR.	Support to identify gaps and constraints in a more institutional manner, and capacity building needs

1.2 Gaps and constraints in inventory preparation

Energy

Although a lot if improvements have been done to collect complete data on the fuel combustion in the energy sector, constraints still hinder the completeness and consistency of the process. The main challenges include (1) underdeveloped institutional arrangements data monitoring and collection, (2) the unavailability of specific data and/or the inaccessibility of existing data for adopting tiers 2 and (3) the use of default emission factors from IPCC guidelines instead of Lebanon fuel-specific emission factors. Table 86 presents in detail the gaps related to the inventory preparation of the energy sector.

Table 86: Gaps related to the preparation of GHG emissions in the energy sector

Gaps	Description
Underdeveloped data collection for the inventory	1. Lack of institutional arrangement for data monitoring and reporting 2. Absence of the role of the Central Administration of Statistics, Ministry of Transport and Ministry of Energy and Water to develop and activity data 3. Inconsistency of information between different governmental agencies 4. Lack of an energy balance for Lebanon 5. Lack of information on private generation in the industrial, commercial and residential sector 6. Lack of data on passenger kilometres and on off-road vehicles 7. Lack of accurate data on fuel combustion in national aviation and navigation 8. Lack of knowledge to conduct uncertainty assessment
Unavailable and/or unshared specific data for tiers 2 and 3 calculations	1. Lack of road transport activity data on annual fuel consumption per type of fuel and yearly average vehicle mileage per category 2. Lack of technology-related information per power plant 3. Lack of standardized/centralized data reporting system and protocols for data accessibility.
Use of IPCC default emissions factors	1. Lack of Lebanon-specific methodologies using advanced bottom-up approaches for inventory preparation 2. Lack of fuel-specific emission factors for Lebanon 3. Lack of capacity of national laboratories to calculate carbon content of fuels

Industrial processes

The main gap of the industrial processes GHG inventory preparation is related to not estimating emissions from consumption of Halocarbons and SF_6. These estimations, if included in the national GHG inventory, would probably significantly change Lebanon's currently estimated total net emissions due to the very high global warming potential of Halocarbons. The National Ozone Unit in Lebanon will publish a survey on consumption of Halocarbons in Lebanon in the very near future as part of the project "Enabling Activities for the Early Ratification of the Kigali Amendments" funded by the Multilateral Fund Secretariat.

Industrial processes in Lebanon is one of the national inventory chapters with a lot of potential for improvement. However, due to its insignificance in the overall national emissions scheme, time and budget have not yet been prioritized for these improvements. The latter include an adjustment of historical data on lime production, a detailed survey on production of asphalt roofing and use of road paving material, the initiation of regular preparation and publishing of surveys on all the food and drinks subcategories (beer, wine, fish, meat, poultry, bread, cakes and biscuits, coffee beans, sugar, margarine and animal feed) as most of the numbers used so far in Lebanon's inventories are based on assumptions and estimations.

Finally, the current BUR does not include information regarding Solvent and Other Product Use due to lack of detailed methodology for inventory preparation for this sector in the 1996 and 2000 IPCC guidelines as well as the lack of published activity data. This category covers mainly NMVOC emissions resulting from the use of solvents and other product containing volatile compounds. It also includes evaporative emissions of greenhouse gases arising from other types of product use such as N_2O emissions from medical use. It is however believed that these emissions from categories considered under this sector (i.e. paint, application, degreasing and dry cleaning, printing and publishing, degreasing and dry cleaning, chemical product manufacture and processing) would not be significant in the context of the national GHG inventory.

Agriculture

The calculation of emissions from the agriculture sector necessitates a solid scientific base of data and parameters, which is a challenging issue in Lebanon. The gaps and constraints reported in BURI are still valid for the preparation of BURII, namely the scattering and inconsistency of data throughout agencies, the lack of institutional arrangements for data sharing as well as the inadequacy of default emission factors to local conditions. Some of the data challenges were overcome in the BURII, however technical and capacity building needs related to the preparation of the inventory in the agriculture sector are still a necessity, as presented in Table 87.

Table 87: data-specific gaps related to the preparation of GHG emissions in the agriculture sector

Gaps or constraints	How it was tackled in BURII	Recommendation
Data on imported beef: lack of detailed archiving from BUR I on data source and related contacts at the syndicate of beef importers; the Ministry of Agriculture does not collect this data.	Imported beef not included in national GHG inventory of BUR II, and recalculations performed for the entire time series covered in the inventory.	Develop appropriate institutional arrangements with the Ministry of Agriculture to make data on imported beef readily available for every round of inventory.
Data on Swine, Camels, Horses, Mules, Asses: not available at the Ministry of Agriculture.	Obtained from FAOSTAT, considered a secondary source of information.	Provide support to the Ministry of Agriculture in order to gather and regularly publish data on Swine, Camels, Horses, Mules, Asses.
Data on nitrogen fertilizer consumption: not available at the Ministry of Agriculture, not segregated by chemical at the Lebanese customs. Assumption that all imported fertilizer is consumed nationally.	Extrapolation from data series made available from BUR II.	Provide support to the Ministry of Agriculture in other to gather and regularly publish data on Nitrogen fertilizer consumption.
Data on crop production: available at the Ministry of Agriculture only until the year 2009.	Obtained from FAOSTAT, considered a secondary source of information.	Provide support to the Ministry of Agriculture in other to gather and regularly publish data on crop production.
Fraction of manure nitrogen per	Fractions adopted from BUR I	Provide support to the Ministry of Agriculture

manure management system: no survey exists for accurate estimations.	based on expert judgment.	in order to perform a complete survey of manure management systems in Lebanon.
Burning of agricultural residues: the assumption is that it does not occur in Lebanon, at least during the period covered by the inventory. However, no published study confirms this information.	Burning of agricultural residues was considered not occurring in the BUR II based on expert judgement.	Provide support to the Ministry of Agriculture in order to perform a complete survey on disposal of agricultural residues.
Fraction of crop residue removed from field: no survey exists for accurate estimations.	Fractions adopted from BUR I based on expert judgment.	Provide support to the Ministry of Agriculture in order to perform a complete survey on disposal of crop residues removed from fields.

Land use, land use change and forestry

The gaps in the preparation of the LULUCF inventory in relation to emission and removals factors are related to the unavailability of country specific data (and the use of Tier 1 IPCC default assumptions that the net change is zero. More specifically, emission/removals for the subcategories Land converted to Croplands and Land converted to Grassland were not estimated due to lack of data. Accordingly, the notation key NE (not estimated) was used. Further data (when available) on areas of grasslands along with their management systems (e.g. status of grazing,) can help in providing new insights on their level of contribution in GHG emissions or removals in the future. Also, alternatives to estimate emissions and removals from the land use subcategories and pools declared as "Not Estimated" in this report could be made available in future inventory submissions. These include the design and implementation of an operational mechanism for continuous spatial monitoring and assessment of land subcategories with the combined use of satellite remote sensing and Geographic Information System (GIS) data in addition to data published by official reports. This, however, requires the direct coordination of relevant ministries (i.e., Ministry of Agriculture and Ministry of Environment).

Waste and wastewater

Similar to the other sectors, the challenges in the calculation of waste and wastewater related emissions are mainly linked to the availability of complete and accurate data on waste and wastewater generation as well as adopted management and treatment practices.

Table 88 summarizes the gaps identified in the calculation of the GHG emissions from the waste sector.

Table 88: Gaps for the calculation of GHG emissions from the waste sector

Gaps	Description
Estimation of population and waste generation rate	- Population is based on data from CAS that is only available for 2 years. No census on Lebanese population is available - Studies on waste generation analysis conducted are outdated
Methodology of quantification of waste and wastewater	- Waste and wastewater generation rates are not based on quantitative exercises and are often estimated based on population counts. - Industrial wastewater is not clearly addressed and related information is missing
Estimation of methane generation and recovery rates	- Data on methane recovery is not made available from all landfills and for all reporting years - Methodology of 1996 Revised IPCC guidelines does not take into account the lag time between waste disposal and methane generation
Estimation of wastewater disposal practices	- No information is documented on the methods used to disposed of wastewater in urban versus rural areas
Absence of national emission factors	- The use of default emissions factors might under or overestimate emissions from waste and wastewater generation and disposal

1.3 Gaps and constraints in capturing and reporting of mitigation actions

Mitigation measures are mainly achieved in the power and forestry sectors, as reported in section III. Unfortunately, emission reduction initiatives in the industrial, transport, agriculture and waste sectors are few and not well documented. Therefore, there are gaps in the list of measures reported, which leads to believe that the emission reductions achieved by Lebanon are underestimated as reported in the present BUR. Consequently, capacity building is much needed on the national level to improve monitoring and reporting of sectoral mitigation activities. While some improvements have been brought in the second BUR compared to the first one, especially in terms of identifying information related to the progress of implementation of some actions in the energy sector, more capacity building is needed to address the challenges presented in Table 89 and Table 90.

Table 89: Data gaps in preparing mitigation actions for the other sectors

Gaps and constraints – other sectors	
Transport	- Limited data available on the progress of activities related to public transport initiatives - Absence of clear workplan and indicators for the Government's Transport Strategy - Difficulty in estimating the climate-change related component, achievements and budget of transport development projects - Difficulty in estimating emissions reductions from the complete or partial implementation of the Transport Strategy, and specifically the revitalization of public transport
Agriculture	- Limited data available on cropland management, livestock and manure management, and good agricultural practices - Difficulty in estimating the climate-change related component, achievements and budget of agriculture development projects - Absence of information on the implementation progress of the Ministry of Agriculture's 5-year plan
Industrial	- Absence of a strategy to improve the environmental performance of the industrial sector, including reduction of emissions from industrial processes

Processes	- Limited data on the implementation of industrial activities with a co-benefit to reduce GHG emissions
Waste	- Slow progress of waste and wastewater management activities in Lebanon - Difficulty in estimating the climate-change related component, achievements and budget of waste and wastewater management projects

Table 90: Data gaps in capturing and reporting mitigation actions for the energy sector

Data gaps – Energy Mitigation actions	
Decentralized Solar PV Installations	- Data collected for PV installations is a result of a survey conducted by UNDP-DREG project. The survey covers a big share of the market, yet it is not guaranteed to be covering 100% of the real installations. - Data collected on PV installations involves currently active companies, but does not include companies that were but are no longer in business. These companies might have good contribution to installations performed prior to 2012. - Donor-funded PV projects include CEDRO implementations only. Other donor-funded installations that might have taken place are accounted for within the privately-installed cumulative values. - PV Installations taking place before 2012 are available in cumulative numbers. Thus the average emission factor and budget estimate for the year 2010 and 2011 are used.
Solar-Powered Water Pumping	- Donor-funded PV pumping projects include USAID and UNDP implementations only. Other donor-funded installations that might have taken place are accounted for within the privately-installed cumulative values
Solar-Powered Public Street Lighting	- Donor-funded PV Public Street Lighting projects include CEDRO, UNIFIL, and Live Lebanon implementations only. Other donor-funded installations that might have taken place are accounted for within the privately-installed cumulative values.
Solar Water Heating	- Data collected for SWH installations is a result of a survey conducted by LCEC. The survey covers a big share of the market, yet it is not guaranteed to be covering 100% of the real installations. - Data collected on PV and SWH installations involves currently active companies, but does not include companies that were but are no longer in business. These companies might have good contribution to installations performed prior to 2012 - Donor-funded SWH projects include CEDRO, SIDA, and Italian Cooperation implementations only. Other donor-funded installations that might have taken place are accounted for within the privately-installed cumulative values.
Energy Conservation Measures	- Data collected on energy audits and energy conservation measures involves the largest companies in the market. There are definitely initiatives undertaken by the facility owners or by third parties that cannot be quantified - Budget related to energy saving measures cannot be made available.
Biomass Space Heating	- For pellet stoves, it is not clear what these stoves are replacing, thus the emission factor used is for EDL and private generators. In some cases, these stoves might be replacing diesel heaters.
Other Renewables	- Other renewable energy installations done by private sector could not

	be quantified. Yet they are expected to have minor effect on the cumulative values. - For the micro-hydro installation, the average saving of 2,000 kWh per installed kW is a rough estimate based on international market data. No similar data is available for these systems in Lebanon.
Other Energy Efficiency	- For photo sensors, savings are calculated assuming all photo sensors and timers are installed immediately and properly maintained. In fact some were installed at a later stage, and others are not properly maintained, which reduces their performance and saving potential.

1.4 Gaps and constraints in reporting of finance and capacity building needs and support received

Reporting of financial support needed and received

Lebanon has yet to enhance its capacity to undertake MRV of support with respect to mapping domestic and international climate finance flows, clarifying the support received, identifying support gaps, enhancing related decision-making and ultimately supporting Lebanon's NDC implementation. Lebanon is still not able to provide a comprehensive report on finance needs and received, due to the challenges presented in Table 91.

Table 91: Challenges hindering complete and transparent climate finance reporting

Data collection	Climate finance monitoring is challenging mainly because of untraceable finance flows, and the lack of disaggregated data. This is the case for all finance flows between international donors, central and subnational government, NGOs and the private sector Furthermore, when data is available, it is not disaggregated per source of funding, the type of support (grant, loan, concessional loan, guarantee etc.), percent of disbursement, etc.
Institutional arrangements	The needed arrangements to formulate and communicate climate finance in Lebanon are not established. There is little awareness in the institutions on the importance of tracking finance and its relationship to efficient policy- making.
Definition and methodology synchronization	There is neither definition of climate finance nor an understanding of estimating the incremental cost/budget of climate change mitigation and adaption benefits. This in turn affects the understanding of climate finance across different national institutions and stakeholders and hinders the coherence and consistency of climate finance information. Moreover, there is no established methodology for identifying and tracking capacity-building or technology transfer related to climate change.
Progress tracking	No indicators exist to assess the effectiveness of climate finance; progress towards lowering greenhouse gas emissions or increasing resilience is not being tracked. Therefore, it is challenging to assess the effectiveness of climate finance.

Efforts are underway to define climate finance and devise a process to establish a system for MRV of support received (including capacity-building and technology transfer) and their respective financing and linkages to NDC goals.

Reporting of capacity building needed and received

There are many improvements in the present BUR related to reporting of capacity building needs. They are due to a better understanding of the BUR requirements, the improved compilation activities and the ICA and FSV processes.

1.5 Gaps and needs in establishing of a national MRV system

Lebanon has not yet a defined a comprehensive MRV framework for mitigation and adaptation actions and policies due to the technical constraints described before as well as weak institutional arrangements, which hinder the country's readiness to comply with Modalities, Procedures and Guidelines (MPGs) under the Paris Agreement. Various efforts undertaken by different national ministries, local governments and private sector have had limited impact in efficiently assessing implementation progress of NDC and informing national climate policy.

Lebanon's first BUR stressed the necessity for the creation of a MRV unit to overcome these challenges. Following the development of Lebanon's NDC, and the entry into force of the Paris Agreement, the envisaged MRV unit has further been conceptually developed into an MRV Coordinating Entity (MRVCE), which still needs to be established.

Concretely, the MRVCE will primarily enable the measuring of the progress of climate policies, through NDC goals, will be responsible in periodically evaluating the national transparency framework's effectiveness and will also assist in identifying support needed. In addition, the MRVCE will coordinate all reporting activities under the UNFCCC and progress on NDC implementation. In addition, it will build capacities of national institutions to implement transparency-related activities and procedures.

There is also a need to develop a web based knowledge management platform targeted to relevant institutions to centralize and publish climate information, while building on existing systems. The platform can host 1) the GHG inventory system, 2) the tracking system for climate action (NDC intranet) and 3) adopted tools and methodologies.

Lebanon needs support in elaborating the MRVCE's detailed design, including proposed governance structure, legal and institutional arrangements as well as operating cost-analysis, and possible financing sources. Therefore, Lebanon will be seeking support from the GEF under the Capacity Building Initiative for Transparency funding window.

2 Information on support received

Climate finance from multilateral and bilateral sources plays an important role in advancing climate action in Lebanon. It has contributed to the implementation of sectoral policies and programs and supported initiatives from governmental and non-governmental institutions. Therefore, having a clear understanding of these finance flows is crucial to assess outcomes of support received and optimize available and future climate resources.

The Ministry of Environment is the National Designated Authority to the Green Climate Fund (GCF). Lebanon has not yet submitted proposals to the GCF, but the NDA has issued a no-objection letter for the IFC green bond cornerstone programme. Lebanon is currently seeking support from the GCF to prepare its National Adaptation Plan (NAP) through the readiness programme and is working with the UNDP-UNEP NAP-GSP programme to prepare and submit the proposal.

Building on the progress of UNFCCC negotiations related to transparency of reporting on climate finance, and based on recommendations from the ICA process, Lebanon has attempted in the present BUR to gather readily available and trusted information, in a format that, if developed and improved, could inform the global stocktake more easily. Given the gaps and constraints previously mentioned related to reporting on support received; only information on climate related projects that have been approved by donors and whose beneficiary is the Ministry of Environment since the submission of BURI has been considered in this report (Table 92).

It is worth nothing that the tables below do not provide a comprehensive overview of the financial, technical and capacity building support received in relation to climate change in the country. It is envisaged that future BURs will allocate time and funding to expand the scope of reporting on support received to other ministries and institutions.

Table 92: Financial support received by the Ministry of Environment since the submission of the first BUR

Donor	Project/initiative	Expected outputs	Budget *	Timeframe
Global Environment Facility	Enabling activities for the preparation of Lebanon's Second Biennial Update Report to the UNFCCC	To fulfill decisions 1/CP.16 and 2/CP.17, which request non-Annex I Parties to submit BURs	USD 352,000	2016 – 2018
European Union, Australian Government, German Government	Complementary support under the Low Emission Capacity Building programme	- Enhanced NDC implementation and synchronization with SDGs - Increased mitigation investment by the public and private sectors - Gender mainstreamed in NDC	USD 802,500 - fund allocation	2018 – 2019
European Union – ClimaSouth project	Formulating a MRV Framework for Support Received	- To strengthen Lebanon's capacity to undertake MRV of support received - To identify all climate change related projects in Lebanon, their respective financing and linkages to NDC goals - To verify if support identified is being disbursed in priority mitigation and adaptation areas to achieve Lebanon's NDC. - To improve Lebanon's climate finance reporting to the UNFCCC as per the Paris Agreement, to better inform the global stocktake and further reconcile support provided and received	Euros 40,000 – technical assistance	2017 - ongoing
European Union – ClimaSouth project	Management and Information System for Climate Action (MISCA)	- Create an internet portal dedicated to the Ministries of Environment and Energy that facilitates sharing and access to activity data, policy information,	Euros 60,000 – technical assistance	2017 - ongoing

		related actors and finance. - Automatically generate results of CO_2 emitted and avoided - Establish institutional arrangements to anchor MISCA in the national transparency framework		
European Union – ClimaSouth project	NAMA support	- Drafting of transport and forestry NAMAs is completed	Euros 30,000 - technical assistance	2017 – ongoing
European Union – ClimaSouth project	Engaging the Lebanese private sector in climate action – support to the Lebanon Climate Act	- Establish Business Knowledge Platforms to enhance capacities of private sector on implementing climate action - Publish business manual on how to create value from climate change published	Euros 60,000 – technical assistance	2016 – 2017
GIZ	(Adaptation to Climate Change in the Water Sector in the MENA Region (ACCWAM)	-to mainstream adaptation to climate change in water policies and actions plans in the region, including Lebanon	NA	2011-2017

*Budget includes the allocated amounts from the donors and not disbursed amount

In terms of capacity building, experts from ministries, governmental agencies and from academic institutions have been nominated to participate in trainings related to climate change and to join the UNFCCC Roster of Expert. Consequently, the country has now a team of experts in various fields (namely energy, agriculture, LULUCF, waste and transport) that have an improved knowledge of the national inventories, national communications and BURs. This has contributed in improving the preparation and compilation of the present GHG inventory. However, unfortunately, Lebanon does not have the required resources to plan and implement a comprehensive training programme to develop the capacities of specialists in different ministries and agencies who should be fully involved in the BUR process. Initiatives in this sense remain sporadic and subject to the availability of funds.

Table **93** presents the participation of representatives of Lebanon in capacity building events related to climate change since the submission of the first BUR.

Table 93: Capacity building received by the Ministry of Environment

Donor	Title of Workshop	Objectives	Date and place	Capacity building indicator
UNFCCC Secretariat	Hands on training on the preparation and reporting of mitigation actions (Asia-Pacific and Eastern European regions)	Enhance preparation and implementation of mitigation actions and provision of knowledge on reporting information in national	September 2017 Siem Reap, Cambodia	1 national expert trained

		communications and biennial update reports		
GIZ - FAO	GHG inventories for the energy and AFOLU sectors as a basis for updating and monitoring NDCs	Enhance capacities of GHG inventory experts for a more transparent inventory system Share success stories and lessons learned from inventory preparation and sensitize on the importance of sound data collection Train experts on inventory methods	August 2017 Rome, Italy	3 national experts trained
UNFCCC Secretariat	Regional training workshop on national adaptation plans (NAPs) for Asia	Enhance the capacity of developing countries to address medium and long-term adaptation needs through the formulation and implementation of NAPs	June 2017 Manila, the Philippines	1 national expert trained
GIZ	Good-practice workshop on the BUR and ICA process for Non-Annex I countries	Enhance the understanding of the BUR and ICA process, share good practices and lessons learned, and discuss how those experiences can be applied for the improvement of MRV systems in general.	April 2017 Berlin, Germany	1 national expert trained
UNDP–UNEP National Adaptation Plan – Global Support Programme (NAP-GSP)	Supporting countries to advance their national adaptation plan (NAP) process	Improve the understanding of the NAPs process; take stock of the existing guidance and tools and exchange information on the mechanisms and options for supporting NAPs.	April 2017 Amman, Jordan	1 national expert trained
UNFCCC Secretariat	Workshop on the Building of Sustainable National Greenhouse Gas Inventory Management Systems, and the use of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories for the Asia-Pacific and the	Enhance capacities of national experts to adopt the 2006 IPCC guidelines for national inventories	September 2016 Incheon, Republic of Korea	1 national expert trained

	Eastern European Regions			
Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE)	Regional training workshop for the Asian and Eastern European region on the preparation of biennial update reports from non-Annex I Parties	Enhance the capacity of national experts from non-Annex I Parties in understanding and applying the "UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention"	April 2016 Colombo, Sri Lanka	1 national expert trained

VI. Other information considered relevant to the achievement of the convention

With a view to facilitating the integration of climate change considerations into relevant social, economic and environmental policies and actions in accordance with Article 4, paragraph 1 (f), of the Convention, Lebanon has undertaken steps various initiatives with schools and with the private sector, namely the development and dissemination of a teacher's guide on climate change and a guide for businesses in Lebanon to create value from climate change.

1. Teacher's guide on climate change for schools in Lebanon

The guidebook aims to provide teachers in schools across Lebanon with a wide range of activities and exercises which can be integrated into their teaching subjects and classes in order to enhance student knowledge and skills on climate change. The guidebook was developed with the aim to engage both teachers and students in climate change through an approach that emphasizes critical thinking, interactive dialogues, practical and solutions-based learning, and creative projects. The activities and exercises have been developed with particular focus on the impacts, challenges and opportunities regarding climate change in Lebanon, and include national statistics, data, facts and case studies on climate change in Lebanon. They cover a wide range of topics for primary, middle and secondary cycles across both the scientific and socio-political aspects of climate change.

The Ministry of Environment has engaged in a series of awareness activities to disseminate the guidebook to schools and has partnered with UNESCO and the Ministry of Education to develop the Arabic version of the guidebook and integrate it officially in the Lebanese curriculum.

2. How to create value from climate change: a guide for businesses in Lebanon

The guidebook, primarily intended for businesses in Lebanon, has been developed as part of the Lebanon Climate Act (LCA) initiative with support from the EU Cimasouth project and the UNDP LCEB project. The guidebook provides information for businesses to gain a better and deeper understanding of the risks that climate change poses to the modern world and capitalise on opportunities arising from climate change. It is a tool to help companies develop and implement plans to effectively take part in climate change action on the scale of each business. Non-state actors can also benefit from the guidebook to design, implement and monitor their climate actions.

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Annexes

Annex I. GHG inventory technical annex

Lebanon's GHG inventory - summary report for national GHG inventory 2013

Greenhouse gas source and sink categories		CO_2 emissions / removals CO_2 (Gg)	CO_2 removals	CH_4 CO_2 eq. (Gg)	N_2O CO_2 eq. (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)	HFCs (Gg)	PFCs* (Gg)	SF_6 * (Gg)	Other fluorinated (Gg)	Total gross CO_2 CO_2 eq. (Gg)
Total national emissions and removals 2013		**23,246.21**	**-3,518.80**	**96.68**	**1,008.11**	**88.67**	**374.77**	**117.19**	**119.01**	NE	NE	NE	NE	**26,284.69**
1. Energy		20,551.07		2.12	179.56	88.67	374.61	76.88	117.24					20,775.10
A. Fuel combustion	Reference approach[2]	21,072.72												
	Sectoral approach	20,551.07		2.12	179.56	88.67	374.61	76.88	117.24					20,775.10
1. Energy industries		7,367.39		6.25	18.44	19.83	1.49	0.50	69.42					7,392.08
2. Manufacturing industries and construction		4,403.84		2.23	9.89	10.63	0.53	0.27	28.28					4,415.96
3. Transport		5,987.93		26.74	143.69	54.23	371.06	75.83	5.58					6,158.35
4. Other sectors		2,791.91		9.26	7.55	3.98	1.54	0.29	13.96					2,808.72
5. Other (please specify)		0.00		0.00	0.00	0.00	0.00	0.00	0.00					0.00
B. Fugitive emissions from fuels			-	NO		NO	NO	NO	NO					
1. Solid fuels				NO		NO	NO	NO	NO					
2. Oil and natural gas				NO		NO	NO	NO	NO					

[2] The IPCC reference approach allows to validate the results of the sectoral approach, which considers energy consumption using a bottom up approach, whereas the IPCC reference approach considers energy suppusing top down approach This requires a balance of primary fuels produced, plus imports, minus exports, minus international bunkers and minus net changes in stocks.

Greenhouse gas source and sink categories	CO_2 emissions / removals CO_2 (Gg)	CO_2 removals	CH_4 CO_2 eq. (Gg)	N_2O CO_2 eq. (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)	HFCs (Gg)	PFCs* (Gg)	SF_6 * (Gg)	Other fluorinated (Gg)	Total gross CO_2 CO_2 eq. (Gg)
2. Industrial processes	**2,545.42**		**0.00**	**0.00**	**0.00**	**0.00**	**40.31**	**1.77**					**2,545.42**
A. Mineral products	2,545.42				0.00	0.00	26.12	1.77					**2,545.42**
B. Chemical industry	NE		NE	NE	NE	NE	NE	NE					-
C. Metal production	NO		NO	NO	NO	NO	NO	NO					-
D. Other production	0.00				0.00	0.00	14.19	0.00					0.00
E. Production of halocarbons and sulphur hexafluoride									NO	NO	NO	NO	
F. Consumption of halocarbons and sulphur hexafluoride									NE	NE	NE	NE	
G. Other (please specify)	NO		NO	NO	NO	NO	NO	NO					
3. Solvent and other product use	NE			NE			NE						-
4. Agriculture			**305.55**		**682.00**	**0.00**	**0.00**	**0.00**					**987.55**
1.a. Enteric fermentation			**265.44**										
1.b. Manure management			**40.11**	170.50			0.00						210.61
2. Rice cultivation			NO				NO						
3. Agricultural soils			0.00	511.50			0.00						511.50
4. Prescribed burning of savannas			NO	NO	NO	NO	NO						-
5. Field burning of agricultural residues			NO	NO	NO	NO	NO						-

Greenhouse gas source and sink categories	CO_2 emissions / removals CO_2 (Gg)	CO_2 removals	CH_4 CO_2 eq. (Gg)	N_2O CO_2 eq. (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)	HFCs (Gg)	PFCs* (Gg)	SF_6 * (Gg)	Other fluorinated (Gg)	Total gross CO_2 CO_2 eq. (Gg)
6. Other (please specify)			NO	NO	NO	NO	NO						0.00
5. Land use, land use change and forestry (LULUCF)**	**149.67**	**-3,518.79**	**0.23**	**0.04**	**0.01**	**0.16**							**149.95**
1. Changes in forest and other woody biomass stocks	0.00	0.00											0.00
2. Forest and grassland conversion	0.00	0.00	0.00	0.00	0.00	0.00							0.00
3. Abandonment of managed lands		0.00											0.00
4. CO_2 emissions and removals from soil	0.00	0.00											0.00
5. Other (please specify)	0.00	0.00	0.00	0.00	0.00	0.00							0.00
6. Waste	**0.05**		**1,680.11**	**146.50**	**0.00**	**0.00**	**0.00**	**0.00**					**1,826.66**
A. Solid waste disposal on land			1,279.14										**1,279.14**
B. Wastewater handling			400.97	146.51	0.00	0.00	0.00						**547.47**
C. Waste incineration (and open burning)	0.05				0.00	0.00	0.00	0.00					**0.0502**
D. Other (please specify)			0.00	0.00	0.00	0.00	0.00	0.00					0.00
7. Other (please specify)													
Memo items													808.05
International bunkers	**878**		**NE**	**NE**	NE	NE	NE	NE					**878**
A. Aviation	784		**NE**	**NE**	NE	NE	NE	NE					784

Greenhouse gas source and sink categories	CO_2 emissions / removals CO_2 (Gg)	CO_2 removals	CH_4 CO_2 eq. (Gg)	N_2O CO_2 eq. (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)	HFCs (Gg)	PFCs* (Gg)	SF_6 * (Gg)	Other fluorinated (Gg)	Total gross CO_2 CO_2 eq. (Gg)
B. Marine	94		**NE**	**NE**	NE	NE	NE	NE					94
Multilateral operations	NO												
CO_2 emissions from biomass	16												16
CO_2 captured	NO												
Long-term storage of CO_2 in waste disposal sites	NO												

Notes:
** Optional for Level 1 and Level 2 reporting*
*** Results reflect calculations of emissions from LULUCF based on 2003 GPG for LULUCF. Details of the calculation are presented in*

Table 52.
N.B.: Shaded cells are not applicable.
Source: Table 1 and Table 2 in the annex to UNFCCC decision 17/CP.8 and Table A.15

Annex II. Activity data and emission factor - indirect gases in industrial processes

Summary of data sources used in the GHG inventory for the industrial processes sector

Reporting category	Activity data needed	Source used in BUR II
Production and use of miscellaneous mineral products	Asphalt for road paving	Lebanese customs through Ministry of Economy and Trade. HS code: 27.15.00.10
	Asphalt for roofing – blowing process	This activity data is calculated using the following equation*: quantity of asphalt blown = bitumen import – asphalt for road paving. Lebanese customs through Ministry of Economy and Trade for asphalt for road paving except values for the period 2010-2013 which were extrapolated due to inconsistencies with numbers of imported bitumen. HS code: 27.15.00.10 Ministry of Energy and Water for bitumen import
Food and drink	Wine production	Union Vinicole du Liban
	Beer production	The only beer producing company during the period covered by the inventory.
	Fish production	Nader et.al, 2014 up to the year 2011. Personal communication with Dr. Shadi Indari for the years 2012 and 2013.
	Meat production	Ministry of Agriculture (for locally produced meat). Extrapolation was performed for the year 2013 due to unavailability of data.
	Poultry production	Ministry of Agriculture (for locally produced poultry).
	Bread production	Estimated from wheat import (Lebanese customs through Ministry of Economy and Trade, except from 2013 values which retrieved directly from customs website. HS codes: 10.01.90.00 and 11.02.20.00) and production (Ministry of Agriculture). It is estimated that 50% of wheat is used for bread production, and 50% for cakes and biscuits. The amount of wheat used for bread making was multiplied by a factor of 0.92 based on the fact that each tonne of wheat produces 920 kg of bread.
	Cakes and biscuits production	Estimated from wheat import (Lebanese customs through Ministry of Economy and Trade, except from 2013 values which retrieved directly from customs website. HS codes: 10.01.90.00 and 11.02.20.00) and production (Ministry of Agriculture). It is estimated that 50% of wheat is used for bread production, and 50% for cakes and biscuits. The amount of wheat used for cakes and biscuits production was multiplied by a factor of 4 based on the fact that each tonne of wheat produces 4 tonnes of cakes/biscuits.

*The annual weight of asphalt binder (cutback) used in road paving is required to prepare estimates of maximum likely emissions of NMVOCs from this source. This amount is derived from asphalt cement consumption according to the following formulas:

Weight of Cutback Asphalt = Weight of Asphalt Cement + Weight of Diluent Weight of Diluent = Volume of Diluent x Density of Diluent (0.7 kg/l)

Volume of Diluent = Volume of Cutback Asphalt x 0.45 (45% of diluent in Cutback Asphalt)

Volume of Cutback Asphalt = Volume of Asphalt Cement / 0.55 (55% Asphalt Cement in Cutback Asphalt) Volume of Asphalt Cement = Weight of Asphalt Cement / Density of Asphalt Cement (1.1 kg/l)

Activity data for industrial processes in Lebanon for selected years

Year	1994	2000	2006	2011	2013
Quantity of asphalt roofing produced (t) - blowing process	2,550	18,084	20,222	16,205	14,492
Quantity of road paving material used (t)	844,035	111,987.57	35,940.83	89,124.88	81,527.20661
Quantity of beer produced (hl)	8,612	132,888	158,740	211,587	215,110
Quantity of wine produced (hl)	20,417	33,187	43,356	70,000	62,000

Activity data for food production in Lebanon for selected years

Year	1994	2000	2006	2011	2013
Quantity of meat produced (t)	NA	19,348	18,916	51,401	
Quantity of fish produced (t)	NA	8,640	8,090	8,072*	8,822*
Quantity of poultry produced (t)	NA	107,200	129,999	32,099,986	33,419,717
Quantity of bread produced (t)	NA	187,083	177,758	263,733.6	334,303
Quantity of cakes and biscuits produced (t)	NA	813,404	772,862	1,146,668	1,453,491

*Numbers of fish catch provided for North Lebanon coast only, they constitue 40% of total national fish catch according to personal communication with Shadi el Indari. The numbers in the table are the adjusted numbers by calculation.

Calculation of weight of asphalt binder (cutback) used in road paving

A	B	C	D	E	F	G
Weight imported road paving material (kg)	**Weight imported road paving material (t)**	**Volume of imported road paving material**	**Volume of cutback asphalt**	**Volume of diluent**	**Weight of diluent**	**Weight of cutback asphalt (activity data in tonnes)**
	B = A / 1,000	C = B / 1.1	D = C / 0.55	E = D x 0.45	F = E x 0.7	G = B + F
53,613,000	53,613	48,739.09	88,616.53	39,877.44	27,914.21	81,527.21

The annual weight of asphalt binder (cutback) used in road paving is required to prepare estimates of maximum likely emissions of NMVOCs from this source. This amount is derived from asphalt cement consumption according to the following formulas:

Weight of Cutback Asphalt = Weight of Asphalt Cement + Weight of Diluent Weight of Diluent = Volume of Diluent x Density of Diluent (0.7 kg/l)

Volume of Diluent = Volume of Cutback Asphalt x 0.45 (45% of diluent in Cutback Asphalt)

Volume of Cutback Asphalt = Volume of Asphalt Cement / 0.55 (55% Asphalt Cement in Cutback Asphalt) Volume of Asphalt Cement = Weight of Asphalt Cement / Density of Asphalt Cement (1.1 kg/l)

Emission factors and other parameters adopted in the national greenhouse gas inventory

Reporting categories	Emission factor and other parameters	Source of emission factor
Cement production	0.51 t CO_2/t clinker produced	Nationally developed emission factor, SNC (MoE/UNDP/GEF, 2011)*
	Correction factor for cement kiln dust (CKD): 1.02*	IPCC Good Practice Guidance and Uncertainty Management, p.3.12
	0.3 kg SO_2/t cement produced	Revised 1996 IPCC guidelines, reference manual, p.2.7
Lime production	0.79 t CO_2/t quicklime produced	Revised 1996 IPCC guidelines, reference manual, p.2.9
Soda ash use	415 kg CO_2/t soda ash used	Revised 1996 IPCC guidelines, reference manual, p.2.13
	320 kg NMVOCs/t road paving material used	Revised 1996 IPCC guidelines, reference manual, p.2.14
Production and use of miscellaneous mineral products	2.4 kg NMVOCs/t asphalt roofing produced	Revised 1996 IPCC guidelines, reporting instructions, p.2.9
	0.095 kg CO/t asphalt roofing produced	Revised 1996 IPCC guidelines, reference manual, p.2.13
	0.035 kg NMVOCs/hl beer produced	Revised 1996 IPCC guidelines, reference manual, p.2.41
	0.3 kg NMVOCs/t fish processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t meat processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	0.3 kg NMVOCs/t poultry processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	8 kg NMVOCs/t bread processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	8 kg NMVOCs/t bread processed	Revised 1996 IPCC guidelines, reference manual, p.2.42
	1 kg NMVOCs/t cakes and biscuits processed	Revised 1996 IPCC guidelines, reference manual, p.2.42

Annex III. Activity data for the agriculture sector

Detailed poultry calculation for the year 2013

Year	Laying Hens (used for meat)	Broilers	Traditional chicken	TOTAL	Broilers adjusted to 60 days alive	Total adjusted to days alive
2013	2,500,000	56,000,000	1,000,000	59,500,000	9,205,479	12,705,479

Calculation of F_{BN} for 2013

Crop	Fresh weight (tonnes)	DM	Factor	$Frac_{NCRBF}$	F_{BN}
Beans, dry	426	1	2	0.03	25.56
Beans, green	24,439	0.85	2	0.03	1,246.39
Broad beans, horse beans, dry	150	1	2	0.03	9.00
Chick peas	2,435	1	2	0.03	146.10
Alfalfa	20,000	0.5	1	0.03	300.00
Lentils	1,471	1	2	0.03	88.26
Lupins	115	1	2	0.03	6.90
Peas, dry	2,495	1	2	0.03	149.70
Peas, green	4,090	0.85	2	0.03	208.59
Vetches	825	0.9	1	0.03	22.28
Total					2,202.77

Annex IV. Land-use classification, definitions and disaggregation

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations
Settlements	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.	This category includes all developed land, including transportation infrastructure and human settlements	Dense urban area Unorganized dense urban area Moderately dense urban area Moderately dense unorganized urban area Low density urban area Low density unorganized urban area Tourist resort Archeological site Large equipment Industrial or commercial zone Harbor zone Airport Train station Highway Other type of road Farm building Farm building with field crops Farm building with deciduous fruit trees Quarry Dump Sea filling Urban sprawl and /or construction site Vacant urban land Green urban space Large sport or leisure equipment	No disaggregation needed
Cropland	This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the threshold used for the forest land category, consistent with the selection of national definitions.	This category includes arable and tillage land. More specifically, the following classes were considered under this category: crops, olive groves, vineyards, deciduous fruit trees, bananas, citrus trees, and greenhouse cultivations.	Field crops in large area	Annual
			Field crops combined with olive	Annual
			Field crops combined with vines	Annual
			Field crops combined with deciduous fruit trees	Annual
			Field crops combined with citrus trees	Annual
			Field crops combined with greenhouses	Annual
			Field crops in small plots or terraces	Annual
			Urban sprawl on field crops	Annual
			Olives	Perennial

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations
			Olives combined with field crops	Perennial
			Olives combined with vines	Perennial
			Olives combined with deciduous fruit trees	Perennial
			Olives combined with citrus trees	Perennial
			Olives combined with intensive field crops	Perennial
			Olives combined with greenhouses	Perennial
			Vineyards	Perennial
			Vineyards combined with field crops	Perennial
			Vineyards combined with olives	Perennial
			Vineyards combined with deciduous fruit trees	Perennial
			Vineyards combined with intensive field crops	Perennial
			Vineyards combined with greenhouses	Perennial
			Deciduous fruit trees	Perennial
			Deciduous fruit trees combined with field crops	Perennial
			Deciduous fruit trees combined with olives	Perennial
			Deciduous fruit trees combined with vines	Perennial
			Deciduous fruit trees combined with citrus trees	Perennial
			Deciduous fruit trees combined with banana trees	Perennial
			Deciduous fruit trees combined with intensive field crops	Perennial
			Deciduous fruit trees combined with greenhouses	Perennial
			Citrus trees	Perennial
			Citrus trees combined with field crops	Perennial
			Citrus trees combined with olives	Perennial
			Citrus trees combined with deciduous fruit trees	Perennial
			Citrus trees combined with banana trees	Perennial
			Citrus trees combined with intensive field crops	Perennial
			Citrus trees combined with greenhouses	Perennial
			Banana trees	Perennial
			Banana trees combined with deciduous fruit trees	Perennial
			Banana trees combined with citrus trees	Perennial

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations
			Banana trees combined with intensive field crops	Perennial
			Banana trees combined with greenhouses	Perennial
			Urban sprawl on orchard	Perennial
			Intensive filed crops	Annual
			Intensive filed crops combined with olives	Annual
			Intensive filed crops combined with deciduous fruit trees	Annual
			Intensive filed crops combined with citrus trees	Annual
			Intensive filed crops combined with greenhouses	Annual
			Greenhouses	Annual
			Greenhouses combined with field crops	Annual
			Greenhouses combined with vines	Annual
			Greenhouses combined with deciduous fruit trees	Annual
			Greenhouses combined with citrus trees	Annual
			Greenhouses combined with banana trees	Annual
			Greenhouses combined with intensive field crops	Annual
			Urban sprawl on greenhouses	Annual
Forest land	Forest: This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided at the national level into managed and unmanaged and also by ecosystem type as specified in the IPCC Guidelines.6 It also includes systems with vegetation that currently falls below, but is expected to exceed, the threshold of the forest land category. Managed forest: All forests	This category included the following:	Dense pine forests (mainly *Pinus brutia* and *Pinus pinea*)	Coniferous
			Dense cedre forests (*Cedrus libani*)	Coniferous
			Dense fir forests (*Abies Cilicia*)	Coniferous
			Dense cypress forests (*Cupressus ssp.*)	Coniferous
			Dense oak forests (*Quercus ssp.*)	Broadleaf
			Dense broadleaves forests (*Platanus, Populus, Salix*)	Broadleaf
			Mixed dense forests	Mixed
			Urban sprawl on dense forest	Mixed
			Low density pine forests (*Pinus brutia* and *Pinus pinea*)	Coniferous
			Low density cedre forests (*Cedrus libani*)	Coniferous
			Low density Juniper forests (*Juniperus ssp.*)	Coniferous
			Low density fir forests (*Abies, Cilicia*)	Coniferous
			Low density cypress forests (*Cupressus ssp.*)	Coniferous
			Low density oak forests (*Quercus ssp.*)	Broadleaf

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations
	subject to some kind of human interactions (notably commercial management, harvest of industrial round-wood (logs) and fuelwood, production and use of wood commodities, and forest managed for amenity value or environmental protection if specified by the country), with defined geographical boundaries.		Low density broadleaves forests (*Platanus, Populus, Salix*)	Broadleaf
			Low density mixed forests	Mixed
			Urban sprawl on low density forest	Mixed
			Shrubland	Broadleaf
			Shrubland with dispersed trees	Broadleaf
			Urban sprawl on shrubland	Broadleaf
Grassland	This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the thresholds used in the forest land category. This ategory also includes all grassland from wild lands to recreational areas as well as agricultural and silvo-pastural systems, subdivided into managed and unmanaged, consistent with national definitions.	This category includes rangelands and pasture land that is not considered as cropland. More specifically, it included moderately dense herbaceous vegetation, and highly dense herbaceous vegetation.	Moderately dense herbaceous vegetation	Annual grasses
			Low density herbaceous vegetation	Annual grasses
Wetland	This category includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or	This category includes land that is covered or saturated by water for all or part of the year. More specifically, it included the following classes: surface water bodies, lakes,	Continental humid zone	Flooded areas (Artificial reservoirs and hill lakes)
			Marine humid zone	
			Water plane (reservoir)	
			Hill lake	
			Stream or river	

	Definition according to IPCC GPG for LULUCF	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF recommendations
	settlements categories. This category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.	rivers, and reservoirs.	Harbor basin	
Other land	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.	This category included bare soil, rock, ice, and recently burned forested lands	Bare rock	No need for disaggregation
			Urban sprawl on bare rock	
			Bare soil	
			Beach	
			Sand dune	
			Burned area	

List of activity data

	only for calc. purposes	Extrapolation				Baseline			Interpolation								Interpolation				
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
FF-Total	**258646.65**	**258475.95**	**258304.34**	**258131.73**	**257957.98**	257890.00	257628.13	257172.00	257142.81	257113.63	257059.19	256905.94	256543.94	256236.63	256088.25	255775.00	255575.03	255375.06	254771.13	254463.13	254106.19
Coniferous	35274.24	35257.05	35239.76	35222.37	35204.87	35216.00	35187.56	35121.00	35116.50	35112.00	35102.81	35083.69	35063.13	35028.06	35022.31	34977.44	34960.44	34943.44	34887.56	34871.06	34822.44
Broadleaf	196658.18	196517.58	196376.23	196234.06	196090.95	196008.00	195792.44	195451.75	195431.06	195410.38	195366.69	195244.75	194924.19	194682.31	194544.06	194300.38	194131.47	193962.56	193467.06	193184.13	192925.38
Mixed	26714.23	26701.32	26688.35	26675.30	26662.16	26666.00	26648.13	26599.25	26595.25	26591.25	26589.69	26577.50	26556.63	26526.25	26521.88	26497.19	26483.13	26469.06	26416.50	26407.94	26358.38
GG-Total	318130.90	318023.29	317915.11	317806.28	317696.75	317600.00	317497.13	317237.13	317212.41	317187.69	317158.00	317018.88	316755.56	316573.94	316558.25	316314.69	316180.03	316045.37	315697.12	315518.06	315180.62
CC-Total	333242.83	333069.80	332895.87	332720.90	332544.79	332364.00	332082.13	331856.69	331819.22	331781.75	331669.56	331279.94	331167.25	330804.06	330776.75	330505.06	330081.53	329658.00	329415.12	328959.31	328364.69
Perennial	160701.36	160646.49	160591.33	160535.84	160479.98	160354.00	160287.75	160243.25	160230.06	160216.88	160185.56	160126.56	160100.63	160047.50	160041.00	159937.69	159719.69	159501.69	159376.06	159235.25	158970.00
Annual	172541.46	172423.32	172304.54	172185.07	172064.81	172010.00	171794.38	171613.44	171589.16	171564.88	171484.00	171153.38	171066.63	170756.56	170735.75	170567.38	170361.84	170156.31	170039.06	169724.06	169394.69
FF-Burned		**NE**	**NE**	**NE**	**NE**	0.00	1048.63	330.00	73.19	73.19	304.00	62.50	423.69	1197.00	708.00	25.81	427.72	427.72	161.13	603.00	127.56
Coniferous		NE	NE	NE	NE	0.00	122.88	54.25	6.47	6.47	31.25	5.31	37.44	126.56	83.44	6.56	59.97	59.97	14.63	37.69	4.75
Broadleaf		NE	NE	NE	NE	0.00	870.00	217.06	53.66	53.66	251.88	53.31	347.56	1012.63	568.38	16.56	311.59	311.59	133.56	548.31	44.25
Mixed		NE	NE	NE	NE	0.00	55.75	58.69	13.06	13.06	20.88	3.88	38.69	57.81	56.19	2.69	56.16	56.16	12.94	17.00	78.5625
FF-Burned		**NE**	**NE**	**NE**	**NE**	0.00	1048.63	330.00	73.19	73.19	304.00	62.50	423.69	1197.00	708.00	25.81	427.72	427.72	161.13	603.00	127.56
Fuel Type 3		NE	NE	NE	NE	0.00	280.50	98.63	5.94	5.94	204.81	34.44	163.69	631.69	157.81	13.69	184.59	184.59	58.06	262.31	78.5625
Fuel Type 4		NE	NE	NE	NE	0.00	482.69	97.63	31.38	31.38	59.69	17.06	134.56	379.81	213.00	8.00	155.59	155.59	53.06	185.13	44.25
Fuel Type 5		NE	NE	NE	NE	0.00	6.94	14.75	5.34	5.34	12.75	4.19	1.81	32.56	24.56	0.00	7.00	7.00	2.88	10.25	0
Fuel Types 6&7		NE	NE	NE	NE	0.00	278.50	119.00	30.53	30.53	26.75	6.81	123.63	152.94	312.63	4.13	80.53	80.53	47.13	145.31	4.75
GG-Burned		**NE**	**NE**	**NE**	**NE**	0.00	198.38	125.50	148.47	148.47	492.19	96.44	95.94	815.06	42.75	12.56	271.00	271.00	182.38	242.75	37.88
Fuel Type 1		NE	NE	NE	NE	0.00	148.13	78.50	76.44	76.44	287.44	50.06	74.69	638.69	28.19	6.13	206.72	206.72	109.06	184.88	37.875
Fuel Type 2		NE	NE	NE	NE	0.00	50.25	47.00	72.03	72.03	204.75	46.38	21.25	176.38	14.56	6.44	64.28	64.28	73.31	57.88	0
CC-Burned		**NE**	**NE**	**NE**	**NE**	0.00	493.56	501.75	250.94	250.94	528.50	222.69	344.06	334.44	274.81	542.00	675.09	675.09	585.19	1305.81	9.5625
LS-Total		**451.34**	**453.73**	**456.40**	**459.40**	0.00	646.62	941.56	91.38	91.38	196.31	682.00	738.00	852.13	191.38	828.50	758.16	758.16	1195.06	942.88	1248.25
FS		**170.70**	**171.60**	**172.61**	**173.75**		261.87	456.13	29.19	29.19	54.44	153.25	362.00	307.31	148.38	313.25	199.97	199.97	603.94	308.00	356.94
Coniferous		17.19	17.28	17.39	17.50	0.00	28.44	66.56	4.50	4.50	9.19	19.13	20.56	35.06	5.75	44.88	17.00	17.00	55.88	16.50	48.625

Broadleaf		140.60	141.34	142.18	143.11	0.00	215.56	340.69	20.69	20.69	43.69	121.94	320.56	241.88	138.25	243.69	168.91	168.91	495.50	282.94	258.75
Mixed		12.91	12.98	13.05	13.14	0.00	17.88	48.88	4.00	4.00	1.56	12.19	20.88	30.38	4.38	24.69	14.06	14.06	52.56	8.56	49.5625
GS		107.61	108.18	108.82	109.54	0.00	102.88	260.00	24.72	24.72	29.69	139.13	263.31	181.63	15.69	243.56	134.66	134.66	348.25	179.06	296.6875
CS		173.02	173.94	174.96	176.11	0.00	281.88	225.44	37.47	37.47	112.19	389.63	112.69	363.19	27.31	271.69	423.53	423.53	242.88	455.81	594.63
Perennial		54.87	55.16	55.49	55.85	0.00	66.25	44.50	13.19	13.19	31.31	59.00	25.94	53.13	6.50	103.31	218.00	218.00	125.63	140.81	265.25
Annual		118.15	118.77	119.47	120.26	0.00	215.63	180.94	24.28	24.28	80.88	330.63	86.75	310.06	20.81	168.38	205.53	205.53	117.25	315.00	329.375
LF-Total		**NE**	**NE**	**NE**	**NE**	0.00	305.00	305.00	305.00	305.00	278.00	278.00	278.00	278.00	278.00	52.00	52.00	147.73	52.00	381.21	302.62
FAO, 2010 & MOE, 2013		NE	NE	NE	NE	0.00	305.00	305.00	305.00	305.00	278.00	278.00	278.00	278.00	278.00	0.00	0.00	95.73	0.00	95.73	
AFDC		NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	52.00	52.00	52.00	52.00	52.00	
LRI		NO	NO	NO	NO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	233.48	
LW-Total		**NE**	**NE**	**NE**	**NE**	0.00	NE	NE	NE	NE	NE	NE	NE	NE	NE	37	NE	NE	NE	NE	3597.56
OW		**NE**	**NE**	**NE**	**NE**	0.00	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**37**	**NE**	**NE**	**NE**	**NE**	3.75
LC		**NE**	**NE**	**NE**	**NE**	0.00	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
LG		**NE**	**NE**	**NE**	**NE**	0.00	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**
LO		**NE**	**NE**	**NE**	**NE**	0.00	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**	**NE**

NE: Not Estimated (No activity data available) - NO: Not Occuring

- FF = forest land remaining forest land
- GG = grassland remaining grassland
- CC = cropland remaining cropland
- WW = wetlands remaining wetlands
- SS = settlements remaining settlements
- OO = other land remaining other land
- LF = lands converted to forest land
- LG = lands converted to grassland
- LC = lands converted to cropland
- LW = lands converted to wetlands
- LS = lands converted to settlements
- LO = lands converted to other land

List of E/R factors

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Average annual net increment in volume suitable for industrial processing	I_V	3.26	FF/ FL-1a_1of4	0	IR	not needed anymore since a default for G_W is used
Basic wood density	D	3.26	FF/ FL-1a_1of4	0	IR	not needed anymore since a default for G_W is used
Biomass Expansion factor for conversion of annual net increment (including bark) to above ground tree biomass increment	BEF_1	3.26	FF/ FL-1a_1of4	0	IR	not needed anymore since a default for G_W is used
Average annual aboveground biomass increment	G_W	3.26 3.26	FF/ FL-1a_1of4 LF/ FL-2a_1of1	3 (Coniferous), 4 (Broadleaved), 3.5 (Mixed) 5.725 (Coniferous)	IPCC GPG Default Table 3A.1.5 IPCC GPG Default Table 3A.1.6, experts' surveys (E. Chneis)	
Root-shoot ratio appropriate to increments	R	3.26 3.26	FF/ FL-1a_1of4 LF/ FL-2a_1of1	0.27	FAO 2005	
Carbon fraction of dry matter	CF	3.25 3.33 3.25 3.57 3.107 3.140	FF/ FL-1a_2of4 FF/ FL-1b_1of3 LF/ FL-2a_1of1 LF/ FL-2b_2of2 GG/GL-1a_2of2 WL-2a2_1of1	0.5	IPCC GPG Default	
Annually extracted volume of roundwood	H	3.27	FF/ FL-1a_2of4	0	experts' surveys (E. Chneis, J. Stephan)	
Biomass density	D	3.27	FF/ FL-1a_2of4	0.5001 (Coniferous), 0.58 (Broadleaved)	FAO 2005, IPCC GPG Table 3A.1.9, (Altaş et al., 2007), (Akay et al., 2001)	

<table>
<tr><th>Emission Factor</th><th>Symbol</th><th>Page in GPG</th><th>Land use Category /Sheet name</th><th>Value(s) used</th><th>Source of Value</th><th>Notes</th></tr>
<tr><td></td><td></td><td></td><td>FF/ FL-1a_3of4</td><td></td><td></td><td></td></tr>
<tr><td>Biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark)</td><td>BEF_2</td><td>3.27</td><td>FF/ FL-1a_2of4

FF/ FL-1a_3of4</td><td>1.3 (Coniferous), 1.4 (Broadleaved), 1.35 (Mixed)</td><td>IPCC GPG Default Table 3A.1.10</td><td></td></tr>
<tr><td>Fraction of biomass left to decay in forest due to commercial roundwood gathering</td><td>F_{BL}</td><td>3.27</td><td>FF/ FL-1a_2of4</td><td>0.15</td><td>IPCC GPG Default Table 3A.1.11</td><td></td></tr>
<tr><td>Annual volume of fuelwood gathering</td><td>FG</td><td>3.27</td><td>FF/ FL-1a_3of4</td><td>
<table>
<tr><th>Year</th><th>Non-coniferous (m^3)</th><th>Coniferous C (m^3)</th></tr>
<tr><td>1994</td><td>14628</td><td>3853</td></tr>
<tr><td>1995</td><td>14652</td><td>3952</td></tr>
<tr><td>1996</td><td>14676</td><td>4045</td></tr>
<tr><td>1997</td><td>14700</td><td>4114</td></tr>
<tr><td>1998</td><td>14725</td><td>4089</td></tr>
<tr><td>1999</td><td>14000</td><td>4081</td></tr>
<tr><td>2000</td><td>15000</td><td>4074</td></tr>
<tr><td>2001</td><td>15000</td><td>4063</td></tr>
<tr><td>2002</td><td>15000</td><td>4051</td></tr>
<tr><td>2003</td><td>15000</td><td>4040</td></tr>
<tr><td>2004</td><td>15000</td><td>4028</td></tr>
<tr><td>2005</td><td>15000</td><td>4017</td></tr>
<tr><td>2006</td><td>15000</td><td>3896</td></tr>
<tr><td>2007</td><td>15000</td><td>3900</td></tr>
<tr><td>2008</td><td>15000</td><td>3900</td></tr>
<tr><td>2009</td><td>15000</td><td>3900</td></tr>
<tr><td>2010</td><td>15000</td><td>3866</td></tr>
<tr><td>2011</td><td>15000</td><td>3833</td></tr>
</table>
</td><td>FAOSTAT 2017</td><td>NC volumes for the years 1994-1998 and 2012 are generated by extrapolation of the trend from the years 1999-2011

C volume for the year is generated by extrapolation of the trend from the years 1994-2011</td></tr>
</table>

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
				2012 14725 4064 2013 15000 3769		
Average biomass stock of forest areas	B_W	3.28	FF/ FL-1a_3of4	134 (Coniferous), 122 (Broadleaved), 128 (Mixed)	IPCC GPG Default Table 3A.1.2	
Fraction of biomass left to decay in forest due to disturbance	F_{bl}	3.28	FF/ FL-1a_4of4	0.415	IPCC GPG Default Table 3A.1.12	
Annual transfer into dead wood	B_{into}	3.33	FF/FL-1b_1of3	0	NA	Tier 1 assumes no change
Annual transfer out of dead wood	B_{out}	3.33	FF/FL-1b_1of3	0	NA	Tier 1 assumes no change

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Reference stock of litter under native, unmanaged forest corresponding to state i	$LT_{ref\ (i)}$	3.35	FF/FL-1b_1of3	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on LTref(i) in state i	$f_{mgt\ intensity(i)}$	3.35	FF/FL-1b_2of3	0	NA	Tier 1 assumes no change
Adjustment factor reflecting a change in the disturbance regime on LTref (i) in state i	$f_{dist\ regime(i)}$	3.35	FF/FL-1b_2of3	0	NA	Tier 1 assumes no change
Reference stock of litter under previous state j	$LT_{ref\ (j)}$	3.35	FF/FL-1b_2of3	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on LTref (j)	$f_{mgt\ intensity(j)}$	3.35	FF/FL-1b_2of3	0	NA	Tier 1 assumes no change
Adjustment factor reflecting a change in the disturbance regime on LTref (j)	$f_{dist\ regime(j)}$	3.35	FF/FL-1b_2of3	0	NA	Tier 1 assumes no change
Time period of the transition from state i to j	T_{ij}	3.35 3.40	FF/ FL-1b_3of3 FF/ FL-1c1_1of2	20	IPCC GPG Default	
Reference carbon stock	SOC_{REF}	3.40 3.63 3.75 3.112	FF/FL-1c1_1of2 LF/FL-2c1_1of1 CC/CL-1c1_1of2 GG/GL-1c1_1of2	38 (forest soils) 38 (cropland soils) 38 (grassland soils)	IPCC GPG Default Table 3.2.4 IPCC GPG Default Table 3.3.3 IPCC GPG Default Table 3.4.4	

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Adjustment factor reflecting the effect of a change from the native forest to the forest type in state i	$f_{forest\ type\ i}$	3.40	FF/FL-1c1_1of2	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on forest in state i	$f_{man\ intensity\ i}$	3.40	FF/FL-1c1_1of2	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of a change in the disturbance regime to state i with respect to the native forest	$f_{dist\ regime\ i}$	3.40	FF/FL-1c1_1of2	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of a change from the native forest to the forest type in state j	$f_{forest\ type\ j}$	3.40	FF/FL-1c1_2of2	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on forest in state j	$f_{man\ intensity\ j}$	3.40	FF/FL-1c1_2of2	0	NA	Tier 1 assumes no change
Adjustment factor reflecting the effect of a change in the disturbance regime to state j with respect to the native forest	$f_{dist\ regime\ j}$	3.40	FF/FL-1c1_2of2	0	NA	Tier 1 assumes no change

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Emission factor for CO2 from drained organic forest soils	$EF_{Drainage}$	3.42 3.63	FF/FL-1c2_1of1 LF/FL-2c1_1of1	0	IR	No organic soils (Expert's surveys, T. Darwish)
Mass of available fuel	B	3.49	FF/FL-1d_1of1	12,500 (fuel type 3), 30,000 (fuel type 4), 9,500 (fuel type 5), 12,500 (fuel type 6, 7)	(TRAGSA, 2012)	
Combustion efficiency or fraction of biomass combusted	C	3.49 3.120	FF/FL-1d_1of1 GG/GL-1d_1of1	0.5	IPCC GPG Default Table	
CH4 Emission factor	D	3.49	FF/FL-1d_1of1	9	IPCC GPG Default Table 3A.1.16	
CO Emission factor	F	3.49	FF/FL-1d_1of1	130	IPCC GPG Default Table 3A.1.16	
N2O Emission factor	H	3.49	FF/FL-1d_1of1	0.11	IPCC GPG Default Table 3A.1.16	
NOx Emission factor	J	3.49	FF/FL-1d_1of1	0.7	IPCC GPG Default Table 3A.1.16	
Standing biomass stock in terms of carbon in naturally regenerated forest	$B_{standing\ NatR}$	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration
Mortality rate in naturally regenerated forest	M_{NatR}	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Annual transfer out of dead wood for naturally regenerated forest area	$B_{out\ NatR}$	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration
Standing biomass stock in terms of carbon in artificially regenerated forest	$B_{standing\ ArtR}$	3.57	LF/FL-2b_1of2	0	NA	Tier 1 assumes no change
Mortality rate in artificially regenerated forest	M_{ArtR}	3.57	LF/FL-2b_1of2	0	NA	Tier 1 assumes no change
Annual transfer out of dead wood for artificially regenerated forest area	$B_{out\ ArtR}$	3.57	LF/FL-2b_2of2	0	NA	Tier 1 assumes no change
Annual change in litter carbon for naturally regenerated forest	DC_{NatR}	3.57	LF/FL-2b_2of2	0	IR	No data on natural regeneration
Annual change in litter carbon for artificially regenerated forest	DC_{ArtR}	3.57	LF/FL-2b_2of2	1	IPCC GPG Default Table 3.2.1, experts' surveys (E. Chneis)	
Stable soil organic carbon on previous land use, either cropland or grassland, SOCNon-forest Land	$SOC_{Non-forest\_land}$	3.63	LF/FL-2c1_1of1	0	IPCC GPG Default	
Duration of the transition from $SOC_{Non-forest\ Land}$ to SOC_{ref}	T_{AFF}	3.63	LF/FL-2c1_1of1	20	IPCC GPG Default	
Annual growth rate of perennial woody biomass	G	3.71	CC/CL-1a_1of1	2.1 (unburned perennial woody crops)	IPCC GPG Default Table 3.3.2	

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Annual carbon stock in biomass removed	L	3.71	CC/CL-1a_1of1	63 (burned perennial woody crops)	IPCC GPG Default Table 3.3.2	
Inventory time period	T	3.75 3.112	CC/CL-1c1_1of2 GG/GL-1c1_1of2	20	IPCC GPG Default	
Stock change factor for land use or land-use change type in the beginning of inventory year	$FLU_{(0-T)}$	3.75	CC/CL-1c1_1of2	0.82	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for management regime in the beginning of inventory year	$FMG_{(0-T)}$	3.75	CC/CL-1c1_1of2	1	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for input of organic matter in the beginning of inventory year	$FI_{(0-T)}$	3.75	CC/CL-1c1_1of2	1	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for land use or land-use change type in current inventory year	$FLU_{(0)}$	3.75	CC/CL-1c1_2of2	0.82	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for management regime in current inventory year	$FMG_{(0)}$	3.75	CC/CL-1c1_2of2	1	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for input of organic matter in current inventory year	$FI_{(0)}$	3.75	CC/CL-1c1_2of2	1	IPCC GPG Default Table 3.3.4, experts' surveys (J. Stephan)	
Emission factor for climate type c	EF	3.79	CC/CL-1c2_1of1	0	IR	No organic soils (Expert's surveys, T. Darwish)

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
		3.114	GG/GL-1c2_1of1			
Type of lime	type	3.80 3.115	CC/CL-1c3_1of1 GG/GL-1c3_1of1	0	IR	No lime applied (experts' surveys, J. Stephan)
Total Annual amount of lime applied	amount	3.80 3.115	CC/CL-1c3_1of1 GG/GL-1c3_1of1	0	Experts' surveys (J. Stephan)	No lime applied
Emission Factor (carbonate carbon contents of the materials)	EF	3.80 3.115	CC/CL-1c3_1of1 GG/GL-1c3_1of1	0	IR	No lime applied
Average annual biomass growth of perennial woody biomass	$G_{perennial}$	3.107	GG/GL-1a_1of2	0	IR	No grasslands covered with perennial woody biomass
Average annual biomass loss of perennial woody biomass	$L_{perennial}$	3.107	GG/GL-1a_1of2	0	IR	No grasslands covered with perennial woody biomass
Average annual biomass growth of grasses	$G_{grasses}$	3.107	GG/GL-1a_2of2	0	NA	Tier 1 assumes no change
Average annual biomass loss of grasses	$L_{grasses}$	3.107	GG/GL-1a_2of2	0	NA	Tier 1 assumes no change
Stock change factor for land use or land-use change type in the beginning of inventory year	$FLU_{(0-T)}$	3.112	GG/GL-1c1_1of2	1	IPCC GPG Default Table 3.4.5	

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Stock change factor for management regime in the beginning of inventory year	$FMG_{(0-T)}$	3.112	GG/GL-1c1_1of2	0.95	IPCC GPG Default Table 3.4.5, Darwish & Faour (2008)	
Stock change factor for input of organic matter in the beginning of inventory year	$FI_{(0-T)}$	3.112	GG/GL-1c1_1of2	1	IPCC GPG Default Table 3.4.5, experts' surveys (J. Stephan)	
Stock change factor for land use or land-use change type in current inventory year	$FLU_{(0)}$	3.112	GG/GL-1c1_2of2	1	IPCC GPG Default Table 3.4.5	
Stock change factor for management regime in current inventory year	$FMG_{(0)}$	3.112	GG/GL-1c1_2of2	0.95	IPCC GPG Default Table 3.4.5, Darwish & Faour (2008)	
Stock change factor for input of organic matter in current inventory year	$FI_{(0)}$	3.112	GG/GL-1c1_2of2	1	IPCC GPG Default Table 3.4.5, experts' surveys (J. Stephan)	
Mass of available fuel	B	3.120	GG/GL-1d_1of1	5,000 (fuel type 1), 6,500 (fuel type 2)	(TRAGSA, 2012)	
CH4 Emission factor	D	3.120	GG/GL-1d_1of1	3	IPCC GPG Default Table 3A.1.16	
CO Emission factor	F	3.120	GG/GL-1d_1of1	97	IPCC GPG Default Table 3A.1.16	
N2O Emission factor	H	3.120	GG/GL-1d_1of1	0.11	IPCC GPG Default Table 3A.1.16	
NOx Emission factor	J	3.120	GG/GL-1d_1of1	7	IPCC GPG Default Table 3A.1.16	
Living biomass immediately following conversion to flooded land	B_{After}	3.140	WL-2a2_1of1	0	IPCC GPG Default	

Emission Factor	Symbol	Page in GPG	Land use Category /Sheet name	Value(s) used	Source of Value	Notes
Living biomass in land immediately before conversion to flooded land	B_{Before}	3.140	WL-2a2_1of1	6.08	IPCC GPG Default Tables 3.4.2, 3.4.3	
Carbon stock in living biomass immediately following conversion to settlements	C_{After}	3.143	LS/ SL-2a_1of1	0	IPCC GPG Default	
Carbon stock in living biomass in forest immediately before conversion to settlements	C_{Before}	3.143	LS/ SL-2a_1of1	5 (Annual crops), 63 (Perennial woody crops), 0.8 (Grasslands), 67 (Coniferous forests), 61 (Broadleaved forests), 64 (Mixed forests)	IPCC GPG Default Tables 3.4.8, 3.3.2, 3.4.2, 3A.1.2	

IR: Irrelevant
NA: Not Available

Annex V. Recalculations

Sector	Recalculated categories	Parameter changed	Reasons for recalculation	Years of recalculations	Impact of recalculation
Energy	Residential	Change in Biomass	New data on charcoal production added to biomass use in energy Inclusion of emission factors of non-CO_2 gases	1994-2012	
Industrial processes	Production of Lime	Quantity of lime produced	Revision of data provided by the lime plant	2004 - 2012	An average 11% yearly decrease in CO_2 emissions over the period 2004 - 2012
Agriculture	Domestic livestock: enteric fermentation and manure management	Dairy cows	Revision of numbers by MoA	2008 – 2011 - 2012	An average of 3.3% yearly decrease of CH_4 emissions over the period 2005 – 2012. An average of 1.9% yearly decrease of N_2O emissions over the period 2005 - 2012.
		Other cattle	The source in previous inventory was FAO and Syndicate of beef importers. This inventory adopted a long-term approach of collecting data from the MoA, which does not include beef import in their statistics.	1998 - 2012	
		Sheep	Revision of numbers by MoA	2008 – 2011 - 2012	
		Goats	Revision of numbers by MoA	2008 – 2011 - 2012	
		Camels	Revision of numbers by FAOSTAT	2011 - 2012	
		Poultry	Revision of numbers by MoA	1998 – 2012 except 2004 and 2007	
	Agricultural soils	Dry beans, broad beans and horse beans, chick peas, lentils, dry peas, green peas, oats, carrot and turnips, garlic, onions	Revision of numbers by FAOSTAT	2010 - 2012	An average of 4.5% yearly decrease of N_2O emissions over the period 2005 - 2012.
		Green beans	Revision of numbers by FAOSTAT	2012	
		lupins, barley, maize, potatoes	Revision of numbers by FAOSTAT	2010	

		Average of fraction of residue removed from field for N fixing and non-N fixing crops FracR	Produce automated calculation of Nitrogen input from crop residues (F_{CR}) using UNFCCC excel model as opposed to manual calculations	1994 - 2012	
Waste	Solid waste disposal	Change in population number	Inclusion of Syrian displaced in population estimation	2012	Increase in CH_4 emissions by 5.5% for 2012
		Change fraction of DOC which actually degrades from 0.77 to 0.5	Based on the results of the GHG inventory review of 2011, the value of 0.77 was considered inconsistent with the IPCC GPG leading to an overestimation of emissions. The value of 0.5 (including lignin C) was recommended.	1994-2012	Reduction of CH4 emissions by 35% for all years
	Domestic and industrial wastewater	Change in population number	Inclusion of Syrian displaced in population estimation	2012	Increase in CH_4 emissions by 9.5% for 2012
		Reconsideration of the fractions of disposal of industrial wastewater	Based on the results of the GHG inventory review of 2011, discharge of industrial wastewater in septic tanks was considered inappropriate.	1994-2012	Reduction of CH_4 emissions by 2% for all years
	Waste incineration	Amount of clinical waste incinerated	Availability of new activity data from field-survey in hospitals	2004-2012	Reduction of CO_2 emissions by 83% for the years 2004-2012

Annex VI. Mitigation actions of energy sector

1. Data collection

Data has been collected per sub-category and split by year, using official publications and references from governmental authorities, in addition to personal interviews and online questionnaires submitted to implementing agencies and local suppliers. The references used and stakeholders consulted provide a comprehensive overview of the energy mitigation initiatives undertaken during the period 2012-2013. The collected information has then been merged to report progress by year, and by initiative-leader (private sector, donor or government).
Cumulative energy savings and GHG emission reductions are then presented for two milestone years, 2013 and 2030: The first for energy and GHG savings and the second for energy and GHG avoided.

Data collection for Mitigation actions in the energy sector

Category	Data Collection	Calculation Reference
1 Decentralized PV Installations	MoEW/UNDP/GEF, 2016 CEDRO, 2017 LCEC, 2016	MoE, 2017c Jordan and Kurtz, 2012 Expert judgement
2 Solar Water Pumping	MoEW/UNDP/GEF, 2016 UNDP, 2015 LCEC, 2016	MoE, 2017c Jordan and Kurtz, 2012 Expert judgement
3 Solar Street Lighting	MoEW, 2015 MoEW/LCEC, 2011 CEDRO, 2017 CEDRO, 2015	MoE, 2017c Jordan and Kurtz, 2012 Expert judgement
4 Efficient Street Lighting	MoEW, 2015 MoEW/LCEC, 2011 CEDRO, 2017 CEDRO, 2015	MoE, 2017c LCEC, 2017a
5 Solar Water Heating	UNEP, 2016 CEDRO, 2017	MoE, 2017c
6 Certified Green Buildings	USGBC, 2017 BREEAM, 2017	MoE, 2017c ASHRAE, 2009 Expert judgment
7 Energy Conservation Measures	CEDRO, 2017 LCEC, 2017b Shehadeh, 2017 Bsaibes, 2017 Diab, 2017	MoE, 2017c Expert judgment
8 Biomass Space Heating	CEDRO, 2017 Sfeir, 2017	MoE, 2017c Expert judgment
9 Other Renewables	CEDRO, 2017	MoE, 2017c Expert judgment Jordan and Kurtz, 2012
10 Other Energy Efficiency Measures	MoE, 2017a	MoE, 2017a
11 Power plants	MoEW, 2015	MoEW, 2015

2. Assumptions and calculation methodology

Emission factor

Quantification of greenhouse gas emission reductions is done using national grid emission factors as calculated by the Ministry of Environment. The emission factors are provided for the years 2011 to 2013, split into three sources as presented in the following table. GHG reductions are calculated on yearly basis with the relevant emission factors per year, and the source of power used for the affected systems. For example, GHG emission reductions for street lighting use the EDL grid emission factor, while that for decentralized PV generation uses the EDL and Private Generation grid emission factor.

Grid Emission Factor (Tons CO_2 eq/KWh)	2011	2012	2013
EDL	0.667096	0.667096	0.667096
Private Generation	0.710861	0.710861	0.710861
EDL + Private Generation	0.682	0.682	0.682

Budget calculation

In most cases, budgets are provided by the implementing agency, the donor, or the supplier. In case this data is not made available, the following assumptions are used:

Category	Assumptions	References
PV	The average yearly system budget as reported in the 2015 Solar PV Status Report for Lebanon (MoEW/UNDP/GEF, 2017) is used. This is provided in USD/kWp for years prior to 2010, where no cost per kWp is available, the 2010 average is used.	MoEW/UNDP/GEF, 2017 MoE, 2017
PV Public Street Lights	For some installations, average pole price for the installation year is used	UNEP, 2016
Certified Green Buildings	Green building energy measures are not presented with budgets. The implementation cost is estimated using average payback period of 10 years and average energy cost of 12 USC/kWh.	ASHRAE, 2009
Energy Conservation Measures	When energy efficiency measures are not presented with budgets, the implementation cost is estimated using average payback period of 5 years and average energy cost of 12 USC/kWh. This value is a result of more than 200 energy efficiency measures studies and financial feasibility analysis.	CEDRO, 2017

Capacity and energy efficiency factors

Energy generation potential for renewable energy sources is dependent on the deployed technology and the available resources in the country. In order to quantify the generated energy, capacity factors (kWh/kW) rates are used for the different technologies. These factors are collected from national and international reports and publications. The capacity factor is only used when there is no reported energy savings for the undertaken initiative.

Capacity factors of RE systems

Category	kWh/kW	Reference
PV	1,500	MoEW/UNDP/GEF, 2017
Wind	1,727	CEDRO, 2017
SWH	1,006	UNEP, 2016
PVPSL	2,920	LCEC, 2017a
PV Pumping	1,350	MoEW/UNDP/GEF, 2017
PV-Wind	1,433	CEDRO, 2017
Hydro	3,000	Expert judgment
Biomass	2,000	Expert judgment

In order to calculate savings energy efficiency factors, lifespan, degradation and other parameters are estimated as per the following assumptions:

Assumptions for calculating savings from energy efficiency

Category	Assumptions	References
Energy Efficient Street Lighting	Photosensor and timers installed on a public street lighting pole save an average of 74.47 kWh/year. This value is reported by LCEC in the NEEAP	MoEW/LCEC, 2016
Certified Green Buildings	Quantification of energy savings is done collecting the following information: - Building size in m2 (from company website or USGBC database) - Business as usual consumption based on ASHRAE standards (Ref #6) - Energy consumption reduction is based on the EAC1 score, which identifies the % of energy consumption reduction compared to BAU"	ASHRAE, 2009
Energy Conservation Measures	Green roofs save an average of 5.26 kWh/m^2 per year. This value is a result of an energy modeling performed to a conditioned last roof floor.	CEDRO, 2017

Assumptions for calculating lifespan and degradation

Category	Lifespan	Degradation	Market Characteristics
Solar PV Panels	Lifespan of PV panels is considered 25 years (MoEW/UNDP/GEF, 2017; MoE, 2017)	Efficiency degradation of 0.4% per year for PV panels (MoEW/UNDP/GEF, 2017; MoE, 2017)	
Solar Public Street Lighting	The lifespan used is only four years. Although these systems live longer, but it has been observed that systems are no longer in operation after 4 years, due to the need for new batteries that cannot be afforded by municipalities (UNEP, 2016)		Data available is related to number of poles but not power capacity. In order to quantify the power capacity

			of the system, averages of 120 W/pole and 240 W/pole are used (UNEP, 2016)
Energy Efficient Street Lighting	LED Lamps live for around 50,000 hours. With an average of 10 hrs of operation a day (MoEW, 2015)		
Solar Water Heaters	Lifespan of SWH systems is considered 25 years (MoEW/LCEC, 2011)	Efficiency degradation of 0.25% per year for solar thermal panels (MoEW/LCEC, 2011)	Average system cost: $\$370/m^2$ Average system collection area: 4.12 m^2 kW capacity per m2: 0.7 kW/m^2 Energy saving potential: 704 kWh/m^2 (MoEW/LCEC, 2011)
Biomass Boilers	Lifespan of stoves is considered 25 years (Jordan and Kurtz, 2012)		
Other Renewable Energy	The installed micro-hydro system worked for 2 years only and then stopped operation (expert judgment)		

For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative. Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5.

3. Individual Factsheets on energy mitigation actions

Decentralized Solar PV Installations				
Solar PV installations in residences, commercial institutions, and industrial facilities for power generation.				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	Private Companies	LCEC-BDL	CEDRO-UNDP	-
Geographic Coverage	Lebanon	Lebanon	Lebanon	-
Budget (USD)	$14,648,293	$12,342,796	$12,955,338	$0
Capacity (kW)	4,092	3,758	611	0
kWh Saving/yr	6,524,468	5,651,280	963,975	0
Gg CO2 Reduction/yr	4.462	3.862	0.925	0.000
kWh Avoided/yr	0	0	0	0
Gg CO2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2000 - 2016
Goals	Reduction of GHG emissions by EDL and private generation
	Spread of decentralized power generation
	Promotion of renewable energy as an alternative source of power to diesel generators

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	3,897,184	2.811	0	0.000
2030	213,880,900	150.595	0	0.000

Methodology & Assumptions	Initiative budget is calculated using yearly system budget (USD/kWp) as reported in Ref #1
	Cost rate for years prior to 2010 are not available, thus 2010 average is used for earlier years.
	Lifespan of PV panels is considered 25 years (according to market data)
	Efficiency degradation of 0.4% per year for PV panels as reported by NREL (Ref #8)
	Average capacity factor for PV generators is considered 1500 kWh/kW
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	Installations before 2012 are available in cumulative numbers. Thus the average emission factor and budget estimate for the year 2010 and 2011 are used
	Data collected for PV installations are supposed to be covering the whole Lebanese market, yet the survey performed does not cover 100% of the suppliers in Lebanon
	Donor funded projects include CEDRO implementations only. Other donor-funded installations that might have taken place are within the privately-installed cumulative values

Solar-Powered Water Pumping				
Solar PV installations for agricultural applications and water pumping				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	Private Companies	LCEC-BDL	USAID-OTI & UNDP	-
Geographic Coverage	Lebanon	Lebanon	Bekaa	-
Budget (USD)	$1,251,915	$10,478,096	$151,000	$0
Capacity (kW)	507	1,220	91	0
kWh Saving/yr	684,450	1,647,000	122,850	0
Gg CO_2 Reduction/yr	0.475	0.844	0.087	0.000
kWh Avoided/yr	0	0	0	0

Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2000 - 2016
Goals	Reduction of GHG emissions by EDL and private generation
	Promotion of solar pumping as an alternative solution to onsite diesel generators

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	91,433	0.062	0	0.000
2030	39,061,975	22.214	0	0.000

Methodology & Assumptions	Initiative budget is calculated using yearly system budget (USD/kWp) as reported in Ref #1
	Lifespan of PV panels is considered 25 years (according to market data)
	Efficiency degradation of 0.4% per year for PV panels as reported by NREL (Ref #8)
	Average capacity factor for PV generators is considered 1350 kWh/kW
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	Data collected for PV installations are supposed to be covering the whole Lebanese market, yet the survey performed does not cover 100% of the suppliers in Lebanon
	Donor funded projects include USAID and UNDP implementations only. Other donor-funded installations that might have taken place are within the privately-installed cumulative values

Solar-Powered Public Street Lighting				
Solar PV for public streetlights. Includes addition of new poles and replacement of existing poles				
Source of funding	Private	NEEREA	Donor	Government
Implementing agency	-	-	UNDP, UNIFIL	MPW, MEW
Geographic Coverage	-	-	Lebanon	Lebanon
Budget (USD)	$0	$0	$2,807,000	$4,853,533
Capacity (kW)	0	0	354	433
kWh Saving/yr	0	0	0	1,264,360
Gg CO_2 Reduction/yr	0.000	0.000	0.000	0.864
kWh Avoided/yr	0	0	1,032,979	0
Gg CO_2 Avoided/yr	0.000	0.000	0.625	0.000

Timeframe	2012 - 2016			
Goals	Reduction of GHG emissions by EDL and private generation			
	Improving safety and enhancing security levels in rural areas			
	Promotion of decentralized street lighting solutions			
	Cum. Energy Savings (kWh)	**Cum. CO_2 Reduction (Gg of CO2 eq.)**	**Cum. Energy Avoided (kWh)**	**Cum. CO_2 Avoided (Gg of CO_2 eq.)**
2013	471,148	0.314	79,223	0.025
2030	21,043,149	14.369	4,629,813	2.802
Methodology & Assumptions	Budget data are collected from publications when available. If not available, average pole price for the year is used			
	Data available is related to number of poles but not power capacity. In order to quantify the power capacity of the system, averages of 120 W/pole and 240 W/pole are used			
	Lifespan of 4 years is used. Although these systems live longer, but it has been observed that systems are no longer in operation after 4 years, due to the need for new batteries that cannot be afforded by municipalities			
	Efficiency degradation of 0.4% per year for PV panels as reported by NREL (Ref #8)			
	Average capacity factor for PV street lights is considered 2920 kWh/kW			
	Emission factor used for EDL, varying by year based on the energy mix in that year (Ref #2)			
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5			
	Data about installed systems are collected from UNDP, MEW, Newspapers, and the PSL report			
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative			
Gaps & Constraints	Installations before 2012 are available in cumulative numbers. Thus the average emission factor and budget estimate for the year 2010 and 2011 are used			
	There is no national report that provides accurate numbers about installations			
	Donor funded projects include CEDRO, UNIFIL, and Live Lebanon implementations only. Other donor-funded installations that might have taken place are within the privately-installed cumulative values			

Energy-Efficient Public Street Lighting				
Replacement of existing HPS and LPS street lamps with LED street lamps and the use of photocells and timers				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	-	-	CEDRO-UNDP	-
Geographic Coverage	-	-	Lebanon	-
Budget (USD)	$0	$0	$242,000	$64,345
Capacity (kW)	0	0	44	0
kWh Saving/yr	0	0	127,195	109,843

Gg CO_2 Reduction/yr	0.000	0.000	0.085	0.073
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2012 - 2013
Goals	Reduction of GHG emissions by EDL and private generation
	Improving safety and enhancing security levels in rural areas
	Reduction of wasted energy and programming street lights to operate when needed only

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	245,714	0.164	0	0.000
2030	3,508,568	2.341	0	0.000

Methodology & Assumptions	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	LED Lamps live for around 50,000 hours. With an average of 10 hrs of operation a day
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	According to MEW and NEEAP, Photosensor and timers save 74.47 kWh/yr
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	Savings are calculated assuming all photosensor and timers are installed immediately and properly maintained. In fact some were installed at a later stage, and others are not properly maintained, which reduces their performance and saving potential

Solar Water Heating

solar water heating systems in residential, commercial, industrial, and public institutions

Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	Private Companies	LCEC-BDL	CEDRO, SIDA, Ital Coop	-
Geographic Coverage	Lebanon	Lebanon	Lebanon	-
Budget (USD)	$104,833,196	$6,666,304	$2,298,108	$0
Capacity (kW)	404,761	25,739	5,012	0
kWh Saving/yr	310,885,189	20,211,011	5,776,572	0
Gg CO_2 Reduction/yr	167.362	13.990	4.017	0.000
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2008 - 2015			
Goals	Reduction of GHG emissions by EDL and private generation			
	Spread of solar water heaters as an alternative solution to diesel boilers and electric heaters			
	Supporting the national program of a SWH to every house			

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	358,650,466	246.269	0	0.000
2030	5,943,454,981	3,325.378	0	0.000

Methodology & Assumptions	Using the GSWH report by UNEP & LCEC, the following factors are used: - Average system cost: $370/m^2 - Average system collection area: 4.12 m^2 - kW capacity per m2: 0.7 kW/m^2 - Energy saving potential: 704 kWh/m^2
	Lifespan of SWH systems is considered 25 years (according to market data)
	Efficiency degradation of 0.25% per year for solar panels is used
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	Installations before 2012 are available in cumulative numbers. Thus the average emission factor and budget estimate for the year 2010 and 2011 are used
	Data collected for SWH installations are supposed to be covering the whole Lebanese market, yet the survey performed does not cover 100% of the suppliers in Lebanon
	Donor funded projects include CEDRO, SIDA, and Italian Cooperation implementations only. Other donor-funded installations that might have taken place are within the privately-installed cumulative values

Certified Green Buildings				
Certified green buildings under the BREEAM and LEED schemes				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	Private Companies	-	-	-
Geographic Coverage	Lebanon	-	-	-
Budget (USD)	$29,468,962	$0	$0	$0
Capacity (kW)	0	0	0	0
kWh Saving/yr	0	0	0	0
Gg CO_2 Reduction/yr	0.000	0.000	0.000	0.000
kWh Avoided/yr	24,557,468	0	0	0

Gg CO_2 Avoided/yr	16.752	0.000	0.000	0.000

Timeframe	2012 - 2016
Goals	Reduction of GHG emissions by EDL and private generation
	Promoting green building concepts in new constructions

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	0	0.000	1,326,310	0.905
2030	0	0.000	378,226,515	258.011

Methodology & Assumptions	Data about certified buildings is collected from USGBC and BREEAM database (Ref #12, Ref #13)
	Quantification of energy savings is done collecting the following information: - Building size in m^2 (from company website or USGBC database) - Business as usual consumption based on ASHRAE standards (Ref #6) - Energy consumption reduction is based on the EAC1 score, which identifies the % of energy consumption reduction compared to BAU
	Budget is estimated using average payback period of 10 years and average kWh cost of 12 USC
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5

Gaps & Constraints	Budget related to energy saving measures cannot be made available

Energy Conservation Measures				
Implemented energy conservation measures by energy audit companies and ESCOS, including measures related to lighting, cooling, heating, etc.				
Source of funding	Private	NEEREA	Donor	Government
Implementing agency	Private Companies	LCEC-BDL	-	-
Geographic Coverage	Lebanon	Lebanon	-	-
Budget (USD)	$669,000	$0	$350,000	$0
Capacity (kW)	0	0	0	0
kWh Saving/yr	1,150,000	0	4,268	0
Gg CO_2 Reduction/yr	0.802	0.000	0.003	0.000
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2000 - 2015
Goals	Reduction of GHG emissions by EDL and private generation

	Reducing energy wastage and improving system efficiency

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	240,000	0.166	0	0.000
2030	18,375,423	12.815	0	0.000

Methodology & Assumptions	Data is collected from the most active energy audit companies in Lebanon, covering at least 90% of the market
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	Database is based on personal communication with energy audit companies
	Data might not be covering 100% of the performed activities

Biomass Space Heating				
Biomass and pellet stoves for space heating				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	Private Companies	LCEC-BDL	CEDRO-UNDP	-
Geographic Coverage	Lebanon	Lebanon	Lebanon	-
Budget (USD)	$12,000	$0	$125,000	$0
Capacity (kW)	360	0	5,000	0
kWh Saving/yr	1,078,000	0	10,000,000	0
Gg CO_2 Reduction/yr	0.736	0.000	6.863	0.000
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2008 - 2016
Goals	Reduction of GHG emissions by EDL and private generation
	Avoiding diesel heaters and using pellets stove as an alternative and sustainable solution

	Cum. Energy Savings (kWh)	Cum. CO_2 Reduction (Gg of CO_2 eq.)	Cum. Energy Avoided (kWh)	Cum. CO_2 Avoided (Gg of CO_2 eq.)
2013	2,029,000	1.384	0	0.000

2030	185,205,000	127.032	0	0.000

Methodology & Assumptions	Data is collected from suppliers directly
	Budgets and prices are collected from suppliers and implementing agencies
	Lifespan of stoves is considered 25 years (according to market data)
	Average capacity factor for pellet stoves is considered 2000 kWh/kW
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	For installations taking place before 2012, and in order to quantify the energy saving potential, cumulative installed capacity is assumed to be installed in the middle of the timeframe of the initiative

Gaps & Constraints	The major supplier of biomass pellets only is involved in this activity. There were no other major initiatives undertaken during the reporting period
	It is not clear what these stoves are replacing, thus the emission factor used is for EDL and private generators. In some cases, these stoves might be replacing diesel heaters.
	The average saving of 2000 kWh per installed kW is a rough estimate based on international market data. No similar data is available for these systems in Lebanon.

Other Renewables				
Other renewable technologies including wind, hydro, geothermal, and others				
Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	-	-	CEDRO-UNDP	-
Geographic Coverage	-	-	Lebanon	-
Budget (USD)	$0	$0	$420,000	$0
Capacity (kW)	0	0	87	0
kWh Saving/yr	0	0	104,681	0
Gg CO_2 Reduction/yr	0.000	0.000	0.072	0.000
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2013 - 2014
Goals	Reduction of GHG emissions by EDL and private generation
	Spread of decentralized power generation
	Promotion of renewable energy as an alternative source of power to diesel generators

	Cum. Energy Savings (kWh)	**Cum. CO_2 Reduction (Gg of CO_2 eq.)**	**Cum. Energy Avoided (kWh)**	**Cum. CO_2 Avoided (Gg of CO_2 eq.)**
2013	28,823	0.020	0	0.000

2030	1,289,297	0.886	0	0.000

Methodology & Assumptions	Data is collected from CEDRO-UNDP regarding implemented pilot projects
	Lifespan of PV panels is considered 25 years (according to market data)
	Efficiency degradation of 0.4% per year for PV panels as reported by NREL (Ref #8)
	Average capacity factor for PV generators is considered 1500 kWh/kW
	Average capacity factor for wind generators is considered 1433 kWh/kW
	Average capacity factor for hydro generators is considered 3000 kWh/kW
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	The installed micro-hydro system worked for 2 years only and then stopped operation
Gaps & Constraints	Installations done by private sector could not be quantified. Yet they are expected to have minor effect on the cumulative values

Other Energy Efficiency Measures

Energy efficiency measures undertaken by the public and private sector including energy efficient lighting, equipment, and others

Source of funding	**Private**	**NEEREA**	**Donor**	**Government**
Implementing agency	-	-	-	MEW
Geographic Coverage	-	-	-	Lebanon
Budget (USD)	$0	$0	$0	$7,000,000
Capacity (kW)	0	0	0	0
kWh Saving/yr	0	0	0	255,052,875
Gg CO_2 Reduction/yr	0.000	0.000	0.000	173.962
kWh Avoided/yr	0	0	0	0
Gg CO_2 Avoided/yr	0.000	0.000	0.000	0.000

Timeframe	2011 - 2012
Goals	Reduction of GHG emissions by EDL and private generation
	Spread of decentralized power generation

	Cum. Energy Savings (kWh)	**Cum. CO_2 Reduction (Gg of CO_2 eq.)**	**Cum. Energy Avoided (kWh)**	**Cum. CO_2 Avoided (Gg of CO_2 eq.)**
2013	382,579,313	260.943	0	0.000
2030	2,456,776,437	1,675.676	0	0.000

Methodology & Assumptions	Data is collected from MEW's NEEAP
	Lifespan of CFLs is considered 10,000 hours (according to market data)
	Average working hours per day is considered 3 hours (according to LCEC)
	Emission factor used for EDL with private generation, varying by year based on the energy mix in that year (Ref #2)
	Collected data is provided on yearly basis not monthly basis, so there is no exact reference of the period of initiative implementation (beginning of year or end of year). An assumption that it is being implemented on the 1st of July, thus multiplying kWh and GHG emissions by 0.5
	23W CFLs are distributed, to be replacing 100W lamps
Gaps & Constraints	Installations done by private sector could not be quantified. Yet they are expected to have minor effect on the cumulative values
	The 23W lamps might be replacing incandescent lamps with less than 100W, or maybe installed as new lamps. There is no accurate data about the replace lamps.

Zouk ICE 194 MW (HFO)

General Information: A base load power plant based on ten (10) units of four-stroke medium speed diesel engines, type 18V48/60B is under construction at Zouk site. The engines are of the well-known family of medium speed diesel engines designed and supplied by MAN Diesel & Turbo SE, which has a longstanding experience in providing diesel engines for reliable base load operation. The selected engines will provide dependable power production and high availability ensuring optimal plant performance versus investment cost. The plant design utilizes the energy in the exhaust gases and the hot cooling water from the engines in order to improve the efficiency of the plant by installation of exhaust heat recovery boilers and steam turbine generator.

Zouk (Plant Heat Rate for 10 engines operation at 100% load running on HFO)

With STG: NHR = 7,603 kJ/kWh / Without STG: NHR = 8,067 kJ/kW

Implementing Agency	Ministry of Energy & Water
Geographical Coverage	Zouk
Budget	185,247,000 €
Timeframe	2013-2015
Source of Funding	Danish Export Bank - EKF, Via HSBC, Through MoF
Goals	Increase Generation Capacity Replace Private Generators with more efficient alternative Reduce Emissions
Achievements or Progress	Construction in Progress since 2013. Capacity: 194 MW Net Output: 1,580,479 MWh/Year HFO Consumption: 178.95 g/kWh or 282,827 tonnes HFO/Year
GHG Emission Reduction	2013: No emission reductions yet By 2030: 250,032 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the difference of using Private Generation to produce the same amount of Energy produced by the 4 Reciprocating Engine Plant. PG would need 352,409 tonnes DO/Year to produce the same energy.

Jiyeh ICE 78.2 MW (HFO)	
General Information: A base load power plant based on four (4) units of four-stroke medium speed diesel engines, type 18V48/60B is under construction at Jiyeh site. The engines are of the well-known family of medium speed diesel engines designed and supplied by MAN Diesel & Turbo SE, which has a longstanding experience in providing diesel engines for reliable base load operation. The selected engines will provide dependable power production and high availability ensuring optimal plant performance versus investment cost. The plant design utilizes the energy in the exhaust gases and the hot cooling water from the engines in order to improve the efficiency of the plant by installation of exhaust heat recovery boilers and steam turbine generator. Jiyeh (Plant Heat Rate for 4 engines operation at 100% load running on HFO) With STG: NHR = 7,629 kJ/kWh / Without STG: NHR = 8,188 kJ/kWh	
Implementing Agency	Ministry of Energy & Water
Geographical Coverage	Jiyeh
Budget	83,978,000 €
Timeframe	2013-2015
Source of Funding	Danish Export Bank - EKF, Via HSBC, Through MoF
Goals	Increase Generation Capacity Replace Private Generators with more efficient alternative Reduce Emissions
Achievements or Progress	Construction in Progress since 2013. Capacity: 78.2 MW Net Output: 637,080 MWh/Year HFO Consumption: 179.56 g/kWh or 114,005 tonnes HFO/Year
GHG Emission Reduction Expected	2013: No emission reductions yet By 2030: 100,788 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the difference of using Private Generation to produce the same amount of Energy produced by the four stroke Reciprocating Engine Plant. PG would use 142,054 tonnes DO/Year to produce the same amount of Energy.

DACCPP II 539.2 MW (HFO)	
General Information: A complete indoor gas turbine plant is under construction at Deir Ammar site, comprising 3 Gas Turbines suitable for combined cycle operation burning Natural Gas fuel and also liquid fuels (Light Fuel Oil and Heavy Fuel Oil) with Nox control system (water/steam injection as e.g.). The plant is also equipped with a mini Hydro unit at the condenser outlet to improve the efficiency. DACCPP II (Plant Heat Rate at 100% load running on HFO) With STG & HYDRO: NHR = 7,209 kJ/kWh / NPO=539.2 MW DACCPP II (Plant Heat Rate at 100% load running on NG) With STG & HYDRO: NHR = 7,126.5 kJ/kWh / NPO=569.4 MW	
Implementing Agency	Ministry of Energy & Water
Geographical Coverage	Deir Ammar
Budget	360,966,000 €
Timeframe	2013-2016
Source of Funding	GoL
Goals	Increase Generation Capacity Replace Private Generators with more efficient alternative Reduce Emissions
Achievements or Progress	Construction in Progress since 2013. Capacity: 539.2 MW Net Output: 3,679,200 MWh/Year HFO Consumption: 177.56 g/kWh or 653,278 tonnes/year

GHG Emission Reduction	2013: No emission reductions yet By 2030: 597,849 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the difference of using Private Generation to produce the same amount of Energy produced by the four stroke Reciprocating Engine Plant. PG would use 820,373 tonnes DO/year to produce the same amount of Energy.

ZCCPP 33.5MW Upgrade (DO)	
General Information: The CMF+ upgrade applies the latest design Controlled Diffusion Airfoil (CDA) compressor blades to the V94.2 Gas Turbine. This allows a significant increase in compressor mass flow by approximately 3,5%, augmenting the power output of the GT and the subsequent Steam Turbine (ST) in combined cycle operation. The Si3D upgrade superior design, material and coatings leads to a substantial improvement in turbine performance, and increases the overall power output and efficiency of the gas turbine. ZCCPP (At 100% load BEFORE the Upgrade) With STG: NPO=435 MW ZCCPP (At 100% load AFTER the Upgrade) With STG: NPO=468.5 MW	
Implementing Agency	EDL
Geographical Coverage	Zahrani
Budget	Upgrade cost around 27,500,000 $
Timeframe	2013-2014
Source of Funding	GoL
Goals	Increase the Power Output Improve the Plant Efficiency
Achievements or Progress	Capacity Increase: 33.5 MW Net Output: 249,441MWh/year DO Consumption for Additional Capacity: ZERO tonne/Year
GHG Emission Reduction	By 2013: No emission reductions yet By 2030: 177,315 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the PG power generation that have been displaced by the additional capacity.

DACCPP I 29.5MW Upgrade (DO)	
General Information: The CMF+ upgrade applies the latest design Controlled Diffusion Airfoil (CDA) compressor blades to the V94.2 Gas Turbine. This allows a significant increase in compressor mass flow by approximately 3,5%, augmenting the power output of the GT and the subsequent Steam Turbine (ST) in combined cycle operation. The Si3D upgrade superior design, material and coatings leads to a substantial improvement in turbine performance, and increases the overall power output and efficiency of the gas turbine. DACCPP I (At 100% load BEFORE the Upgrade) With STG: NPO=435 MW DACCPP I (At 100% load AFTER the Upgrade) With STG: NPO=464.5 MW	
Implementing Agency	EDL
Geographical Coverage	Deir Ammar
Budget	Upgrade cost around 27,500,000 $
Timeframe	2013-2014
Source of Funding	GoL
Goals	Increase the Power Output

	Improve the Plant Efficiency
Achievements or Progress	Capacity Increase: 29.5 MW Net Output: 219,657MWh/year DO Consumption for Additional Capacity: ZERO tonnes/Year
GHG Emission Reduction	By 2013: No emission reductions yet By 2030: 156,143 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the PG power generation that have been displaced by the additional capacity.

HFO Conditioning Zouk Power Plant

General Information: The improvement of the quality of HFO before boiler furnace combustion has a significant effect on the emissions as well as the combustion efficiency. Preheating, water washing for salt removal and vanadium inhibitor addition (magnesium additive) as fuel oil clean up measures are typical.

An HFO conditioning solution has been implemented at Zouk Thermal Power Plant with the following results:

Item	Parameter	Baseline Value	Average Achieved Values with HFO Conditioning (normalized to 3% O_2)	Achieved Reduction / Amelioration Values (normalized to 3% O_2)
1	Particulate matter (PM)	331 (mg/Nm^3)	71.26 (mg/Nm^3)	78.5 (%)
2	SO_3	4.81 (mg/Nm^3)	0.428 (mg/Nm^3)	91 (%)
3	CO	1,049 (mg/Nm^3)	77.50 (mg/Nm^3)	92.6 (%)
4	NO_x	682.60 (mg/Nm^3)	481.00 (mg/Nm^3)	29.5 (%)
5	Fouling	Significant	Substantial Reduction	Substantial Reduction
6	Efficiency	91.71 (%)	92.92 (%)	+ 1.21 (%)
7	Acidity Effect (pH)	Significant	3.5 - 4.5	> 3.5

Implementing Agency	EDL
Geographical Coverage	Zouk
Budget	3,000,000 $ / Year
Timeframe	2013-2014
Source of Funding	GoL
Goals	Improve Combustion Efficiency Reduce Fouling and Increase Unit Availability Reduce Emissions Saving in Operating Costs
Achievements or Progress	HFO saving per year around 9,680 tonnes HFO/year
GHG Emission Reduction Expected	By 2013: No emission reductions yet By 2030: 29,895 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from the saving in HFO consumption to produce the same amount of Energy.

PV Beirut River Snake Project	
General Information: BRSS is a 1 MWp solar PV farm built on the top of a river to generate an estimated 1,665 MWh/year.	
Implementing Agency	LCEC
Geographical Coverage	Beirut
Budget	3,100,000 USD
Timeframe	2013-2015
Source of Funding	GoL
Goals	Various capacity building and awareness raising on the technology Benefit various public institutions with this technology
Achievements or Progress	Capacity 1.08 MWp (Peak) Annual saving is around 1,655 MWh/year
GHG Emission Reduction	2013: no emission reductions yet By 2030: 974 tonnes of CO_{2e}/year
Methodology & Assumptions	GHG emission reduction is calculated from reduction of EDL usage and diesel electricity generation.

Annex VII. Mitigation actions of LULUCF

1. Calculation methods of GHG emissions/removals from mitigation actions

The CO_2 removals in reforestation/afforestation projects are summarized in the following equation (in reference to IPCC GPG for LULUCF 2003 p. 3.51).

ANNUAL CHANGE IN CARBON STOCKS IN LAND CONVERTED TO FOREST LAND

$$\Delta C_{LF} = \Delta C_{LF_{LB}} + \Delta C_{LF_{DOM}} + \Delta C_{LF_{Soils}}$$

Where:

ΔC_{LF} = annual change in carbon stocks in Land converted to Forest land, tonnes C yr^{-1}

$\Delta C_{LF_{LB}}$ = annual change in carbon stocks in living biomass (includes above- and belowground biomass) in Land converted to Forest land; tonnes C yr^{-1}

$\Delta C_{LF_{DOM}}$ = annual change in carbon stocks in dead organic matter (includes dead wood and litter) in Land converted to Forest land; tonnes C yr^{-1}

$\Delta C_{LF_{Soils}}$ = annual change in carbon stocks in soils in Land converted to Forest land; tonnes C yr^{-1}

The calculation of annual change in carbon stocks in living biomass in Land converted to Forest land followed the following equation:

ANNUAL INCREASE IN CARBON STOCKS IN LIVING BIOMASS IN LAND CONVERTED TO FOREST LAND

$$\Delta C_{LF_{GROWTH}} = [\Sigma_k A_{INT\_MAN_k} \bullet G_{Total\ INT\_MAN_k} + \Sigma_m A_{EXT\_MAN_m} \bullet G_{Total\ EXT\_MAN_m}] \bullet CF$$

Where:

$\Delta C_{LF_{GROWTH}}$ = annual increase in carbon stocks in living biomass due to growth in "Land converted to Forest land, tonnes C yr^{-1}

$A_{INT\_MAN_k}$ = area of "Land converted to intensively managed forest in condition *k* (including plantations), ha

$G_{Total\ INT\_MAN_k}$ = annual growth rate of biomass in intensively managed forest in condition *k* (including plantations), tonnes d.m. ha^{-1} yr^{-1}

$A_{EXT\_MAN_m}$ = area of "Land converted to extensively managed forest in condition *m*, ha

$G_{Total\ EXT\_MAN_m}$ = annual growth rate of biomass in extensively managed forest in condition *m*, tonnes dm ha^{-1} yr^{-1} (includes natural regeneration)

k, *m* = represent the different conditions in which intensively and extensively managed forests are growing

CF = carbon fraction of dry matter (default = 0.5), tonnes C (tonne d.m.)$^{-1}$

Plantations were assumed to take place on "Other Land". The values for A_{EXT_MAN} were taken from publications and personal communications conducted within the framework of the National Inventory of GHG emissions/removals from the LULUCF sector.

Based on default values, the calculated $G_{Total\ EXT\_MAN}$ was 7.27075. The CF value was the default number of 0.5 and the value for R was taken from FAO (2005)[3] as 0.27. Exact data on the quantity and the type of tree species planted were not available. Accordingly, it was assumed that planted trees were mostly coniferous. For the calculation of $G_{Total\ EXT\_MAN,}$ the value for G_W for plantations was taken as a default from the IPCC GPG Table 3A.1.6 as the average of (Asia/other species-Dry) 6.45 and (Asia/other species-Montane moist) 5 as 5.725 tonnes d.m. ha^{-1} yr^{-1}.

Other assumptions for the calculation of annual change in carbon stocks in dead organic matter and annual change in carbon stocks in soils included no change in dead wood carbon and litter pool in lands converting to forest (Tier 1). Annual change in carbon stocks in soils was also assumed zero due to methodological uncertainties.

The employed extended methodology to estimate GHGs (CO_2 and non CO_2) directly released in fires was as follows (in reference to IPCC GPG for LULUCF 2003 p. 3.49):

ESTIMATION OF GHGS DIRECTLY RELEASED IN FIRES

$$L_{fire} = A \bullet B \bullet C \bullet D \bullet 10^{-6}$$

Where:

L_{fire} = quantity of GHG released due to fire, tonnes
A = area burnt, ha
B = mass of 'available' fuel, kg d.m. ha^{-1}
C = combustion efficiency (or fraction of the biomass combusted), dimensionless.
D = Emission factor, g $(kg\ d.m.)^{-1}$

The extent of burned areas (A) and fire affected fuel types were considered from the assessment conducted within the National Inventory Report of GHG emissions/removals from the LULUCF sector using approach 3. The mass of available fuel (B) was derived from the back mapping of the Prometheus fuel type classes4 and the extent of each type affected by fire:

Prometheus fuel type class	Mass of available fuel (Rothermel averages)
1	5 tonnes/ha
2	6.5 tonnes/ha
3	12.5 tonnes/ha
4	30 tonnes/ha
5	9.5 tonnes/ha
6, 7	12.5 tonnes/ha

The value for C was taken as a default from the IPCC GPG as 0.5. The value of D was taken as default value for each GHG as follows:

Default from the IPCC GPG Table 3A.1.16 (Forest fires, Delmas et al. (1995); CH_4) as 9 G/KG d.m
Default from the IPCC GPG Table 3A.1.16 (Forest fires, Delmas et al. (1995); CO) as 130 G/KG d.m
Default from the IPCC GPG Table 3A.1.16 (Forest fires, Delmas et al. (1995); N_2O) as 0.11 G/KG d.m
Default from the IPCC GPG Table 3A.1.16 (Forest fires, Delmas et al. (1995); NO_X) as 0.7 G/KG d.m

[3] *FAO (2005). National Forest and Tree Resources Assessment 2003-05 (TCP/LEB/2903). Working paper 95, Forest Resources Assessment, Forestry, Beirut.*
[4] *Mitri et al. (2012). Forest fuel type mapping in Lebanon. 18th International science meeting. 22-24 March 2013. Lebanon.*

Individual Factsheets on LULUCF mitigation actions

Development and implementation of pilot landscape restoration plans

Development and implementation of pilot landscape restoration plans	
General information: Reforestation and afforestation projects are conducted in the Shouf Biosphere Reserve to build resilience to climate change through adaptive forest landscape restoration. One of these projects is implemented within the framework of the 40 million trees programme, while the others are implemented with private sponsorships.	
Implementing agency	Al Shouf Cedar Society
Geographical coverage	Barouk and the Municipalities of Barouk, Maasser el Shouf, Mristi (Mount Lebanon) and Saghbine (Beqaa)
Budget	N.A.
Timeframe	2013-2015
Source of funding	MM1, Byblos bank, HSBC bank, European Commission (through MoA), Middle East Airlines, and the private sector.
Goals	Increase resilience to climate change in an altitudinal and continental gradient, from the inner Bekaa Valley to the Mount Lebanon western range, connecting forest patches.
Achievements or progress by 2013	**48.5 Ha** Removal of 0.646491 Gg of CO_2 eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that each ha of planted land comprised 700 seedlings. Also, assuming that the seedlings were successfully planted and maintained over a total cumulative area of 125.5 ha by 2015.

AFDC afforestation/reforestation projects	
General information: various restoration and afforestation activities	
Implementing agency	Association for Forests, Development and Conservation (AFDC)
Geographical coverage	Jesr El Kadi, Deir Aamar, Ashash, Btater, Shartoun, Anjar, Rashaya, Bqerzala, and Kfar Qouk.
Budget	N.A.
Timeframe	2013-2016
Source of funding	Various sources including private sponsorships
Goals	Restore degraded land and increase forest cover in Lebanon
Achievements or progress by 2013	16 ha removal 0.213275 Gg of CO_2 eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that each ha of planted land comprised 700 seedlings. Also, assuming that the seedlings were successfully planted and maintained over a total area of 24.5 ha by 2015 and a total cumulative area of 82.5 ha by 2016.

The Reforestation Initiative of the Ministry of Environment of Lebanon	
General information: MoE has executed from 2002 till 2014 reforestation activities in all Lebanese regions within the context of the National Reforestation Plan. These activities were achieved through two consecutive phases and have covered the reforestation of approximately 834 hectares of forest lands in all the Lebanese Governorates with contributions in some place from NGOs.	
Implementing agency	MoE
Geographical coverage	All Lebanese territories
Budget	In 2001, the Lebanese government allocated in the national budget 25 billion Lebanese Pounds fund (approximately 16.67 million USD) scheduled over five years for the execution of reforestation projects at the national level.
Timeframe	2002-2014
Source of funding	Government of Lebanon
Goals	Restore the country's green cover loss throughout the years
Achievements or progress by 2013	The reforestation of 834 hectares of forest lands fairly distributed in the five Muhafazat, as follows: **Mount Lebanon**: 60 ha: Faraya and Barouk - 45 ha: Hammana, Damour, Ehmej **North Lebanon**: 60 ha: Akkar el Atiqa, Ehden, Bcharri, Tannourine - 54 ha: Kousba, Tannourine, Akkar el Atiqa **Bekaa**: 80 ha: Lala-Baaloul, Khirbet-Anafar, Qaa el Reem, Ras Baalbeck, Chaat, Hermel, Rachaya, Jdita - 104 ha: Tajammoh Baladiyat El – Sahl*, Bouday, Chmestar, Al-Qaa, Al-fakeha-El Jadida, Baalbeck, Rachaya El-Wadi, El-Hermel, Sehmor **South Lebanon**: 50 ha: Jezzine, Al Qraye, Abbassie, Majdelzoun **Nabatieh**: 55 ha: Kfar Rummane, Rmeich, Ebel el Saki, Marjeyoun, Hasbaya - 75 ha: Al-Rihan, Zawtar Esharkieh, El-Merwanieh, Kherbit Selem, Markaba Other reforestation activities for a total of 251 ha involved NGOs. Some of which involved large scale air seeding operations in coordination with the Lebanese Army and some NGOs. Airplane seeding of pine and oak seeds over a total area of 80 hectares in the regions of Jran, Jrabta, Kfifan, Rechmaya, Karm Saddeh, Kobeyat, Deir El-Kamar and Andkit was performed. Based on the promising initial results obtained, this operation was followed with similar applications in the regions of Dahr El-Ahmar, Karaoun and Bkifa over another area of 80 hectares.
Achievements or progress by 2013	9.72 Gg of CO_2 eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that each ha of planted land comprised 700 seedlings. Also, assuming an annual average area of 104.25 ha was successfully planted and maintained from 2005 throughout 2014.

Jouzour Loubnan's reforestation and afforestation activities			
General information: Reforestation/afforestation activities were conducted between 2008 and 2013. Local community groups were involved in reforestation activities which involved the use of native tree species.			
Implementing agency	Jouzour Loubnan		
Geographical coverage	Chabrouh, Ehmej, Ainata, Harf Shlifa and Btedi in the Bekaa valley, Ibl Es Saki, Ehden, and Kfardebiane.		
Budget	946,659 USD (assuming an average cost of 7 USD per seedling for plantation and maintenance)		
Timeframe	2008-2014		
Source of funding	Different sources of funding including the EU, the private sector, and United States Agency for International Development (USAID) through Lebanon Reforestation Initiative		
Goals:	1) Intervene mainly in arid mountainous regions as, on one hand, they are very often dismissed in forestation programs and, on the other hand, the benefits of such forestation are tremendous, and 2) empower local communities, and 3) to promote environmental awareness		
Achievements or progress by 2013	Year	Area (ha)	Yearly CO_2 removal (Gg of CO_2 eq.)
	2008-2011	56.67	0.755395
	2012	46.22	0.616099
	2013	55.93	0.745531
	Total	158.82	2.117025
Total GHG removal by completion of action in 2014	2.575 Gg of CO_2 eq.		
Methodology	IPCC GPG for LULUCF 2003		
Assumptions	Assuming that 1) the seedlings were successfully planted and maintained, 2) each ha of planted land comprised 700 seedlings, and 3) the cumulative area of plantations consisted of 158.82 ha by 2013 distributed as 185 seedlings (in 2008), 5,680 seedlings (in 2010), 11,795 seedlings (in 2010), 22,009 seedlings in (2011), 32,358 seedlings (in 2012), and 39,155 seedlings (i.e., 55.93 ha in 2013)		

<table>
<tr><th colspan="4">Lebanon Reforestation Initiative</th></tr>
<tr><td colspan="4">General information: The Lebanon Reforestation Initiative, funded by USAID and implemented by the United States Forest Service (USFS), works towards providing a successful framework for longer-term technical and financial assistance to expand and protect Lebanon's forests for a sustainable future. The project favors a decentralized approach to engaging communities at the municipal level and focuses on 1) assisting native tree nurseries with technical improvements and enhanced business planning, 2) developing comprehensive forest mapping, 3) promoting the importance of reforestation and biodiversity through community-led activities that foster local ownership and forest sustainability, 4) supporting the planting of quality native seedlings, and 5) strengthening capacities to prevent respond to wildfires.</td></tr>
<tr><td>Implementing agency</td><td colspan="3">Lebanon Reforestation Initiative in partnership with local community groups</td></tr>
<tr><td>Geographical coverage</td><td colspan="3">Tannourine, Bcharreh, Kfarzabad, Aanjar, Rashaya, El Qlaiaa, Ainata, Rmadyeh, and Maqne</td></tr>
<tr><td>Budget</td><td colspan="3">3,192,000 USD by 2015 (assuming an average cost of 7 USD per seedling for plantation and maintenance)</td></tr>
<tr><td>Timeframe</td><td colspan="3">2011-2018</td></tr>
<tr><td>Source of funding</td><td colspan="3">USAID</td></tr>
<tr><td>Goals:</td><td colspan="3">The Lebanon Reforestation Initiative aims to restore Lebanon's native forests and to install commitment to reforestation and wildfire prevention and response, through capacity building of local communities and organizations.</td></tr>
<tr><td rowspan="5">Achievements or progress</td><td>Year</td><td>Area (ha)</td><td>Yearly CO_2 removal (Gg of CO_2 eq.)</td></tr>
<tr><td>2011</td><td>108.69</td><td>1.448806</td></tr>
<tr><td>2012</td><td>182.19</td><td>2.42854</td></tr>
<tr><td>2013</td><td>182.19</td><td>2.42854</td></tr>
<tr><td>Total</td><td>473.07</td><td>6.305886</td></tr>
<tr><td>Total GHG removal by completion of action in 2018</td><td colspan="3">8.683353 Gg of CO_2 eq.</td></tr>
<tr><td>Methodology</td><td colspan="3">IPCC GPG for LULUCF 2003</td></tr>
<tr><td>Assumptions</td><td colspan="3">Assuming that 1) the seedlings were successfully planted and maintained, 2) each ha of planted land comprised 700 seedlings, and 3) the cumulative plantations consisted of a total area of 473.07 ha by 2013 distributed as 76,087 seedlings (i.e., 108.69) in 2011, a total of 127,536 seedlings (i.e., 182.19) in 2012, and a total of 127,536 seedlings (i.e., 182.19 ha) in 2013.</td></tr>
</table>

Annex VIII: Gaps and constraints

In order to fulfill Lebanon's obligations to the UNFCCC in submitting national GHG inventories in line with the IPCC guidelines, further support is needed to continue to develop and consolidate existing technical and institutional capacities.

Many challenges still exist since the preparation of the country's first GHG inventory in 1994 and they are mainly related to unavailability, inaccessibility and inconsistency of activity data and emission factors.

Below is a series of tables presenting the gaps and constraints that were encountered during data collection for the preparation of the inventory of each sector and the proposed measures to address these constraints in the future.

Table A3- 1 Gaps and needs identified in the calculation of GHG emissions from the energy sector

Gaps and constraints	Proposed measures for improvement
Underdeveloped data collection for the inventory - Lack of institutional arrangement for data monitoring and reporting - Absence of an energy balance - Absence of disaggregation of fuel use per subcategory - Missing of activity data on some fuel used - Need to improve the uncertainty calculation methodologies in the QA/QC procedure	- Create a national institutional arrangement for the preparation of the GHG inventory, empowering the CAS, the relevant ministries and concerned public authorities to develop monitoring indicators (such as the mobility monitoring indicator), in charge of collection, measuring, reporting and verifying of energy activity data. - Establish a mobility monitoring indicator platform that should include all activity data needed to estimate Lebanon's energy sector GHG emissions using tiers 2 and 3 of the IPCC guidelines. - Activity data should be reported with uncertainty assessments in order to have statistically acceptable data. - Standardize/centralize data reporting and develop protocols for data accessibility.
Unavailable and/or unshared specific data for tiers 2 and 3 calculations - Missing road transport activity data on annual fuel consumption per type of fuel and yearly average vehicle mileage per category - Activity data of off-road vehicles not considered - Unshared activity data between public/private institutions due to lack of coordination and/or confidentiality	
Use of IPCC default emissions factors since there are no fuel-specific emission factors elaborated for Lebanon.	- Develop Lebanon's fuel-specific emission factors and methodologies. - Conduct measurement campaigns in order to elaborate specific emission factors representative of the Lebanese used fuel and transportation fleet. - Develop GHG emissions estimation models with local research institutes to create Lebanon-specific methodologies using advanced bottom-up approaches for inventory preparation.

Table A3- 2 Gaps and needs identified in the calculation of GHG emissions from industrial processes

Gaps and constraints	Proposed measures for improvement
Activity data organization - Scattered data on fish, meat, chicken, lime, soda ash, asphalt, wine (customs, factories, ministries). - Lack of uniformity in data between different official sources (i.e. meat and poultry production). - Lack of sufficient documentation on data sources in both the Second National Communication (SNC) and Initial National Communication (INC).	**For current inventory:** - Collection of numbers and figures from various sources and research on detailed description of categories considered in each number. Most comprehensive data were adopted for the inventory. - Validation of available data through expert judgment. - Detailed archiving on sources of data. **Suggestions for future inventories:** - Centralization of data compilation management: cooperation initiated with Ministry of Industry in order to update industrial database and launch systematic data collection process from industries.
Activity data availability - Lack of data on bread, cakes and biscuits, and coffee beans. - Lack of data on halocarbons (HFCs and PFCs). - Lack of data for refining inventory to higher tier levels (except for cement).	**For current inventory:** - Wheat production is used to estimate production of bread, cakes and biscuits (based on ratios given by bakeries). - Emissions from HFCs and coffee beans were not estimated. Higher tiers for categories other than cement were not used.
Activity data accessibility - Lack of institutional arrangements for data sharing. - Time delays in accessing and compiling data.	**Suggestions for future inventories:** - Establish protocols and effective networking with data providers (Memorandums of Understanding already signed with various institutions, including the Ministry of Industry).
Activity data compilation Emissions from poultry, meat, fish, bread and cakes and biscuits were calculated using only national production. Emissions from processing of imported poultry, meat fish and wheat were not included (as well as subtraction of exported production).	**For current inventory:** - Consider import and export in final activity data compilation for cakes and biscuits and bread. - Imported poultry and meat was not added to national production since important discrepancies were noted in national production figures of SNC and TNC. Adding import numbers would increase this discrepancy. It is noteworthy that since NMVOCs emitted from the food sector are not included in GHG trend analysis, this discrepancy is not projected to the final figures of the inventory.
National circumstances - Lack of sufficient, updated and homogeneous literature on the industrial sector in Lebanon. - Lack of academics and researchers in the industrial field.	**For current inventory:** - Reliance on personal communications with practitioners and ministry employees. **Suggestions for future inventories:** - Nationwide survey has been launched on a sample of 180 industries from each category in order to capture the general situation of the industrial sector in Lebanon.

Table A3- 3 Gaps and needs identified in the calculation of GHG emissions from agriculture

Gaps and constraints	Proposed measures for improvement
Activity data organization - Scattering of data throughout agencies - Lack of uniformity in data between different official resources	- Centralize data management. - Homogenize statistics between public, private, and international agencies. - Establish an advisory scientific team to facilitate data coordination and ensure data uniformity.
Activity data availability - Lack of data on fertilizer consumption, MMS, and utilization of crop residues in different regions - Lack of data for refining inventory to higher tier levels	- Undertake field surveys to improve data depths. - Establish a monitoring for manure management and crop residue utilization. - Undertake research to refine data for higher tier levels.
Activity data accessibility - Lack of institutional arrangements for data sharing. - Time delays in accessing and compiling data.	- Establish protocols and effective networking with data providers. - Involve industry and monitoring institutions.
Data on emission factors - Inadequate data for country specific emission factors	- Undertake research to conduct measurements to develop local emission factors.
Absence of technical and institutional capacity	- Conduct training for relevant institutions involved in planning, preparation, and analysis of GHG inventory. - Conduct workshop on data management for agriculture. - Conduct training on new inventory and mitigation softwares.

Table A3- 4 Gaps and needs identified in the calculation of GHG emissions from land use, land use change and forestry

Gaps and constraints	Proposed measures for improvement
- Lack of information and records of data changes in forestry and other woody biomass stocks at the institutional level - Lack of comprehensive studies of forests - Lack of studies on annual growth rate for fruit trees - Lack of data related to urban trees - Lack of data on illegal forest and grassland conversion to cropland - Lack of quantitative data on the abandoned terraced lands, and systematic monitoring for ecological indicators - Lack of technology and monitoring equipment - Lack of proper data dissemination - Inconsistency of information for terrestrial observations - Discontinuity in data since they are based on ecological observations that are specific to projects (limited in time and objectives) - Absence of national monitoring system	- Develop growth models for different forest types. - Update forest map to a scale of 1/20,000 showing distribution per forest type. - Acquire equipment including installation of gauging stations, monitoring stations, and maintenance of the existing ones. - Disseminate of data including building database, standardization of reporting procedures, cooperation between public and private sectors, and the use of monthly bulletins. - Centralize data management. - Organize or standardize inventory systems. - Modernize and reorganize the climate monitoring services. - Build capacity in climate modeling and data handling. - Improve access to data and information. - Develop systematic observation systems.

- Lack of sufficient funding for research - Lack of consistency in data collection - Deficiencies in technical expertise and cooperation between different research bodies - Overlapping mandates of different agencies - Lack of data management systems - Lack of specific emission factors of greenhouse gases	- Identify key indicators and vulnerable areas. - Establish monitoring system for snow. - Establish a specialized scientific coordination body. - Enhance terrestrial and ecological systematic monitoring.

Table A3- 5 Gaps and needs identified in the calculation of GHG emissions from the waste sector

Gaps and constraints	Proposed measures for improvement
- Inconsistency of data related to population number - Absence of field surveys for the quantification of waste generation - Inconsistency of data on methane recovery - Industrial wastewater is not clearly addressed and related information is missing. - Inaccuracy of emission factors to reflect national circumstance due to the absence of country-specific emission factors - Absence of data related to wastewater handling and treatment	- Undertake official census on population in Lebanon. - Assign an official institution responsible for disseminating information on population characteristics. - Undertake research on detailed waste characterization and generation. - Institutionalize the reporting of methane recovery rates from solid waste dumpsites. - Undertake research to determine national emission factors for solid waste and wastewater. - Undertake survey on the quantification and characterization of wastewater handling and treatment systems