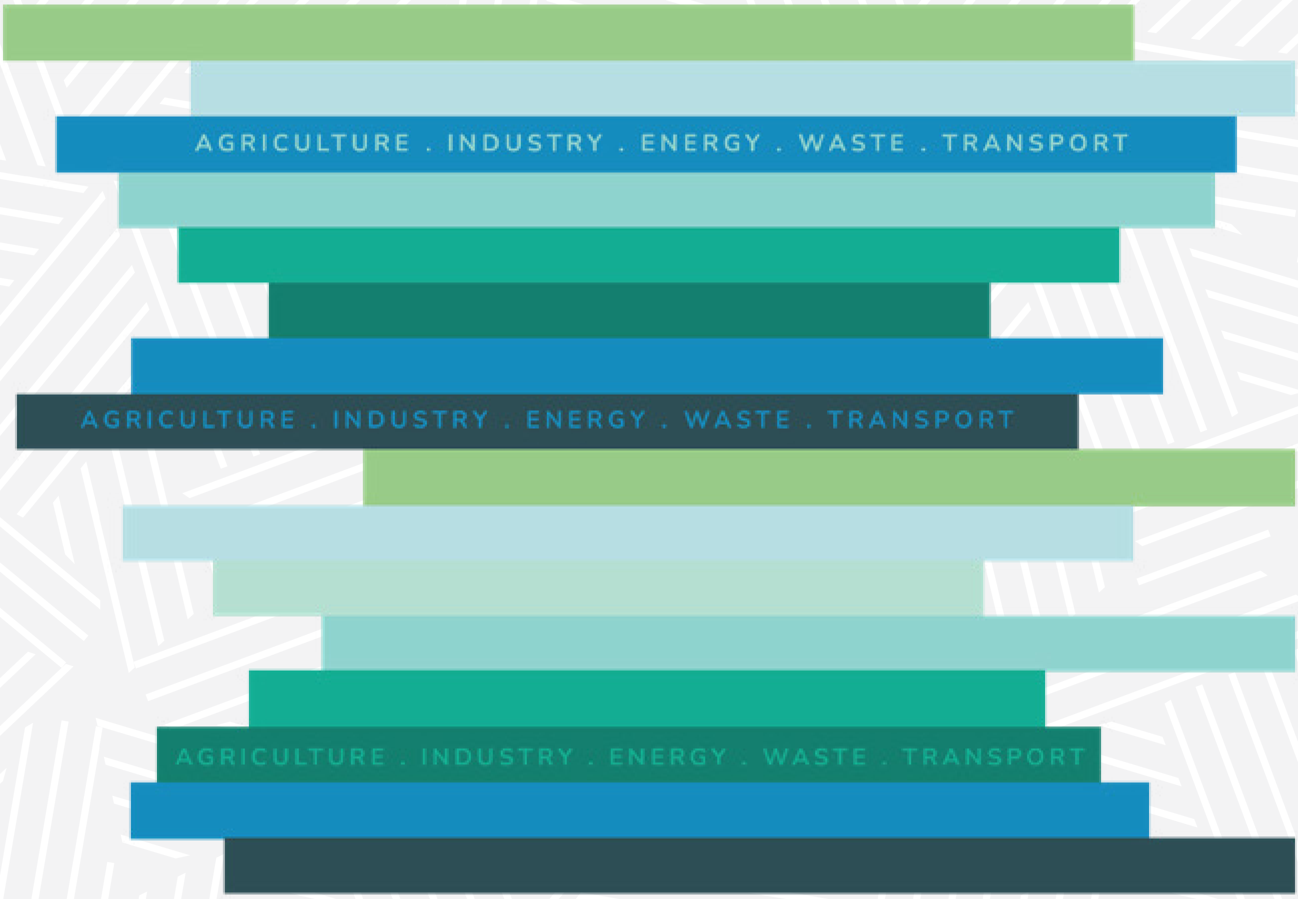
REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT



GREENHOUSE GAS **NATIONAL INVENTORY** REPORT

First Biennial Transparency Report For the United Nations Framework Convention on Climate Change

2024

LEBANON

This document should be referenced as
MoE/UNDP/GEF (2024). Lebanon’s National Greenhouse Gas Inventory Report. Beirut, Lebanon.

UNFCCC focal point
Hala Mounajjed . Acting Head of Environmental Technology Department . Ministry of Environment

For more information
http://climatechange.moe.gov.lb/
climatechange@moe.gov.lb
http://www.undp.org/lebanon

Executed by
Ministry of Environment (MoE), Lebanon

Funded by
Global Environment Facility

Implemented by
United Nations Development Programme, Lebanon

Main Author
Lea Kai . Climate Change advisor . UNDP/ Ministry of Environment (MoE)

Contributing Authors
Leya Zgheib . UNDP/MoE . Adaptation, mitigation actions and support received and needed
Dr. Charbel Afif . Université Saint Joseph . Transport GHG inventory
Dr. Gihane Mansour Aboujaoude . Université Saint Joseph . Transport GHG inventory
Nader Hajj Chehadeh . OTB consult . Energy mitigation actions and support received
Dr. George Mitri . University of Balamand . LULUCF GHG inventory, mitigation actions and support received
Bassam Sabbagh . Ministry of Environment . Waste GHG inventory, mitigation actions and support received
Jacques Chahine . Waste consultant . EDESSA . Waste GHG inventory, mitigation actions and support received

Technical Reviewers
Dr. Vahakn Kabakian . Climate Change advisor . UNDP/ Ministry of Environment
Justin Goodwin . Aether . General guidance and cross-cutting issues
Holly Zhang . Aether . Energy sector of GHG inventory
Kirsten May . Aether . IPPU sector of GHG inventory
Dr. Olga Gavrilova . Aether . Agriculture, LULUCF and cross-cutting issues
Roxy Cottey . Aether . Waste sector of GHG inventory

Editorial Reviewer

Danielle El Chemaly . UNDP/ Ministry of Environment
Wadih Maakaron . UNDP/ Ministry of Environment

Acknowledgements

Energy and Transport

Khadija Noureddine . Ministry of Energy and Water
Dr. Sorina el Mortada . LCEC
Jihad Ghadieh . EDL
Rand Basha . Traffic and Vehicles Management Authority
Selim Saad . Association of Car Importers
Karim Osseiran . UNDP
Nabil Mneimne . UNDP
Marc Ayoub . AUB IFI
Dr. Toni Issa . IPT
Hasmig Khoury . IPT
Alexa Maria Al Hed . IPT
Nicolas Boukhater . ANB
Nada Doughan . AUB
Tala Kambriss . AUB
Noah Yaghmour . AUB

Industrial Processes and Product Use

Jalil Darzi . Cimenterie Nationale
Grace el Azar . Holcim
Dr. Fouad Jaafar . Ciment de Sibline
Ghinwa Fayad . Ciment de Sibline

Agriculture, Forestry and Other Land Use

Dr. Chadi Mohanna . Ministry of Agriculture
Sawsan Bou Fakhreddine . AFDC
Maya Nehme . LRI

Waste and wastewater

Jamila Al Hadi . Ministry of Environment
Talal Farhat . Council for Development and Reconstruction
Rita Gergi . OMSAR
Joseph Kassab . IBC Saida
Pierre Baaklini . Lebanese Waste Management and Drive-throw
Karim Haddad . SICOMO
Rami Nassif . UNDP
Joseph El Ghoul . LACECO
Assaad Zougheib . Zahleh Municipality
Ayman Dandash . Lebanese Eco-Movement

Cross cutting

Marina Akl . UNDP . Gender mainstreaming
John Watterson . RICARDO . GHG inventory
Katherine Shabb . RICARDO . GHG inventory, NDC tracking indicators
Charis Evans . RICARDO . Adaptation, NDC tracking indicators
Sina Wartmann . RICARDO . GHG inventory, NDC tracking indicators
Ellie Voke . RICARDO . NDC tracking indicators
Nour Mucharrafieh . ECODIT . NDC tracking indicators

Concept Design

Lead Designer: Joumana Samaha . UNDP / Ministry of Environment
Graphic Designer: Hiba Kallas

Contents

List of Figures

List of Tables

List of Acronyms

AC	Air Conditioning
AD	Activity Data
AFDC	Association for Forests, Development and Conservation
AFOLU	Agriculture and Forestry and Other Land Uses
ALI	Association of Lebanese Industrialist
API	American Petroleum Institute
BDL	Banque du Liban
BOD	Biochemical Oxygen Demand
BTR	Biennial Transparency Report
BUR	Biennial Update Report
CAPEX	Capital Expenditures
CAS	Central Administration of Statistics
CBIT	Capacity-Building Initiative for Transparency
CEDRE	Conference Economique pour le Developpement par les Reformes avec les Entreprises
CEDRO	Country Energy Efficiency and Renewable Energy Demonstration Project for the Recovery of Lebanon
CD	Cartagena Dialogue for Progressive Action
CDR	Council for Development and Reconstruction
COD	Chemical Oxygen Demand
CoM	Council of Ministers
CRF	Common Reporting Format
CRT	Common Reporting Tables
CTCN	Climate Technology Center and Network
CVF	Climate Vulnerable Forum
DOC	Degradable Organic Carbon
DOCf	Fraction of DOC
DREG	Decentralized Renewable Energy Power Generation
DRR	Disaster Risk Reduction
E/R	Emissions/Removals
EDL	Electricite du Liban
EF	Emission Factor
EIA	Environmental Impact Assessment
ENS	Energy-Not-Supplied
ETF	Enhanced Transparency Framework
EU	European Union
FAO	Food and Agriculture Organization
FOD	First Order Decay
FSV	Facilitative Sharing of Views

FX	Flexibility
GCF	Green Climate Fund
GDO	Gas Diesel Oil
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
GL	Guidelines
GoL	Government of Lebanon
GPG	Good Practice Guidance
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Technologies
GUM	Guide to the Expression of Uncertainty in Measurement
GWP	Global Warming Potential
HDV	Heavy-Duty Vehicles
ICA	International Consultation and Analysis
IE	Included Elsewhere
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IPTEC	IPT Energy Center
KCA	Key Category Analysis
LARI	Lebanese Agricultural Research Institute
LCEC	Lebanese Center for Energy Conservation
LDV	Light-Duty Vehicles
LFG	Landfill Gas
LPG	Liquefied Petroleum Gas
LRI	Lebanese Reforestation Initiative
LULUCF	Land Use, Land Use Change and Forestry
MCF	Methane Correction Factor
MIC	Manufacturing Industries and Construction
MISCA	Management Information System for Climate Action
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoF	Ministry of Finance
MoFA	Ministry of Foreign Affairs
MoEW	Ministry of Energy and Water
MoI	Ministry of Industry
MoIM	Ministry of Interior and Municipalities
MoPWT	Ministry of Public Works and Transport
MoSA	Ministry of Social Affairs
MoUs	Memoranda of Understanding
MPG	Modalities, Procedures and Guidelines

MRF	Material Recovery Facilities
MRV	Measuring, Reporting and Verifying
MRVCE	Measuring, Reporting and Verifying Coordinating Entity
MSW	Municipal Solid Waste
NA	Not Applicable
NC	National Communication
NCV	Net Calorific Value
NDC	Nationally Determined Contribution
NE	Not Estimated
NEEAP	National Energy Efficiency Action Plan
NEEREA	National Energy Efficiency and Renewable Energy Action
NGO	Non-Governmental Organization
NMVOCs	Non-Methane Volatile Organic Compounds
NO	Not Occuring
NWS	National Water Strategy
OBIA	Object-Based Image Analysis
ODS	Ozone Depleting Substances
OMSAR	Office of the Minister of State for Administrative Reform
OPEX	Operating Expenditures
PATPA	Partnership on Transparency in the Paris Agreement
PC	Passenger Cars
PDF	Probability Density Functions
POP	Persistent Organic Pollutants
PRP	Pasture Range and Paddock
PV	Photovoltaics
QA/QC	Quality Assurance/Quality Control
RAC	Refrigeration and Air Conditioning
SNC	Second National Communication
SWDS	Solid Waste Disposal Sites
SWM	Solid Waste Management
TACCC	Transparency, Accuracy, Completeness, Comparability and Consistency
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
WERF	Water Environment Research Foundation
WWTP	Waste Water Treatment Plant

Executive Summary

In 2022, Lebanon emitted 20,519 Gg CO_2eq. (as total emissions), which is a 32% decrease from 2019 (calculated as 30,189 Gg CO_2eq.), mainly due to a significant decrease in energy-related emissions. The economic crisis that started in 2019 exacerbated the problems of electricity supply, with extended power cuts due to the government's inability to secure fuel for power plants and ensure proper maintenance and upgrades of the already fragile infrastructure. An 85% decline in electricity production was observed between 2019 and 2022 with EDL electricity generation plummeting to 2,138 GWh in 2022 (EDL, 2023). This was mainly due to the halt of some power plants (i.e. Jieh and Zouk thermal power plants, Hrayche power plant), and gradual reduction in the reliance on power rental barges until complete halt in 2022.

Still, the main contributor to greenhouse gas emissions in Lebanon remains the energy sector (including transport) with 77% of GHG emissions, followed by industrial processes (12.6%) in reference Figure i.

Transport emissions constitute around 32.5% of total emissions, remaining an important contributor to emissions with 6,662 Gg CO_2eq. in 2022, mainly due to the consumption of gasoline in passenger cars.

The industrial processes sector accounts for approximately 12.6% of total emissions with 2,584 Gg CO_2eq. in 2022. These emissions have seen fluctuations due to varying levels of industrial activity and changes in production processes. Key contributors include cement production and emissions from F-gases from refrigeration and air conditioning.

The AFOLU sector contributes with 3.8% of GHG emissions, with 777.94 Gg CO_2eq. in 2022. These emissions arise from activities such as enteric fermentation in livestock, agricultural soil management, and deforestation. CO_2 removals from forestry and land use change amounted to – 3,243 Gg CO_2, bringing Lebanon's NET emissions to 17,275 Gg CO_2eq. Emissions from this sector are influenced by agricultural practices, land-use changes, and forest management policies.

The waste sector contributes 6.6% of Lebanon's total GHG emissions, with emissions estimated at 1,347 Gg CO_2eq. in 2022. Emissions primarily result from solid waste disposal on land and wastewater treatment, due to the anaerobic decomposition of organic waste in landfills and the treatment of municipal and industrial wastewater. Efforts to improve waste management practices and increase recycling rates are essential for reducing emissions from this sector.

Historically, Lebanon's GHG emissions steadily increased, nearly tripling since 1994, with an average annual growth of 6%. However, this trend shifted significantly following the events of 2019 and the subsequent financial economic crisis. By 2022, total GHG emissions had decreased by 32% compared to 2019, largely due to the COVID-19 pandemic and decrease in economic activity post 2019. These factors significantly reduced energy-related emissions, which had long been the dominant contributor to Lebanon's total GHG output.

The time series of emissions in Figure ii shows, since approximately 2008, a considerable growth in the CO_2eq. total emissions, which are dominated by an increase in energy sector emissions. Between 1994 and 2022, the energy sector, including transport, remained the largest source of GHG emissions, contributing between 66% and 77% of the total.

Over time, emissions experienced periodic declines, notably in 2007, 2010, and after 2019. The 2007 drop was attributed to damage from the July 2006 war, which impaired the electricity distribution network and caused power plants to operate below capacity. In 2010, a shift to natural gas at the Deir Amar plant, along with increased hydropower production, further reduced emissions. However, the most significant decrease occurred after 2019 due to civil unrest and economic collapse that the country has been witnessing since.

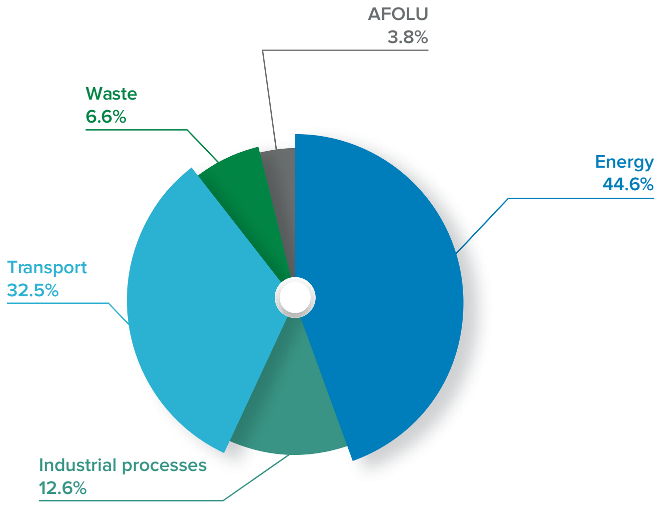


Figure i: Lebanon's national greenhouse gas inventory by category in 2022

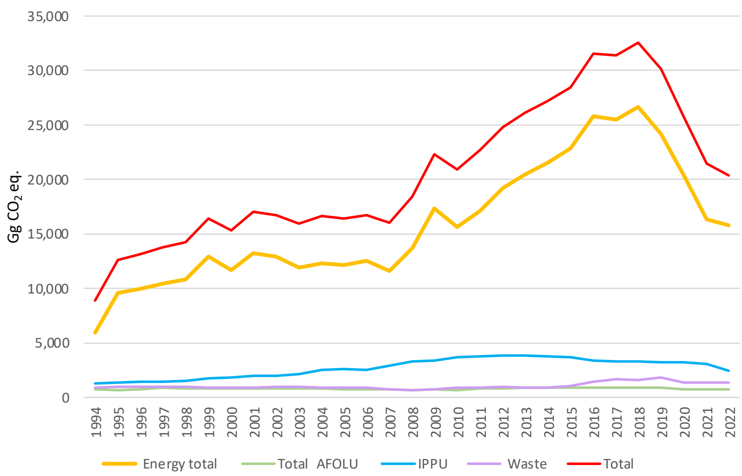


Figure ii: Trend in total and sectoral GHG emissions 1994-2022

Table 1 - Lebanon's GHG emissions and removals for 2022 per gas and category

Greenhouse gas source and sink categories	CO_2 emissions/ removals	CH_4	N_2O	CH_4	N_2O	F-gases	Total emissions	Net emissions
(IPCC code)	Gg	Gg	Gg	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
Total National Emissions and Removals	13,283.3	63.92	2.06	1,789.64	544.77	1,656.51	20,519.78	17,274.22
1 - Energy	**15,613.08**	**2.39**	**0.49**	**66.99**	**129.95**		**15,810.02**	
1.A - Fuel Combustion Activities	15,613.08	2.39	0.49	66.99	129.95		15,810.02	
1.A.1 - Energy Industries	1,444.16	0.06	0.01	1.63	3.10		1,448.89	
1.A.2 - Manufacturing Industries and Construction	2,115.16	0.08	0.02	2.21	4.16		2,121.53	
1.A.3 - Transport	6,509.72	1.47	0.42	41.24	111.46		6,662.43	
1.A.4 - Other Sectors	5,544.04	0.78	0.04	21.90	11.23		5,577.17	
2 - Industrial Processes and Product Use	**900.61**		**0.10**	-	**27.16**	**1,656.51**	**2,584.28**	
2.A - Mineral Industry	900.29	NA	NA	NA	NA	NA	900.29	
2.A.1 - Cement production	898.88	NA	NA	NA	NA	NA	898.88	
2.A.2 - Lime production	0.75	NA	NA	NA	NA	NA	0.75	
2.A.3 - Glass Production	IE	IE	IE	NO	NO	NA		
2.A.4 - Other Process Uses of Carbonates	0.66	NA	NA	NA	NA		0.66	
2.B- Chemical Industry	NO	NO	NO	NO	NO	NA		
2.C - Metal Industry	NO	NO	NO	NO	NO	NA		
2.D - Non-Energy Products from Fuels and Solvent Use	0.32	NA	NA	NA	NA		0.32	
2.D.1 - Lubricant Use	IE	NA	NA	NA	NA			
2.D.2 - Paraffin Wax Use	0.32	NA	NA	NA	NA		0.32	
2.D.3 - Solvent Use	NE	NA	NA	NA	NA			
2.E- Electronics Industry	NO	NO	NO	NO	NO	NA		
2.F - Product Uses as Substitutes for ODS						1,656.51	1,656.51	
2.F.1 – Refrigeration/ Air Conditioning	NA	NA	NA	NA	NA	1,656.51	1,656.51	
2.F.2 - Foam Blowing	NO	NO	NO	NO	NO	NO		
2.F.3 - Fire Protection	NE	NE	NE	NE	NE	NE		
2.F.4 - Aerosols	NO	NO	NO	NO	NO	NO		
2.F.5 - Solvents	NO	NO	NO	NO	NO	NO		
2.G - Other Product Manufacture and Use			0.10		27.16		27.16	
2.G.1 - Electrical Equipment	NE	NE	NE	NE	NE	NE		
2.G.2 - SF_6 and PFCs from Other Product Uses	NE	NE	NE	NO	NO	NO		
2.G.3 - N_2O from Product Uses	NA	NA	0.10	NA		NA	27.16	
2.G.4 - Other	NE	NE	NE	NE	NE	NE		
3 - Agriculture, Forestry, and Other Land Use	**(3,243.27)**	**17.07**	**1.12**	**478.03**	**297.62**		**777.94**	
3.A - Livestock	-	17.06	0.38	477.68	100.97	-	578.65	

Greenhouse gas source and sink categories (IPCC code)	CO_2 emissions/ removals	CH_4	N_2O	CH_4	N_2O	F-gases	Total emissions	Net emissions
	Gg	Gg	Gg	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
3.A.1 - Enteric Fermentation	NA	13.83	NA	387.21	NA		387.21	
3.A.2 - Manure Management	NA	3.23	0.38	90.47	100.97		191.43	
3.B - Land	(3,245.55)	NA	NA	NA	NA		(3,245.55)	
3.B.1 - Forest land	(2,046.11)	NA	NA	NA	NA		(2,046.11)	
3.B.2 - Cropland	(1,218.69)	NA	NA	NA	NA		(1,218.69)	
3.B.3 - Grassland	NE	NE	NE	NE	NE			
3.B.4 - Wetlands	NE	NE	NE	NE	NE			
3.B.5 - Settlements	19.24	NA	NA	NA	NA		19.24	
3.B.6 - Other Land	NO	NO	NO	NO	NO		NO	
3.C - Aggregate sources and non-CO_2 emissions sources on land	2.29	0.01	0.74	0.35	196.66		199.30	
3.C.1 - Emissions from biomass burning		0.01	0.00	0.35	0.10		0.45	
3.C.2 - Liming	NO	NA	NA	NA	NA			
3.C.3 - Urea application	2.29	NA	NA	NA	NA		2.29	
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	0.57	NA	150.71		150.71	
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	0.08	NA	21.02		21.02	
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	0.09	NA	24.83		24.83	
3.D Other								
3.D.1 - Harvested Wood Products	NE	NA	NA	NA	NA		NE	
4 - Waste	**12.87**	**44.45**	**0.34**	**1,244.62**	**90.03**		**1,347.53**	
4.A - Solid Waste Disposal	-	23.58	-	660.10	-		660.10	
4.B - Biological Treatment of Solid Waste	-	0.26	0.02	7.387	4.07		11.45	
4.C - Incineration and Open Burning of Waste	12.87	1.86	0.03	51.95	8.85		73.67	
4.D - Wastewater Treatment and Discharge	-	18.76	0.29	525.20	77.12		602.31	
Memo Items								
International Bunkers	**815.42**	**0.02**	**0.02**	**0.45**	**5.83**		**821.70**	
1.A.3.a.i - International Aviation	694.54	0.01	0.02	0.14	5.04		699.72	
1.A.3.d.i - International water-borne navigation	120.88	0.01	0.00	0.31	0.80		121.98	
Information Items								
CO_2 from Biomass Combustion for Energy Production	34.79							

1. National circumstances, institutional arrangements and cross-cutting information

1.1 Background information on GHG inventories and climate change

Lebanon has already reported several GHG inventories as part of three National Communications and four Biennial Update Reports, with the fourth BUR (BUR4) and the fourth NC (4NC) submitted in December 2021 and 2022, respectively. The GHG inventory chapter in its most recent report, the 4NC presents estimates of emissions and removals of CO_2, and emissions of CH_4, N_2O, and HFCs for all sectors for the years 1994 – 2019. It includes a comprehensive Key Category Analysis (KCA) and uncertainty analysis and discusses the differences between the Sectoral Approach the Reference Approach calculations. The 4NC c ross references back to some methodological detail presented in the BUR4.

Data providers, e.g., Electricité du Liban, Lebanese customs database etc., and methodologies used are presented transparently. A number of categories (e.g. CH_4 and N_2O from road transport, cement production, solid waste and wastewater disposal) are reported using a Tier 2 approach, while the majority of key categories (e.g. CO_2 from liquid fuels in stationary combustion) are reported using a Tier 1 approach.

1.2 Description of national circumstances and institutional arrangements

1.2.1 National focal point

In Lebanon, the Ministry of Environment (MoE) is the national focal point for climate change and is also the focal point of the following climate change related international organizations, centers, initiatives and funding bodies such as:

- United Nations Framework Convention on Climate Change (UNFCCC)
- Intergovernmental Panel on Climate Change (IPCC)
- The Adaptation Fund
- NDC Partnership
- Green Climate Fund (GCF)
- Climate Technology Centre and Network (CTCN)
- Climate Vulnerable Forum (CVF)
- Cartagena Dialogue for Progressive Action (CD)
- Partnership on Transparency in the Paris Agreement (PATPA)
- Initiative for Climate Action Transparency (ICAT)

A climate change project team, supported by multilateral funds, works under the Service of Environmental Technology at the Ministry of Environment, and is responsible amongst others, for the preparation and submission of the National Communications and Biennial Update/Transparency reports.

1.2.2 Inventory preparation process

The national GHG inventory is compiled by a team of 2 at the Ministry of Environment who is financed on a project basis such as the GEF enabling activities for the preparation of NCs, BURs or BTRS and the Capacity Building Initiative for Transparency GEF. The retention of the compilation team therefore highly depends on the ability to continue finding international funding. The team has continuously worked to improve GHG inventory data, involve staff from MoE's air quality team and other ministries to establish sustainable data collection and compilation processes. The air quality team is composed of the UNFCCC focal point and 2 technical experts who are full-time employees at the Ministry of Environment and who also handle other portfolios such as monitoring and maintenance of the national air quality network (currently non-operational), review of EIAs and Audits, follow-up on complaints, and other administrative tasks. The AIr quality department team has witnessed several changes in the team composition due to the high turnover rate of the employees and are constantly overwhelmed due to the continuous understaffing of the Ministry.

The GHG inventory is usually compiled in-house, with sometimes using national experts to improve the accuracy and completeness of some specific sectors and external international experts are recruited for quality assurance.

Extensive stakeholders and key data holders' consultations are conducted during the process to identify and validate information relevant to the inventory. Currently, data collection is only feasible by sending a written request to each Ministry, detailing the data required, and most of the time is slow forthcoming. This also applies to data held by other entities in the Ministries' remit, e.g. agencies or state-owned companies. Even where the data sharing request has been granted by the Minister, obtaining the data from the data providers can take additional effort. The readiness to provide data often relies on the personal relationship of the data providers with the climate change team. In addition, due to scarcity of resources at the Ministries and other entities, data may still not be regularly available and/or be consistent with data provided previously.

Based on a study conducted under the Paris Agreement Partnership for Transparency (PATPA), the Ministry of Environment attempted to establish Memoranda of Understanding with several Ministries, including the Ministry of Energy and Water and the Ministry of Agriculture to allow obtaining data regularly without the need for written requests for data. This was preceded by meetings under the project, where data needs and data use were explained to the Ministries and related agencies and other data providers (e.g. LARI, EDL, customs). However, with the instability of the government, and the frequent changes of Ministers, MoUs did not sems to be a viable approach to obtaining GHG inventory data. The climate change team continues to rely on written requests and personal communications for data collection.

During the GHG inventory preparation process, attempts to abide by a pre-defined GHG inventory cycle have been compromised by various delays in access to funding, access to data, or enabling political environment. These delays affect the approach of data collection, which is mostly undertaken on an ad-hoc manner (as opposed to having a restrained data collection phase) and decrease the time spend and efforts invested in improving methodologies, data validation, Quality Assurance/ Quality Control (QA/QC) and uncertainty analysis.

Through the Capacity Building for Initiative for Transparency (CBIT) project, Lebanon established a transparency strategy establishing sectoral task forces for the priority mitigation and adaptation sectors to enhance the role and engagement of ministries and agencies not only in the preparation of the GHG inventory, but also in collecting data and information for other reporting requirements.

Table 2 - Summary of data providers for GHG inventory preparation

Sector	Data Providers
Energy	• EDL: Electricite du Liban (fuel consumption per power plant) • Lebanese Customs (Lubricant and petroleum coke) • MoEW/LCEC (fuel imports, RE installed) • General directorate of Petroleum (fuel imports) • IPTEC: IPT Energy Center (sectoral estimation of fuel use) • Cement industries (petroleum coke) • Syndicate of cars importers • MoIM- vehicle registration authority (numbers and type of register vehicles)
IPPU	• Cement industries • Lime industries • Lebanese Customs (soda ash import, paraffin wax import) • National Ozone Unit (inventory for refrigeration and cooling sector)
AFOLU	• MoA (validation of all data) • Lebanese Customs (fertlizers imported) • FAO (livestock populations, crop production) • Institute of Environment University of Balamand (changes in Land use) • NGOs (reforestation/afforestation activities, forest fires) • DRR unit (forest fires)
Waste	• MoE (waste quantities, composition, discharge and treatment pathways) • Waste operators (waste quantities treated) • MoEW (wastewater quantities, status of WWTPs) • CDR: Council for Development and Reconstruction (status of WWTPs) • International agencies (UNDP, WB, AFD, USAID)

1.2.3 Archiving of information

During the preparation of BTR1, a structured documentation and archiving approach in the form of a standardized documentation templates and clear responsibilities for archiving of methodologies and data, consultant's reports, expert judgements has been established and adopted.

The documentation templates are based on excel workbook, all computed/generated numbers and equations can be traced. For each category workbook, the following information are filled:

- Category information sheet: name and IPCC code of category/subcategory, key category (yes/no, gas), tier level used, category description and definition (what are the processes that cause emissions).
- Methodology sheet: GHG calculated, equations used (for emissions, emission factor calculation, parameter calculations, etc.), reference of methodology used, explanations on choice of methodology and its known limitations.

- Activity data sheet: type of activity data, unit, date of provision, source of provision, contact details, basis for data provision (official correspondence, personal communication, published material, online website, etc.), geographic coverage of activity data, adjustments applied to activity data (examples: adding imported beef to national beef population, conversion in units of lubricants or paraffin wax, etc.), assumptions in activity data (example: it assumed that all imported/produced material is used in the year of import/production), disaggregated activity data time series adopted in previous BUR, disaggregated activity data time series adopted in current BUR.
- Emission factors sheet: gas, type of emission factor, unit, description of appropriateness to national circumstances, time series covered by emission factor, reference, date of provision, contact details, additional comments, emission factor values adopted in previous inventories, emission factor values adopted in current BUR.
- Parameters sheet same type of information as emission factor sheet, adapted for parameters.
- Recalculations sheet years that have been recalculated, value that has been recalculated (activity data, emission factor, or parameter), description of changes between previous inventories and current ones. Version control and recalculation records system is implemented.

Specific data collection templates for the IPPU and waste sector were also developed as a result of extensive consultations with the Service of Urban Environment at the MoE.

All archives are saved on a cloud system, accessible to authorized personnel to ensure data integrity and availability.

1.2.4 Processes of official consideration and approval of inventory

The process for official consideration and approval of the inventory of the BTR1 is mainly lead by the Ministry of Environment (MoE), as the lead coordinator of climate change policies in Lebanon and the UNFCCC focal point. After the collection and compilation of data, intensive stakeholder validation is undertaken to validate results and confirm assumptions. Then, the climate change team at the Ministry finalized the results and analysis of the GHG inventory and compiled all the chapters of the BTR in line with the IPCC guidelines and the MPGs. The compiled GHG inventory is subjected to an external independent review process consultants to conduct a thorough review of the GHG inventory, focusing on methodologies, emission factors, and assumptions used. Comments and recommendations are then taken into consideration when applicable in the last version of the inventory.

The final GHG inventory report is then approved and endorsed by the Minister of Environment and submitted to the UNFCCC as part of the BTR. The report is also made publicly available on the MoE's and UNFCCC official websites and through other communication channels to ensure transparency and public awareness.

1.3 Brief description of methodologies and data sources used compiled

The GHG inventory in this report covers the year 2022, with a time series for 2020-2022 and the baseline of 2011. The inventory was prepared based on the 2006 IPCC Guidelines, and using the IPCC software version 2.930, including analysis of key categories, uncertainties and generation of trends. One main challenge in the preparation of the BTR1 inventory was the migration of the data from the IPCC software 2.69 to the new version of 2.930 which incurred significant loss of data. Due to time constraints, the whole time series of 1994-2022 was not completely transferred, with missing years for waste and LULUCF specifically.

The inventory is in line with Modalities, Procedures and Guidelines (MPGs) for the enhanced transparency framework as per UNFCCC Decisions 18/CMA.1 and 5/CMA.3.

Emissions of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and F-gases (HFC) were estimated and reported in Gg CO_2eq. (1,000 tonnes) using the 100-year time-horizon global warming potential values of the IPCC Fifth Assessment Report, as referred to in decision 18/CMA.1.

The following sectors are covered: 1. Energy (including transport), 2. Industrial Processes and Product Use (IPPU), 3. Agriculture Forestry and Other Land Use (AFOLU) and 4. Waste (including wastewater).

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

Tier 2 methods were used to estimate emissions from energy industries, transport (for CH4 and N2O), cement manufacturing, product uses as substitutes for Ozone Depleting Substances (F-gases), solid waste disposal and wastewater treatment and discharge, while approach 3 was adopted for the representation of land use areas in some subcategories of AFOLU.

1.4 Brief description of key category

Key categories for Lebanon are determined for both level and trend using Approach 1 from the 2006 IPCC Guidelines. The results from the KCA should be used to identify priorities for the improvement of the national GHG inventory. Emissions from key categories should be estimated using higher tier methods: Tier 2 or Tier 3. Currently, only the following categories adopt a Tier 2 /approach 3 methodology:

- 1.A.1. Electricity Generation (CO_2 emissions from diesel use)
- 1.A.3.b Road Transportation (only for CH_4 and N_2O emissions)
- 2.A.1 Cement production
- 2.F.1 Refrigeration and A/C
- 3.B Land
- 4.A Solid Waste Disposal
- 4.D Wastewater Treatment and Discharge.

The remainder of key categories identified are only estimated with a Tier 1 methodology due to lack of activity data, lack of country-specific emission factors, and inventory team resource limitations.

Table 3 - Key categories by level assessment (LA) for 2022 with LULUCF

IPCC Category code	IPCC Category	Greenhouse gas	2022 Ex,t (Gg CO_2eq.)	Ex,tl (Gg CO_2eq.)	Lx,t	Cumulative Total of Column F
1.A.3.b	Road Transportation - Liquid Fuels	CO_2	6,509.72	6,509.72	0.27	0.27
1.A.4	Other Sectors - Liquid Fuels	CO_2	5,544.04	5,544.04	0.23	0.50
3.B.1.a	Forest land Remaining Forest land	CO_2	(2,007.69)	2,116.62	0.09	0.59
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	2,115.15	2,115.15	0.09	0.68
2.F.a	Refrigeration and Air Conditioning	FHC	1,656.50	1,656.50	0.07	0.75
1.A.1	Energy Industries - Liquid Fuels	CO_2	1,444.16	1,444.16	0.06	0.81
3.B.2.a	Cropland Remaining Cropland	CO_2	(1,233.31)	1,233.31	0.05	0.86
2.A.1	Cement production	CO_2	898.88	898.88	0.04	0.90
4.A	Solid Waste Disposal	CO_2	665.53	665.53	0.03	0.93
4.D	Wastewater Treatment and Discharge	CO_2	525.21	525.21	0.02	0.95
3.A.1	Enteric Fermentation	CO_2	387.22	387.22	0.02	0.96

1.5 Brief description of QA/QC plan

Quality Control

The inventory team uses a system of routine technical activities to measure and control the quality of the inventory that is being developed, including standardised notations in the documentation sheets to document changes, data sources and necessary improvements.

Updated inventory results are verified by sum checks and by using the previous data sets to compare trends and understand drivers. The sum checks are performed for the totals and for the sectors to ensure no data is lost. The transfer of activity data from the documentation sheets to IPCC model is done manually and double checked by an internal reviewer to decrease the chance for inserting errors. Recalculations files, comparing the current and the previous submission, allow to check that no changes were made unless necessary and documented.

General and sectoral QC activities include automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies.

Other QA/QC procedures included involve updating and specifying Activity Data (AD) and Emission Factors (EFs) according to the 2006 IPCC Guidelines and integrating them into spreadsheets that align with CTF tables. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

Table 4 - List of general QC procedures applied to BTR1

QC Activity	Procedures
Collection, input and computation of data	
Transcription errors between data input and reference	• Cross-check descriptions of activity data and emission factors with information on categories and ensure that these are properly recorded and archived • Confirm that bibliographical data references are properly cited in the internal documentation • Cross-check a sample of input data from each category for transcription errors. • Utilize electronic data where possible to minimize transcription errors • Use automatization (e.g. calculation formulae and Lookup functions in Excel) to minimize user/entry error • Do not include values like emission factors, net calorific values, assumptions into formulae, rather link them to documented cells • Ensure spreadsheets contain clear instructions for updating and a description of how the spreadsheet works • Ensure a record is kept in the spreadsheets of developments, how these have been implemented and checked • Where possible, provide links to the data sources
Quality of activity data	• Assess appropriateness of data sources • Determine the level of QC performed by the data collection agency and document it. • Ensure that qualifications of individuals providing expert judgement for estimates are appropriate and properly recorded
Appropriateness of emission factors	• Evaluate whether national conditions are similar to those used to develop the IPCC default factors • Compare country-specific factors to IPCC defaults; document any significant discrepancies • Consider options for obtaining country-specific factors
Calculations	• Reproduce a representative sample of emissions/removals calculations • Record the work done and the findings. Record any improvements identified
Units and conversion factors	• Check that units are properly labelled in calculation sheets and the data and methodology documentation sheet • Check that units are correctly carried through from beginning to end of calculations • Check that conversion factors are correct • Check that temporal and spatial adjustment factors are used correctly
Consistency	• Identify parameters (e.g., activity data, constants) that are common to multiple categories and confirm that there is consistency in the values used for these parameters in the emissions/removals calculations

QC Activity	Procedures
Documentation	
• Check that there is detailed internal documentation to support the estimates and enable duplication of calculations • Check that every primary data element has a reference for the source of the data • Check that inventory data, supporting data, and inventory records are archived and stored to facilitate detailed review • Check that the archive is closed and retained in secure place following completion of the inventory	
Calculation	
Completeness	• Confirm that estimates are reported for all categories and for all years from the appropriate base year over the period of the current inventory • For subcategories, confirm that the entire category is being covered- If not provide justifications to notation keys • Check that known data gaps that result in incomplete category emissions/removals estimates are documented, including qualitative evaluation of the importance of the estimate in relation to total net emissions (e.g. subcategories classified as 'not estimated') • Review the use of notation keys and the associated assumption to ensure they are correct
Time series consistency	• For each category, compare current inventory estimates to previous estimates, if available • Check for consistency in the method used for calculations throughout the time series • Check if there any unusual or unexplained trends noticed for activity data or other parameters across the time series • Compare to socio-economic factors that might significantly influence the trend • Compare to previous year's results to maintain the trend • Check methodological and data changes resulting in recalculations
Uncertainty	• Check that the uncertainty analysis is complete • Check that the values are aligned with the default values of the IPCC guidelines or countries with similar circumstances.

Quality assurance

Lebanon's GHG inventory reported under BTR1 has been subject to review by an international expert to assess the effectiveness of the internal QC programme, to verify that quality objectives were met and to reduce any inherent bias in the inventory processes.

Some of the recommended improvements from BUR4 were applied in the preparation this BTR1, as per section 8.2. Other improvements -requiring time and resources- will be applied in subsequent GHG inventories. Results and recommendations from the reviews of previous BURs through the International Consultation and Analysis (ICA) and Facilitative Sharing of Views (FSV) were considered also in the BTR and the recommendations are prioritized in terms of their contribution to total GHG emissions and the magnitude of the flagged issue.

1.6 General uncertainty assessment

Uncertainty estimates have been done at different inventory levels (from inputs data to the national annual estimates of emissions or removals, and emissions or removals trends) using approach 1 for all the inventory except for transport activity data where the Monte Carlo/Approach 2 was used, as per the IPCC Good Practice Guidances (IPCC, 2000; 2003), and the IPCC 2006 Guidelines (IPCC, 2006). Sectoral experts investigated the uncertainty parameters coming under their field of work, and uncertainties have been calculated for CO_2, CH4 and N_2O (The analyse does not include the emissions of HFCs). The estimated overall uncertainty of the total inventory reached 8.5% in 2022, with the corresponding uncertainty in trend 1994-2022 estimated to 35%. Details of uncertainty calculation are presented in Annex II.

1.7 General assessment of completeness

All sources of direct GHG gases included in the IPCC guidelines are covered by the inventory, as well as all the direct GHGs. The geographical coverage is complete.

For the notation keys, the following have been used in the 2022 inventory:

NO (Not Occurring): This notation key is used for activities in a particular source or sink category that do not occur in Lebanon. The highest number of source categories marked with NO is found in IPPU and agriculture sector.

NE (Not Estimated): Emissions of CO_2, CH_4 and N_2O from domestic aviation, glass production, non-energy products and solvent use, harvested wood products and changes in land use in wetlands and other lands in addition to emissions of PFCs, SF_6 and NF_3, are not estimated because of lack of activity data and/or because their likely level of emissions is below 0.1% of the national total GHG emissions (20.5 Gg CO_2eq.).

IE (Included Elsewhere): There are a few categories marked with IE because relevant data are not available on the reporting level and emissions are therefore included in some other categories. These sources include emissions from domestic navigation and lubricants, as presented in Table 5.

NA (Not Applicable): This notation key is used for activities in a given source/sink category that do not result in emissions or removals of a specific gas.

FX (Flexibility): this notation key is used for activities where Lebanon has used the flexibility provisions provided by the MPGs.

Table 5 - Methodological tiers used in the national GHG inventory in the inventory year 2022

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs	SF_6	NF_3
	Method	EF	Method	EF	Method	EF	Method	EF			
1. Energy	**T1/T2**	**D/CS**	**T1**	**D**	**T1**	**D**					
A. Fuel combustion activities	T1/T2	D/CS	T1	D	T1	D					
1. Energy industries	T1/T2	D/CS	T1	D	T1	D					
a.Public electricity and heat production	T1/T2	D/CS	T1/T2	D/CS	T1/T2	D/CS					
i. Electricity Generation	T1/T2	D/CS	T1/T2	D/CS	T1/T2	D/CS					
ii. Combined Heat and Power Generation (CHP)	NO	NO	NO	NO	NO	NO					
b. Petroleum refining	NO	NO	NO	NO	NO	NO					
c. Manufacture of solid fuels and other energy industries	NO	NO	NO	NO	NO	NO					

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF						
2. Manufacturing industries and construction	T1/NE	D/NE	T1/NE	D/NE	T1/NE	D/NE								
3. Transport	T1	D	T2	D	T2	D								
a. Domestic aviation	NE	NE	NE	NE	NE	NE								
b. Road transportation	T1	D	T2	D	T2	D								
c. Railways	NO	NO	NO	NO	NO	NO								
d. Domestic navigation	IE	IE	IE	IE	IE	IE								
e. Other transportation	NO	NO	NO	NO	NO	NO								
4. Other sectors	T1	D	T1	D	T1	D								
a.Commercial/ institutional	T1	D	T1	D	T1	D								
b. Residential	T1	D	T1	D	T1	D								
c. Agriculture/ forestry/ fishing	T1	D	T1	D	T1	D								
5. Other	NO	NO	NO	NO	NO	NO								
B. Fugitive emissions from fuels	NO	NO	NO	NO	NO	NO								
1. Solid fuels	NO	NO	NO	NO	NO	NO								
2. Oil and natural gas	NO	NO	NO	NO	NO	NO								
a. Oil	NO	NO	NO	NO	NO	NO								
b.Natural Gas	NO	NO	NO	NO	NO	NO								
3. Other emissions from energy production	NO	NO	NO	NO	NO	NO								
C. CO_2 Transport and storage	NO	NO												
2. Industrial Processes and Product Use	**NE,NA, NO**	**NE, NA, NO**	**NA, NO**	**NA, NO**	**NE,NA, NO**	**NE, NA, NO**	**NE, NA, NO**							
A. Mineral Industry	T1/T2/ NE	D/CS/ NE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
B. Chemical Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
C. Metal Industry	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
D. Non-Energy Products from Fuels and Solvent Use	T1/NE/IE	D/NE/IE	NE	NE	NE	NE	NE							
E. Electronics Industry	NO	NO	NO	NO	NO	NO	NO							
F. Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	NA	NA	NA	T2	D	NE	NE	NE	NE	NE	NE
G. Other Product Manufacture and Use	NA, NO	NA, NO	NA, NO	NA, NO	T1	D	NA	NA	NE	NE	NE	NE	NE	NE
H. Other	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO	NA, NO								
3. Agriculture, Forestry, and Other Land Use	**T3/T1/ NE**	**CS/D/ NE**	**T3/T1**	**CS/D**	**T3/T1**	**CS/D**								
A. Livestock	NA	NA	T1	D	T1	D								
1. Enteric Fermentation	NA	NA	T1	D	T1	D	-	-	-	-	-	-	-	-
2. Manure Management	NA	NA	T1	D	T1	D	-	-	-	-	-	-	-	-

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs	SF_6	NF_3
	Method	EF	Method	EF	Method	EF	Method	EF			
B. Land	T2	D	NA	NA	NA	NA					
1. Forest Land	T2/NE/ IE/NO	D	NA	NA	NA	NA					
a. Forest Land Remaining Forest Land	T2	D	NA	NA	NA	NA					
b. Land Converted to Forest Land	T2/NE/ IE/NO	D	NA	NA	NA	NA					
2. Cropland	T2/NE/ NO	D	NA	NA	NA	NA					
a. Cropland Remaining Cropland	T2	D	NA	NA	NA	NA					
b. Land Converted to Cropland	NE/NO	D	NA	NA	NA	NA					
3. Grassland	T2/NE/ NO	D	NA	NA	NA	NA					
a. Grassland Remaining Grassland	T2	D	NA	NA	NA	NA					
b. Land Converted to Grassland	T2/NE/ NO	NA	NA	NA	NA	NA					
4. Wetland	NE	NE	NA	NA	NA	NA					
a. Wetland Remaining Wetland	NE	NE	NA	NA	NA	NA					
b. Land Converted to Wetland	NE	NE	NA	NA	NA	NA					
5. Settlements	T2	D	NA	NA	NA	NA					
a. Settlements Remaining Settlements	T2	D	NA	NA	NA	NA					
b. Land Converted to Settlements	T2	D	NA	NA	NA	NA					
6. Other Land	NE	E	NA	NA	NA	NA					
a. Other Land Remaining Other Land	NE	NE	NA	NA	NA	NA					
b. Land Converted to Other Land	NE	NE	NA	NA	NA	NA					
c. Aggregate sources and non-CO_2 emissions sources on Land	T1	D	T1	D	T1	D					
1. Emissions from biomass burning	T1	D	T1	D	T1	D					
2. Liming	NO	NO									
3. Urea Application	T1	D									
4. Direct N_2O Emissions from managed soils	NA	NA	NA	NA	T1	D					
5. Indirect N_2O emissions from managed soils	NA	NA	NA	NA	T1	D					
6. Indirect N_2O Emissions from manure management	NA	NA	NA	NA	T1	D					
7. Rice cultivations	NO	NO	NO	NO	NO	NO					
8. Other	NO	NO	NO	NO	NO	NO					
D. Other	NE/NO	NE/NO									
1. Harvested Wood Products	NE	NE									
2. Other	NO	NO									
4. Waste	**T2**	**D**	**T1**	**D**	**T1**	**D**					

Categories by sources and sinks	CO_2		CH_4		N_2O		HFCs		PFCs		SF_6		NF_3	
	Method	EF	Method	EF	Method	EF	Method	EF						
A. Solid Waste Disposal			T2/T1	CS/D	T2/T1	CS/D								
1. Managed Waste Disposal Sites	NA	NA	T2	CS	NA	NA								
2. Unmanaged Waste Disposal Sites	NA	NA	T1	D	NA	NA								
3. Uncategorized Waste Disposal Sites	NA	NA	T1	D	NA	NA								
B. Biological Treatment of Solid Waste	NA	NA	T1	D	T1	D								
C. Incineration and Open Burning of Waste	T1	D	T1	D	T1	D								
1. Waste Incineration	T1	D	T1	D	T1	D								
2. Open Burning of Waste	T1	D	T1	D	T1	D								
D. Wastewater Treatment and Discharge	T2/T1	CS/D	T2	CS	T2	CS								
1. Domestic Wastewater Treatment and Discharge	T2	CS	T2	CS	T2	CS								
2. Industrial Wastewater Treatment and Discharge	T1	D	T1	D	T1	D								
E. Other	NO	NO	NO	NO	NO	NO								
Memo items: (1)	**T1/ NO**	**D/ NO**	**T1/ NO**	**D/ NO**	**T1/ NO**	**D/ NO**								
International bunkers	T1	D	T1	D	T1	D								
Aviation	T1	D	T1	D	T1	D								
Navigation	T1	D	T1	D	T1	D								
Multilateral operations	NO	NO	NO	NO	NO	NO								
CO_2 emissions from biomass	T1	D	NA	NA	NA	NA								
CO_2 captured	NO	NO	NO	NO	NO	NO								
For domestic storage	NO	NO	NO	NO	NO	NO								
For storage in other countries	NO	NO	NO	NO	NO	NO								

Abbreviations: T1 - Tier 1 method; T2 - Tier 2 method; T3 – Tier 3 method; D - Default; CS – Country Specific; IE - Included Elsewhere; NA - Not Applicable; NE - Not Estimates; NO - Not Occurring

Explanation for the use of Notation Key NE: CO_2, CH_4, and N_2O Emissions from Category 1A3aii – domestic aviation was not estimated since emissions are negligible, and data is not readily availableCO_2, CH_4, and N_2O Emissions from Category 1A2a to 1A2l are not reported in an disaggregated way- related emissions are all reported under 1A2m-specified industry

CO_2 Emissions from Category 2D – Non-Energy Products from Fuels and Solvent Use were not estimated due to a lack of data for this category.

PFC Emissions from Category 2F – Product Uses as Substitutes for Ozone Depleting Substances were not estimated due to a lack of data for this category.

PFC and SF_6 and NF_3 Emissions from Category 2G – Other Product Manufacture and Use were not estimated due to a lack of data for this category.

CO_2 Emissions from Category 3B4 – Wetland were not estimated due to a lack of data for this category.

CO_2 Emissions from Category 3B6 – Other Land were not estimated due to a lack of data for this category.

CO_2 Emissions from Category 3D1 – Harvested Wood Products were not estimated due to a lack of data for this category.

Explanation for the use of Notation Key IE: CO_2, CH_4, and N_2O Emissions from Category 1A3dii Domestic Navigation are reported under A4ciii Fishing (mobile combustion)

CO_2 Emissions from Category 2A3 Glass production are reported under 2A4b (other uses of soda ash)

CO_2, CH_4, and N_2O Emissions from lubricants are reported under 1A1ai Electricity generation

1.8 Metrics

Emissions of Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and F-gases (HFC) were estimated and reported in Gg CO_2eq. (1,000 tonnes) using the 100-year time-horizon global warming potential values of the IPCC Fifth Assessment Report, as referred to in decision 18/CMA.1.

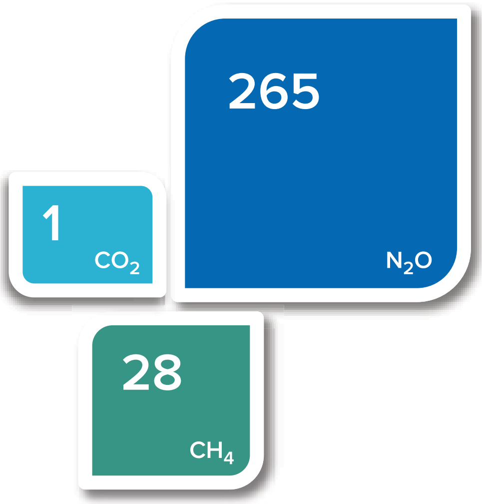


Figure 1: Global Warming Potential (IPCC, 2014)

1.9 Summary of any flexibility applies

Lebanon has used flexibility provision in several areas of the GHG emission inventory, as presented in the below table and in the CRTs, in line with Decision 5/CMA.3.

Table 6 - Lebanon's use of flexibility provisions in BTR1

Area of flexibility	Flexibility provisions	Party decision to apply flexibility
Key category analysis: Option to identify fewer key categories; less complex methodologies can be used to estimate GHG emissions/ removals for categories that are not key	Flexibility to identify key categories using a threshold no lower than 85% in place of the 95% threshold defined in the IPCC guidelines.	Not Applied
Uncertainty assessment: Option to report only qualitative uncertainty information if quantitative input data are not available	Flexibility to provide, at a minimum, a qualitative discussion of uncertainty for key categories, using the IPCC guidelines, both for the latest inventory year and the trend, instead of quantitatively estimating and qualitatively discussing the uncertainty of the emissions and removal estimates for all categories, including inventory totals, for at least the starting year and the latest reporting year of the inventory time series and also estimating the trend uncertainty for these same categories/inventory totals for the entire time series.	Not Applied

Area of flexibility	Flexibility provisions	Party decision to apply flexibility
Completeness: Option to use a higher threshold for insignificant categories	Flexibility to consider emissions insignificant if the likely level of emissions is below 0.1% of the national total GHG emissions, excluding LULUCF, or 1,000 kt CO_2eq. instead of 0.05% of the national total GHG emissions, excluding LULUCF, or 500 kt CO_2eq., whichever is lower. If flexibility is chosen, the total national aggregate of estimated emissions for all gases from categories considered insignificant shall remain below 0.2%of the national total GHG emissions, excluding LULUCF, as opposed to 0.1 per cent.	Not Applied: The likely level of emissions is 20.56 Gg CO_2eq. for 2022. The list of categories for which the estimates have not been completed is reported in Table 6.
QA/QC: Encouragement to develop a QA/QC plan and provide information on general QC procedures implemented	In place of the mandatory requirement to elaborate a QA/QC plan, developing country Parties that need flexibility in the light of their capacities are encouraged to elaborate an inventory QA/QC plan in accordance with the IPCC guidelines, including information on the inventory agency responsible for implementing QA/QC.	Not Applied
Gases: Option to report fewer GHGs	In place of the mandatory requirement to report on seven gases, flexibility to report at least three gases (CO_2, CH_4 and N_2O) as well as on any of the additional four gases (HFCs, PFCs, SF_6 and NF_3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Paris Agreement, or have been previously reported.	Applied: The estimates have not been completed for PFCs, SF_6 and NF_3.
Time series: Option to report a shorter time series and an earlier "latest reporting year"	In place of the mandatory requirement to report a consistent annual time series starting in 1990, flexibility to report data covering, at a minimum, the reference year/period for a Party's NDC and, in addition, a consistent annual time series from at least 2020 onward. The latest reporting year for those Parties that choose to apply this flexibility shall be no more than three years prior to the submission of the national inventory report, compared with no more than two years for all other Parties.	Applied: Lebanon reported the emissions and removals for 2011 (the reference year of the NDC), and for the period 2020-2022. However, it should be noted that although historical data is available since 1994, time and technical constraints did not allow the migration of the whole time-series between the 2 versions of the IPCC software.

2. General emission and removal trends for aggregated GHG emissions and removals

In 2022, Lebanon emitted 20,519 Gg CO_2eq. (as total emissions), which is a 32% decrease from 2019 (calculated as 30,189 Gg CO_2eq.), mainly due to a significant decrease in energy-related emissions. The economic crisis that started in 2019 exacerbated the problems of electricity supply, with extended power cuts due to the government's inability to secure fuel for power plants and ensure proper maintenance and upgrades of the already fragile infrastructure. An 85% decline in electricity production was observed between 2019 and 2022 with EDL electricity generation plummeting to 2,138 GWh in 2022 (EDL, 2023). This was mainly due to the halt of some power plants (i.e. Jieh and Zouk thermal power plants, Hrayche power plant), and gradual reduction in the reliance on power rental barges until complete halt in 2022.

Still, the main contributor to greenhouse gas emissions in Lebanon remains the energy sector (including transport) with 77% of GHG emissions, followed by industrial processes (12.6%) (Figure 2). Transport emissions constitute around 32.5% of total emissions, remaining an important contributor to emissions with 6,662 Gg CO_2eq. in 2022, mainly due to the consumption of gasoline in passenger cars.

The industrial processes sector accounts for approximately 12.6% of total emissions with 2,584 Gg CO_2eq. in 2022. These emissions have seen fluctuations due to varying levels of industrial activity and changes in production processes. Key contributors include cement production and emissions from F-gases from refrigeration and air conditioning.

The AFOLU sector contributes with 3.8% of GHG emissions, with 777.94 Gg CO_2eq. in 2022. These emissions arise from activities such as enteric fermentation in livestock, agricultural soil management, and deforestation. CO_2 removals from forestry and land use change amounted to – 3,243 Gg CO_2, bringing Lebanon's NET emissions to 17,275 Gg CO_2eq. Emissions from this sector are influenced by agricultural practices, land-use changes, and forest management policies.

The waste sector contributes 6.6% of Lebanon's total GHG emissions, with emissions estimated at 1,347 Gg CO_2eq. in 2022. Emissions primarily result from solid waste disposal on land and wastewater treatment, due to the anaerobic decomposition of organic waste in landfills and the treatment of municipal and industrial wastewater. Efforts to improve waste management practices and increase recycling rates are essential for reducing emissions from this sector.

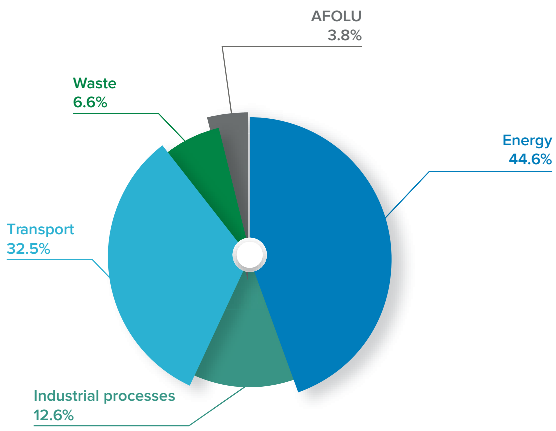


Figure 2: Lebanon's national greenhouse gas inventory by category in 2022

Table 7 - Lebanon's GHG emissions and removals for 2022 per gas and category

Greenhouse gas source and sink categories	CO_2 emissions/ removals	CH_4	N_2O	CH_4	N_2O	F-gases	Total emissions	Net emissions
(IPCC code)	Gg	Gg	Gg	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
Total National Emissions and Removals	13,283.3	63.96	2.06	1,789	544.77	1,656.51	20,519.04	17,275.58
1 - Energy	**15,613.08**	**2.39**	**0.49**	**66.99**	**129.95**		**15,810.02**	
1.A - Fuel Combustion Activities	15,613.08	2.39	0.49	66.99	129.95		15,810.02	
1.A.1 - Energy Industries	1,444.16	0.06	0.01	1.64	3.10		1,448.90	
1.A.2 - Manufacturing Industries and Construction	2,115.16	0.08	0.02	2.21	4.16		2,121.53	
1.A.3 - Transport	6,509.72	1.47	0.42	41.24	111.46		6,662.43	
1.A.4 - Other Sectors	5,544.04	0.78	0.04	21.90	11.23		5,577.17	
2 - Industrial Processes and Product Use	**900.61**		**0.10**	-	**27.16**	**1,656.51**	**2,584.28**	
2.A - Mineral Industry	900.29	NA	NA	NA	NA	NA	900.29	
2.A.1 - Cement production	898.88	NA	NA	NA	NA	NA	898.88	
2.A.2 - Lime production	0.75	NA	NA	NA	NA	NA	0.75	
2.A.3 - Glass Production	IE	IE	IE	NO	NO	NA		
2.A.4 - Other Process Uses of Carbonates	0.66	NA	NA	NA	NA		0.66	
2.B- Chemical Industry	NO	NO	NO	NO	NO	NA		
2.C - Metal Industry	NO	NO	NO	NO	NO	NA		
2.D - Non-Energy Products from Fuels and Solvent Use	0.32	NA	NA	NA	NA		0.32	
2.D.1 - Lubricant Use	IE	NA	NA	NA	NA			
2.D.2 - Paraffin Wax Use	0.32	NA	NA	NA	NA		0.32	
2.D.3 - Solvent Use	NE	NA	NA	NA	NA			
2.E- Electronics Industry	NO	NO	NO	NO	NO	NA		
2.F - Product Uses as Substitutes for ODS						1,656.51	1,656.51	
2.F.1 – Refrigeration/ Air Conditioning	NA	NA	NA	NA	NA	1,656.51	1,656.51	
2.F.2 - Foam Blowing	NO	NO	NO	NO	NO	NO		
2.F.3 - Fire Protection	NE	NE	NE	NE	NE	NE		
2.F.4 - Aerosols	NO	NO	NO	NO	NO	NO		
2.F.5 - Solvents	NO	NO	NO	NO	NO	NO		
2.G - Other Product Manufacture and Use			0.10		27.16		27.16	
2.G.1 - Electrical Equipment	NE	NE	NE	NE	NE	NE		
2.G.2 - SF_6 and PFCs from Other Product Uses	NE	NE	NE	NO	NO	NO		
2.G.3 - N_2O from Product Uses	NA	NA	0.10	NA		NA	27.16	
2.G.4 - Other	NE	NE	NE	NE	NE	NE		

Greenhouse gas source and sink categories (IPCC code)	CO_2 emissions/ removals	CH_4	N_2O	CH_4	N_2O	F-gases	Total emissions	Net emissions
	Gg	Gg	Gg	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
3 - Agriculture, Forestry, and Other Land Use	**(3,243.27)**	**17.07**	**1.12**	**478.03**	**297.62**		**777.94**	
3.A - Livestock	-	17.06	0.38	477.68	100.97	-	578.65	
3.A.1 - Enteric Fermentation	NA	13.83	NA	387.21	NA		387.21	
3.A.2 - Manure Management	NA	3.23	0.38	90.47	100.97		191.43	
3.B - Land	(3,245.55)	NA	NA	NA	NA		(3,245.55)	
3.B.1 - Forest land	(2,046.11)	NA	NA	NA	NA		(2,046.11)	
3.B.2 - Cropland	(1,218.69)	NA	NA	NA	NA		(1,218.69)	
3.B.3 - Grassland	NE	NE	NE	NE	NE			
3.B.4 - Wetlands	NE	NE	NE	NE	NE			
3.B.5 - Settlements	19.24	NA	NA	NA	NA		19.24	
3.B.6 - Other Land	NO	NO	NO	NO	NO		NO	
3.C - Aggregate sources and non-CO_2 emissions sources on land	2.29	0.01	0.74	0.35	196.66		199.30	
3.C.1 - Emissions from biomass burning		0.01	0.00	0.35	0.10		0.45	
3.C.2 - Liming	NO	NA	NA	NA	NA			
3.C.3 - Urea application	2.29	NA	NA	NA	NA		2.29	
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	0.57	NA	150.71		150.71	
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	0.08	NA	21.02		21.02	
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	0.09	NA	24.83		24.83	
3.D Other								
3.D.1 - Harvested Wood Products	NE	NA	NA	NA	NA		NE	
4 - Waste	**12.87**	**44.45**	**0.34**	**1,244.62**	**90.03**		**1,347.54**	
4.A - Solid Waste Disposal	-	23.57	-	660.10	-		660.10	
4.B - Biological Treatment of Solid Waste	-	0.26	0.02	7.37	4.07		11.45	
4.C - Incineration and Open Burning of Waste	12.87	1.86	0.03	51.95	8.85		73.67	
4.D - Wastewater Treatment and Discharge	-	18.76	0.29	525.20	77.12		602.31	
Memo Items								
International Bunkers	**815.42**	**0.02**	**0.02**	**0.45**	**5.83**		**821.70**	
1.A.3.a.i - International Aviation	694.54	0.01	0.02	0.14	5.04		699.72	
1.A.3.d.i - International water-borne navigation	120.88	0.01	0.00	0.31	0.80		121.98	
Information Items								
CO_2 from Biomass Combustion for Energy Production	34.79							

Historically, Lebanon's GHG emissions steadily increased, nearly tripling since 1994, with an average annual growth of 6%. However, this trend shifted significantly following the events of 2019 and the subsequent financial economic crisis. By 2022, total GHG emissions had decreased by 32% compared to 2019, largely due to the COVID-19 pandemic and decrease in economic activity post -2019. These factors significantly reduced energy-related emissions, which had long been the dominant contributor to Lebanon's total GHG output.

The time series of emissions in Figure 3 shows, since approximately 2008, a considerable growth in the CO_2eq. total emissions, which are dominated by an increase in energy sector emissions. Between 1994 and 2022, the energy sector, including transport, remained the largest source of GHG emissions, contributing between 66% and 77% of the total.

Over time, emissions experienced periodic declines, notably in 2007, 2010, and after 2019. The 2007 drop was attributed to damage from the July 2006 war, which impaired the electricity distribution network and caused power plants to operate below capacity. In 2010, a shift to natural gas at the Deir Amar plant, along with increased hydropower production, further reduced emissions. However, the most significant decrease occurred after 2019 due to civil unrest and economic collapse that the country has been witnessing since.

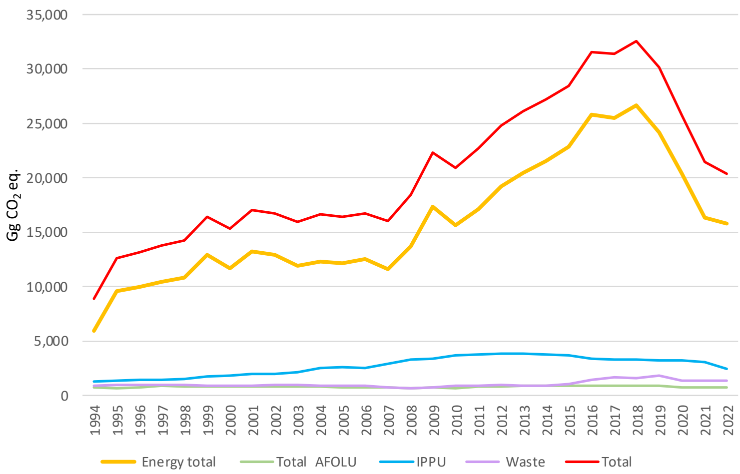


Figure 3: Trend in total and sectoral GHG emissions 1994-2022

Table 8 - Trend of emissions during the period 1994-2022 (in Gg)

	Total GHG emissions	Energy	Industry	AFOLU (without LULUCF)	AFOLU (wit LULUCF)	Waste
1994	8,882	5,919	1,275	747	-2,290	940
2022	20,519	15,810	2,584	778	(2,465)	1,347
% change 1994-2022	131%	167%	103%	4%	8%	43%

In terms of sectoral changes, emissions from the energy sector, including transport, are estimated at 15,810 Gg CO_2eq. in 2022, which is a decrease of 35% in 2019. The decrease is mainly due to the reduction in import and consumption of fuel amidst the crisis and the increase in renewable energy generation. The category Energy Industries, which reflects operation of EDL power plants, witnessed the sharpest decrease of 85% in emissions due to the closure of 3 main power plants operating on fuel oil (Zouk, Jieh, Hryache) and the decrease of operation of diesel-fueled power plants. Manufacturing industries and construction represent 13.6% of energy emissions, while the commercial and residential sectors account for 29.9% and 4.27% respectively, with emissions generated from the consumption of diesel oil for private generation and heating, as well as Liquified Petroleum Gas (LPG) for cooking.

Emissions from the transport sector conserved a steady increase concurrent with the increase in the vehicle fleet and demand for gasoline until 2019, then witnessed a sharp decrease of 35% in emissions during the years 2020 and 2022 from the COVID-19. In 2022, studies showed that transport patterns went back to the pre-covid period for passenger cars only, while detecting a significant decrease in kms driven for LDVs and HDVs, reflecting overall in a decrease of 13% in emissions between 2019 and 2022.

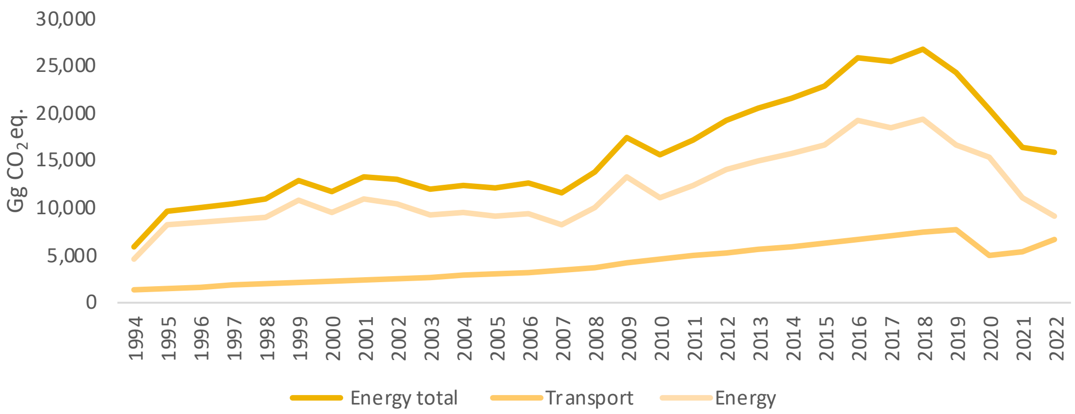


Figure 4: GHG emissions from 1.A Energy for the time series 1994-2022

The Industrial Processes and Product Use (IPPU) GHG emissions have decreased by 20.49% from 2019, mainly due to decrease in production of cement during the 2020-2022 period amidst the crisis.

Total GHG emissions from the AFOLU category decreased from 2019 (15%) (Figure 3) primarily due to the decrease in the use of fertilizers causing significant increases in CH_4 and N_2O emissions (Table 8). Despite this increase, the share of emissions of the AFOLU category is still insignificant relatively to Lebanon's total GHG emissions, maintaining a share of around 3% during the last decade.

3. Energy (CRT 1.A)

3.1 Overview of the sector

The Lebanese power sector has been struggling for years to ensure consistent electricity supply and quality of service while ensuring a balance in the sector's fiscal budget and the reduction of its deficit. Numerous hurdles confront the power sector, including the financial crisis, fixed tariff structure below the average production cost, aged power plants with high operational costs and low efficiencies, substantial technical losses in distribution and transmission networks, non-technical losses from illegal connections, heightened demand due to an influx of displaced Syrians, and other factors.

Under the Administrative Tutelage of the MoEW, the Lebanese power sector is operated by the Electricité du Liban (EDL), an independent state-owned utility that generates, transmits, and distributes electricity to all Lebanese districts. Lebanon primarily relies on fossil fuel combustion for energy, with most of the electricity generated by power plants. Lebanon heavily depends on imported primary energy requirements, except for hydropower.

Despite having multiple power plants, the country faces a substantial electricity deficit, compelling the Lebanese population to resort to private neighborhood generators that supply electricity to residential, commercial and some industrial areas during power cuts.

However, the economic crisis that started in 2019 exacerbated the problems of electricity supply, with extended power cuts due to the government's inability to secure fuel for power plants and ensure proper maintenance and upgrades of the already fragile infrastructure. An 85% decline in electricity production was observed between 2019 and 2022 with EDL electricity generation plummeting to 2,138 GWh in 2022 (EDL, 2023) (Figure 5) This was mainly due to the halt of some power plants (i.e. Jieh and Zouk thermal power plants, Hrayche power plant), and gradual reduction in the reliance on power rental barges until complete halt in 2022. This has culminated in prolonged daily blackouts nationwide reaching 23 hours a day, which was partially met by costly highly polluting diesel-operated generators operating outside the legal framework (Saghir et.al., 2022).

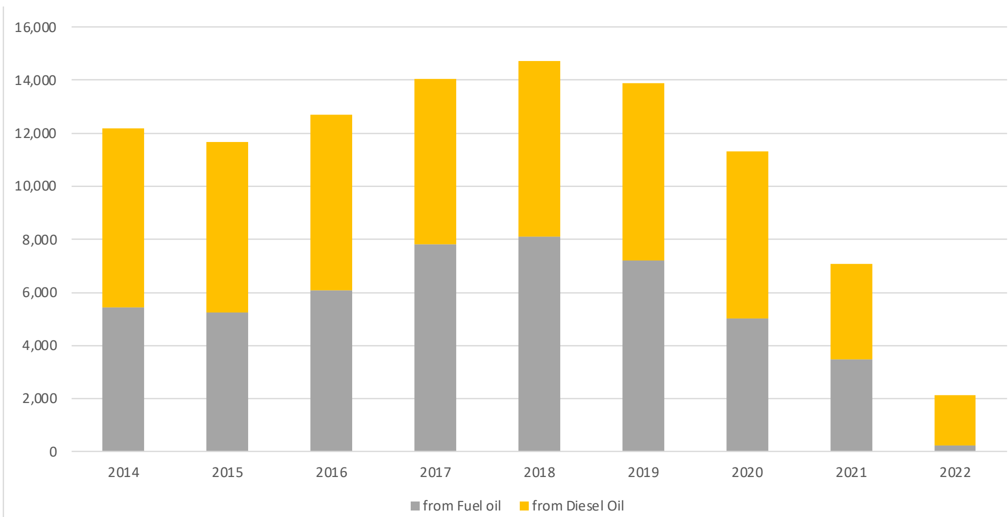


Figure 5: Annual Net Energy Production of Power Plants and Barges in Lebanon between 2014 to 2022 (EDL, 2023)

The unmet electricity demand by EDL had risen from 22% in 2008 to 37% in 2018 (Ahmad, 2023) and to 76% in 2022 (considering a total supply of 3,648 GWh and a demand of 15,117 GWh). In addition, the increase in fuel cost and consequent increase in "subscription" fees for neighbourhood generators has forced citizens to either invest in decentralized solar solutions, or simply accept living without electricity. In fact, studies estimate that after the crisis, only 50-60% of Lebanese population fully met their electricity demand through reliance on private generators. Although the percent has increased to 70% in 2022 due to the adjustments of the currency and salaries, it is still below the 80% that was estimated before 2019.

Table 9 - Main data on electricity production, supply and demand for the year 2019- 2022

Electricity production, supply and demand	2020	2021	2022
	Energy (GWh)		
Total production by EDL thermal power plants	11,324	7,079	2,138
Technical losses	18%	18%	18.9%
Total thermal supply after losses	9,286	5,804	1,734
Hydro	1,007	575	633
RE PV	132	309	1,262
Naameh LFG	23	18	18
Total RE	1,163	902	1,914
Total supply	10,450	6,707	3,648
Demand	24,273	21,846	16,380
Energy Not Supplied (ENS)	13,823	15,139	12,732
Private Generation (PG)*	6,912	7,569	8,913
*Calculated as 50% of ENS in 2020 and 2021 and 70% of ENS in 2022			

The shortage of public electricity supply, the increase in EDL tariff and the decreased reliance on private generators has widened the market of renewable energy, specifically decentralized PVs, which increased from 112 GWh in 2019 to 1,263 GWh in 2022. Consequently, residents, industrialists corporate and healthcare providers started to reduce their consumption from conventional power sources and invest in off-grid and hybrid solar PV systems. It is estimated that most of the systems were installed in the industrial and commercial sectors, and in mount Lebanon and the Beqaa (LCEC, 2023).

Figure 6: Solar PV capacity and generation in 2022 (LCEC, 2023)

The decrease in electricity production by EDL was due to a reduced import and consumption of fossil fuel consumption. Notably, in 2022 after the COVID-19 pandemic hit and the economic crisis, there was a sharp decrease in fuel oil and diesel imports by 95% and 23%, respectively, resulting in the sharp decline in energy production and emissions.

Diesel oil consumption declined at a slower pace compared to fuel oil, the latter phasing out (Figure 7) due to the halt of fuel oil power plants, specifically Zouk Thermal, Jieh Thermal, and Hrayche power plants. Today, Deir Ammar and Zahrani power plants collectively generate almost 90% of Lebanon's supply. As such, their switch from diesel fuel to natural gas is expected to significantly reduce their emissions.

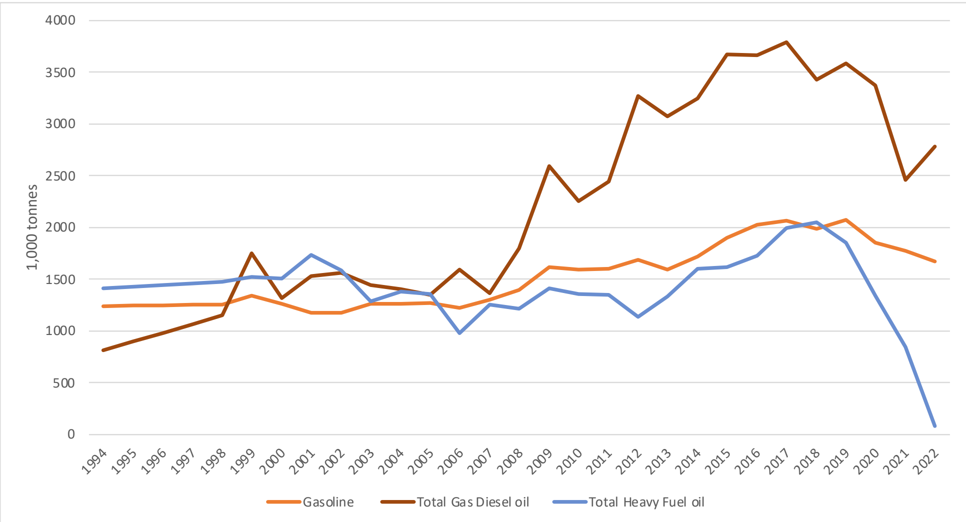


Figure 7: Fuel imported to Lebanon during the period 2019-2022

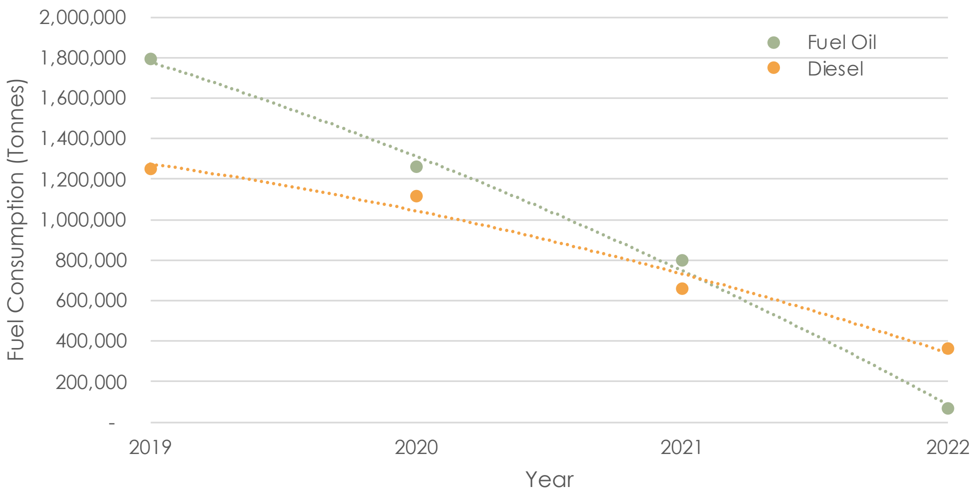


Figure 8: Trends in Annual Diesel Oil and Fuel Oil Consumption of Power Plants and Barges in Lebanon between 2019 to 2022

Regarding other stationary combustion sources, specifically manufacturing industries and construction, which involve the use of petroleum coke, heavy fuel oil, and diesel oil, also declined during the last period due to reduced industrial activities. In comparison, the residential and commercial sector's consumption of diesel oil for electricity and heating and LPG for cooking maintained a stable trend.

As for road transport, Lebanon's transport fleet mainly consists of passenger cars due to the absence of a developed public transportation sector and infrastructure for railway or other urban or national public networks (only a few bus lines currently exist; they are managed by the private sector). Based on data from the Ministry of Interior and Municipalities – Traffic, Truck and Vehicle Management Authority, the operational fleet distribution at a national level for 2022 consisted of 2,428,888 vehicles with 80% of them being Passenger Cars (PC) and the majority of these cars fall within the age range of 12 to 17 years old.

The main fuel type used in road transport in Lebanon is gasoline; only Heavy-Duty Vehicles (HDV), vehicles with more than 3.5 tonnes capacity, such as trucks and big buses, run on diesel. In 2002, Decree No. 7858/2002 banned the use of diesel fuel for light and medium-duty engines (Afif et al., 2008). The average transport fleet age is 20 years. With a high percentage of vehicles that are not equipped with catalysts (around 35%). In fact, catalysts are usually removed without being replaced as part of a common practice to avoid high maintenance costs in the absence of effective law enforcement banning such practices (Waked and Afif, 2012).

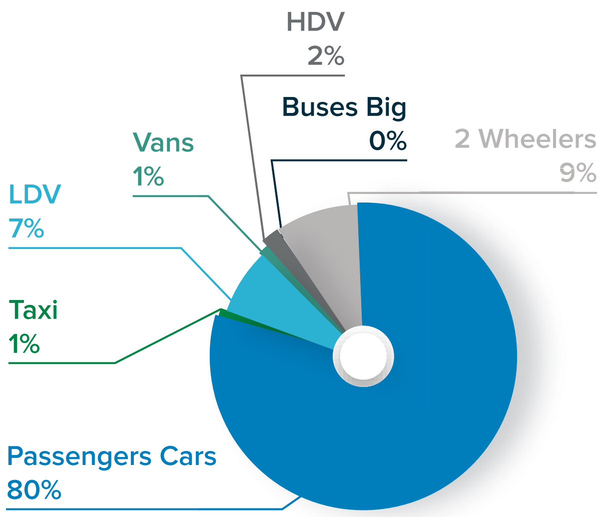


Figure 9: Distribution of Vehicle Fleet in 2022

GHG emissions in 2022

In 2022, emissions from the energy sector, including transport, are estimated at 15,810 Gg CO_2eq., which is a decrease of 35% in 2019. The decrease is mainly due to the reduction in import and consumption of fuel amidst the crisis and the increase in renewable energy generation. The category Energy Industries, which reflects operation of EDL power plants, witnessed the sharpest decrease of 85% in emissions due to the closure of 3 main power plants operating on fuel oil (Zouk, Jieh, Hryache) and the decrease of operation of diesel-fueled power plants. Manufacturing industries and construction represent 13.6% of energy emissions, while the commercial and residential sectors account for 29.9% and 4.27% respectively, with emissions generated from the consumption of diesel oil for private generation and heating, as well as LPG for cooking.

The decrease in emissions from 2019 to 2022 is reflected in the national grid emission factor, which is estimated at 0.613 tonnes CO_2 per MWh in 2022, compared to 0.663 tonnes CO_2 per MWh in 2019. This is mainly due to the decrease in fossil-based production and the significant increase in renewable energy in the mix.

Lebanon

Electircity Emission Fatcor

0.613

Tonnes CO_2eq./MWh

2022

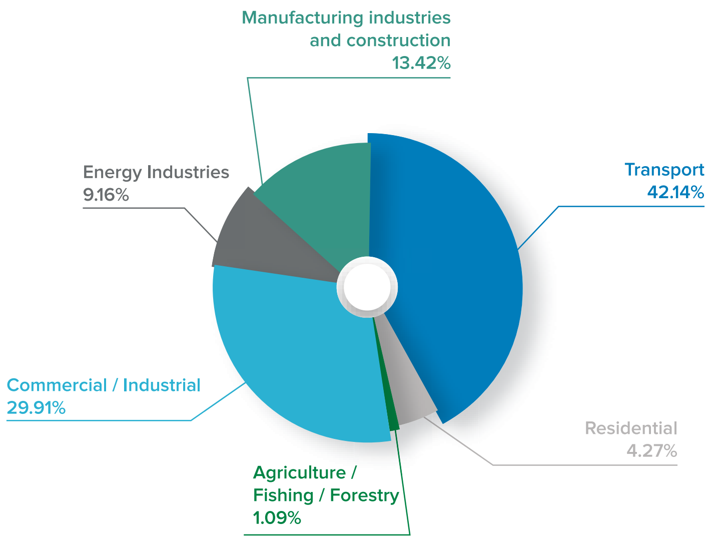


Figure 10: Emissions distribution per energy sub-category in 2022

Table 10 - GHG emissions from Energy sector in 2022

	CO_2	CH_4	N_2O	Total
	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
1 - Energy				
1.A - Fuel Combustion Activities	**15,613.08**	**66.991**	**129.95**	**15,810.023**
1.A.1 - Energy Industries	1,444.15	1.636	3.10	1,448.89
1.A.2 - Manufacturing Industries and Construction	2,115.15	2.21	4.16	2,121.52
1.A.3 - Transport	6,509.72	41.24	111.45	6,662.42
1.A.4 - Other Sectors - Commercial	4,701.39	17.66	10.07	4,729.13
1.A.4 - Other Sectors - Residential	671.19	3.58	0.79	675.57
1.A.4 - Other Sectors - Agriculture/ fishing/forestry	171.45	0.64	0.36	172.46

Due to the decrease in the emissions from electricity generation, road transport became the main source of GHG emissions in 2022 with 6,662 Gg CO_2eq. in 2022, making up 42% of total energy-related emissions and 32.5% of the total national emissions. This is considered as a decrease of -13% from 2019 (7,665 Gg CO_2eq.).

Despite the overall reduction in fleet emissions per kms—covering passenger cars, motorcycles, light-duty, and heavy-duty vehicles—from 258g CO_2eq./km in 2019 to 215g CO_2eq./km, the emission factor for passenger cars has remained steady at 194g CO_2eq./km. This indicates that changes in driving patterns have not impacted emissions from passenger cars.

Lebanon

Fleet Emission Fatcor

215

CO_2eq./Km driven

2022

Road Transportation is responsible for the prevailing part of the emissions in Transport category – contributing to more than 99.8% of total emissions in 2022. CO_2 is the main gas emitted with 98% contribution. As for the contribution of the different vehicle categories, passenger cars have the highest share of the 2022 emissions with 73% of the road transport GHG emissions (in CO_2eq.), while LDV/vans and HDV/buses, account for 13% and 10% respectively (Figure 11).

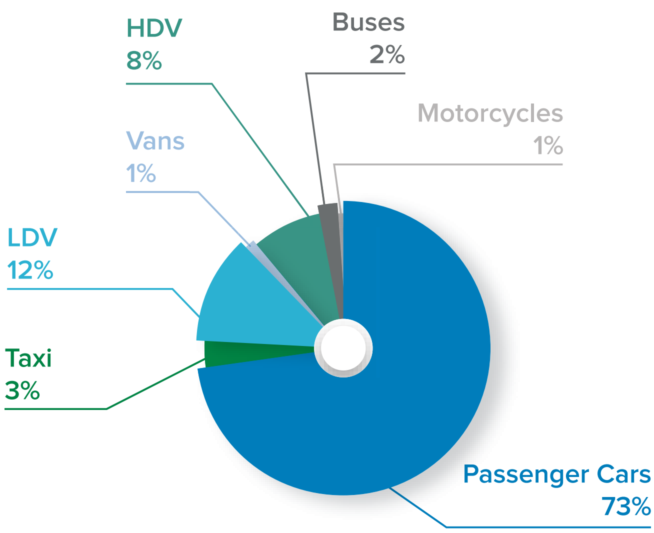


Figure 11: Emissions distribution per type of vehicle in 2022

Table 11 - GHG emissions from transport sector in 2022

	CO_2	CH_4	N_2O	Total
	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.	Gg CO_2eq.
1.A.3 - Transport	**6,509.72**	**41.24**	**111.46**	**6,662.43**
1. A.3.a - Civil Aviation	NE	NE	NE	NE
1.A.3.b - Road Transportation	6,509.72	41.24	111.46	6,662.43
1.A.3.b.i Passenger Cars	4,998.97	31.39	89.73	5,120.19
1.A.3.b.i.1 - Passenger cars with 3-way catalysts t	2,988.97	4.59	65.14	3,058.69
1.A.3.b.i.2 - Passenger cars without 3-way catalysts	2,010.00	26.80	24.59	2,061.39
1.A.3.b.ii Light-duty trucks	**825.07**	**8.10**	**12.27**	**845.44**
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	245.48	0.38	5.36	251.21
1.A.3.b.ii.2 - Light-duty trucks without 3-way catalysts	579.59	7.73	6.92	594.23
1.A.3.b.iii Heavy-duty trucks and buses	**623.44**	**0.92**	**8.70**	**633.06**
1.A.3.b.iv Motorcycles	**62.24**	**0.83**	**0.76**	**63.84**

The “Road Transportation” category is identified as a Key Category (CO_2 emissions) in terms of both level and trend assessment. GHG emissions from Road Transportation have grown continuously over the period of 1994-2018 at an average of 7%, concurrently with the increase in the number of registered vehicles in Lebanon during this period. However, transport’s emissions after 2019 were highly impacted by the socio-economic crisis and the removal of subsidies on gasoline, which were further exacerbated by the COVID-19 and the consequent lockdowns. The Vehicle Kilometres Travelled (VKT) data collected for this period show a decrease in kilometres travelled for taxis by up to 30%, while kilometres travelled by Vans, LCV, Trucks and Buses decreased by 30 to 50% compared to 2019 data. Yet, data on passenger cars shows only an interim decrease in kilometres driven in 2020 and 2021 (from 12,000 Kms in 2019 to a median of 9,000 km in 2020 and 9,400 km in 2021) followed by a back-to-normal situation in 2022, with an estimated 12, 894 km for 2022 (Figure 12).

The reduced travelled kilometres, leading to a reduced fuel consumption, had a significant impact on the emissions from road transport, with a decrease in 2022 of -12.7% from 2019 (7,635 Gg CO_2eq.).

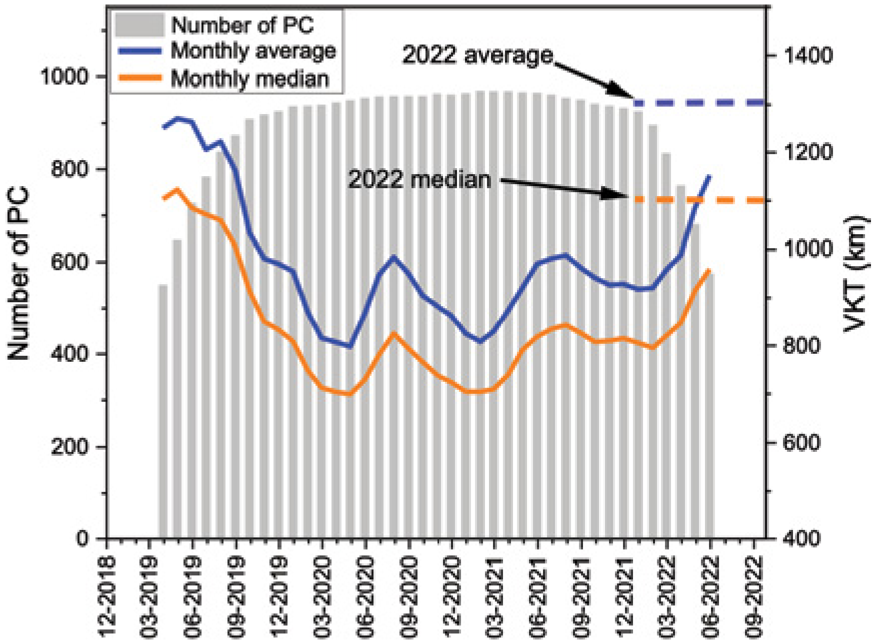


Figure 12: Number of Passenger Cars (PC) considered for the 2020-2021 period along their resulting VKT

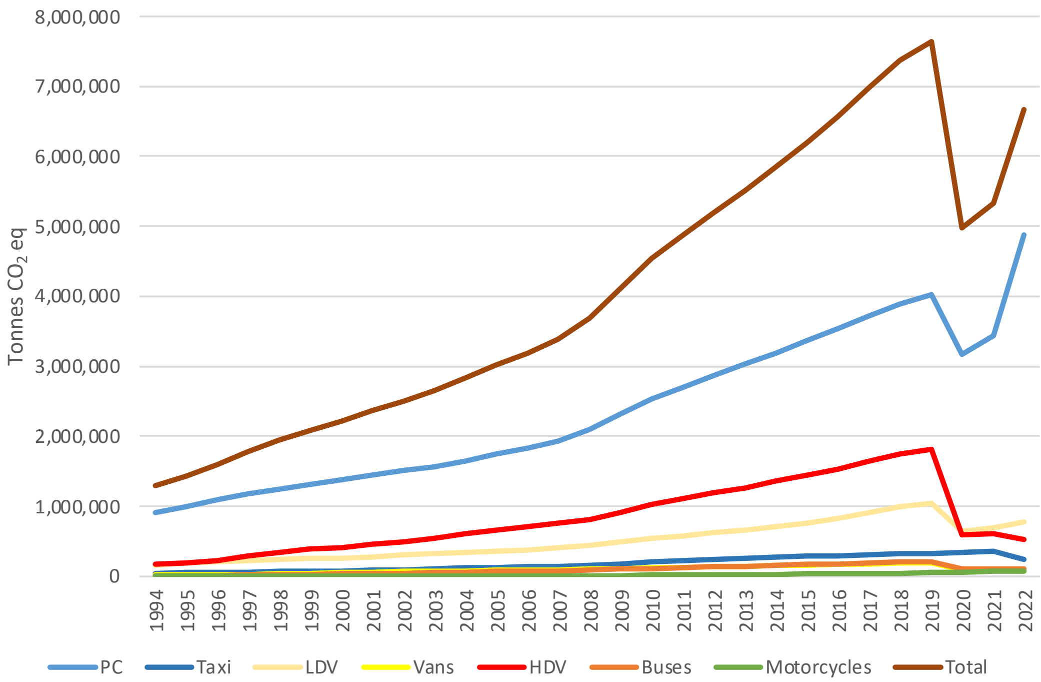


Figure 13: GHG emissions time series for the transport category (1994-2022)

Manufacturing industries and construction represent 24.6% of energy emissions, with the main sources of emissions in manufacturing industries are the consumption of Petcoke which has a high CO_2 emission factor and the consumption of diesel oil in privately owned or "neighborhood" generators which are used to replace the ever-increasing public electricity shortages.

As for the commercial and residential sectors, they account for 20.11% and 5.13% respectively, with emissions being mainly generated from the consumption of diesel oil for private generation in the commercial sector and heating LPG for cooking in residential sector.

3.2 Fuel combustion

According to the IPCC 2006 guidelines, the source category "Energy" covers all combustion sources of CO_2, CH_4 and N_2O emissions (1.A), fugitive emissions associated with the production, transport and distribution of fossil fuels (1.B) and Carbon Dioxide transport, injection and geological storage (1.C). Since no oil production activities, refineries or gas pipelines exist in the country, and Carbon Capture and Storage activities are not undertaken, emissions from (1.B) and (1.C) are reported as Not Occurring (NO) in the inventory reporting tables.

Fuel combustion activities (1.A) 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 (residential and commercial/institutional sectors and agriculture/forestry/fisheries).
- Transport, including domestic civil aviation, road transport, and domestic navigation.

Previous inventories reported in National Communications and BURs used the Tier 1 methodology due to the absence of an energy balance for Lebanon, and the absence of information on specific carbon content of the imported fuel. However, since all of the energy subcategories have been identified as key categories and as part of Lebanon's improvement plans, the carbon content of diesel oil used in 1.A.1 energy industries has been calculated for the first time in Lebanon. Hence, the Tier 2 methodology is adopted for the category 1.A.1. Details on the calculation of the fuel-specific Carbon emission factor is available in Annex IV.

In the transport sector, data was not made available for the calculation of the carbon content of gasoline and diesel oil used in vehicles, therefore, the Tier 1 methodology was adopted for CO_2 emission calculations. However, a Tier 2 methodology was adopted for the calculation of emissions of CH_4 and N_2O where respective emissions factors were available at a disaggregated level including vehicle technology, fuel and operating conditions.

Table 12 - Reporting categories under 1.A Energy

Reporting categories	Description	Remarks	Methodology
1.A.1 Energy industries	Emissions from combustion of gas/diesel oil, heavy fuel oil and lubricants for electricity generation from thermal power plants. Emissions from the use of landfill gas for energy production.	Since lubricants are mixed with another fuel for co-combustion in the engine, the emissions are all estimated and reported under Energy Industries	Emissions are calculated based on the Tier 1/Tier 2 methodology and disaggregated by power plant and fuel type.

Reporting categories	Description	Remarks	Methodology
1.A.2 Manufacturing industries and construction	Emissions from combustion of gas/diesel oil, heavy fuel oil, petroleum coke and Liquefied Petroleum Gas (LPG) for electricity or energy generation for own use in industries.	Gas/diesel oil is considered to be used mainly for electricity production within the industrial facilities generators and in residential neighborhoods. Petroleum coke is only used by cement industries.	Emissions are calculated based on the Tier 1 methodology.
1.A.3 Transport	Refer to Table 13		
1.A.4 Other sectors			
1.A.4.a. Commercial and institutional sector	Emissions from combustion of gas/diesel oil for electricity generation, 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. Part of the fuel consumed by neighborhood generators is considered under this category.	Emissions are calculated based on the Tier 1 methodology.
1.A.4.b. 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.
1.A.4.c. Agriculture, forestry and fisheries	Emissions from combustion of diesel oil for stationary and mobile activities related to agriculture, forestry and fishing.		Emissions are calculated based on the Tier 1 methodology.

Table 13 - Reporting categories under 1.A.3 transport

Reporting categories	Description	Remarks	Methodology
1.A.3.a Aviation			
1.A3.aii. International Aviation International bunkers	Flights that depart in one country and arrive in a different country.	Emissions are not included in national totals, as they are reported under international bunkers.	Emissions from international aviation are calculated based on the Tier 1 methodology.
1.A.3.aii. Aviation	Military helicopters; civil, commercial aircraft; and private jet- and propeller-type aircraft.	Emissions from military aircraft are not calculated due to the confidentiality of activity data for military cases.	This category has not been calculated in this inventory – so it is reported as NE.
1.A.3.b. Road transport	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.	Emissions are estimated using the Tier 1 methodology for CO_2 emissions and Tier 2 methodology for CH_4 and N_2O emissions
1.A.3.c. Railways	Activity not occurring in Lebanon		
1.A.3.d Waterborne Navigation			
1.A.3.d.i. International waterborne navigation International bunkers	Vessels of all flags that are engaged in international water-borne navigation	Emissions are not included in national totals, as they are reported under international bunkers.	Emissions from international navigation are calculated based on the Tier 1 methodology.

Reporting categories	Description	Remarks	Methodology
1.A.3.dii. Domestic waterborne navigation	Vessels that depart and arrive in the same country.	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 1A4ciii, agriculture/forestry /fisheries category of the energy sector.	Emissions from domestic navigation are calculated based on the Tier 1 methodology.

Most of the fuel used in Lebanon is imported every year to cater for the energy demand of the Lebanese population and economy. The period 2020-2022 witnessed major changes in fuel imports amid the economic crisis and the COVID-19 pandemic, as illustrated in Figure 14. Even with the situation being back to normal, fuel import have decreased by 23% for diesel oil and 95% heavy fuel oil compared to 2019 respectively (Table 14), giving space to the deployment of renewable energy. Indeed, with the removal of fuel subsidies and the increasing shortages of electricity supply, solar energy installations have skyrocketed in 2022, increasing the share of renewables in the energy mix.

Table 14 - Quantities of fuel imported for the period 2020-2022 and base year of 2011

1,000 Tonnes	2011	2020	2021	2022
Gasoline	1,598.42	1,855.75	1,771.75	1,673.63
Jet Kerosene	223.88	96.791	129.784	226.96
Gas Diesel oil	2,448.07	3,376.86	2,458.98	2,780.95
Heavy Fuel oil	1,347.37	1,339.38	845.89	83.56
LPG	196.67	238.21	228.46	242.17
Bitumen	59.19	17.711	18.59	20.82
Lubricants	35.24	30.15	40.08	35.78
Petroleum coke	335.60	75.16	44.93	128.96

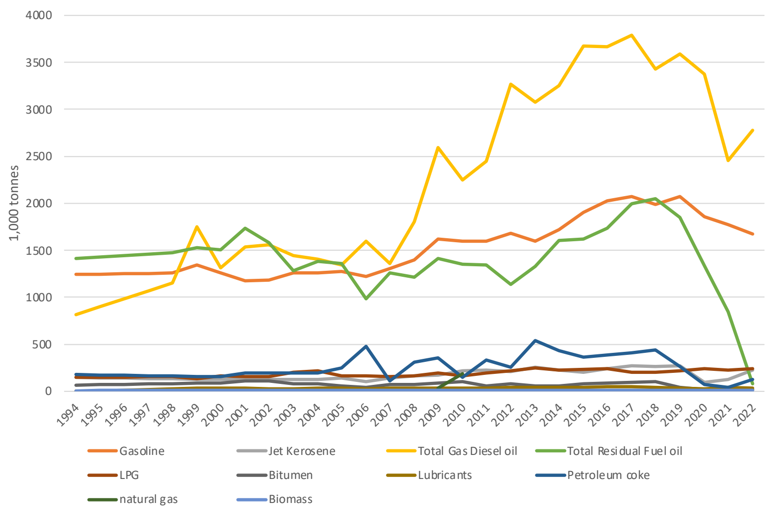


Figure 14: Fuel imports to Lebanon during 1994-2022

3.2.1 Comparison of the sectoral and reference approach

Per the IPCC 2006 guidelines, carbon dioxide emissions in the energy sector necessitate calculation via both the reference and sectoral approaches. The former relies on comprehensive primary energy consumption data to estimate fuel usage and subsequent emissions, while the latter dissects energy consumption across sectors and fuels for CO_2 calculation. Divergence between the 2 Approaches should remain minimal, around 5% or less, when compared to the total carbon flows involved.

In Lebanon, carbon dioxide emissions for the energy sector are calculated according to the two approaches. Stock change considerations in the reference approach apply solely to Energy Industries (fuel oil and gas/diesel oil) with available power plant stock data, while other fuel types lack stock change considerations due to data scarcity, assuming all imported fuels are consumed within the calendar year. However, during the 2020 and 2021 period, fuel smuggling activities were noted from Lebanon to Syria, impacting actual consumption in the Lebanese market. Although not officially estimated, an estimation was conducted to determine the smuggled amounts, which were accounted under “exports” in the reference approach (methodology adopted presented in Annex IV).

As shown in Table 15, the difference between the 2 approaches in 2022 is -2.21%. The difference is mainly due to the difference between the Net Calorific Values (NCVs) and emission factors whereby the reference approach uses default NCV and carbon content of fuel whereas the sectoral approach uses country and fuel specific NCV and CO_2 emission factor, with the most detectable difference in Residual Fuel oil.

Table 15 - Difference between reference and sectoral approach in 2022

	CO_2 emissions (Gg)	% difference
Reference approach	15,959	-2.21%
Sectoral approach	15,613	

3.2.2 International bunker fuels

International bunkers include international aviation and international 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 jet kerosene, as reported in the MoEW annual reports of imported fuel. Related GHG emissions from international aviation are estimated to 827.70 Gg CO_2eq. in 2022. Gasoline consumption of domestic civil aviation is reported as Not Estimated (NE) in 2022 since no data is available for use in this inventory.

Table 16 - GHG emissions from international bunkers for 2022

	Emissions (Gg CO_2eq)			
Categories	CO_2	CH_4	N_2O	Total CO_2eq
International Bunkers	815.420	0.45	5.83	821.70
1.A.3.a.i - International Aviation	694.54	0.14	5.04	699.72
1.A.3.d.i - International water-borne navigation	120.88	0.31	0.80	121.98
Information Items				
CO_2 from Biomass Combustion for Energy Production	34.78			

3.2.3 Feedstock and non-energy use of fuels

Some of the imported fuels are used as raw materials for the production of other products in industries, or for non-energy purposes such as bitumen and lubricants. 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.

3.2.4 Energy industries (CRT 1.A.1)

3.2.4.1 Category description

The category covered under 1.A.1 energy industries is limited to 1.A.1.a.i electricity generation (1.A.1) which includes all fuel used in the thermal power plants to generate electricity. The remaining categories such as 1.A.1.B petroleum refining and 1.A.1.c. manufacture of solid fuels are reported as not occurring.

In Lebanon, the category 1.A.1 Energy Industries Since this category is a key category under the level and trend assessments, Tier 1 and 2 methodologies have been used with annual fuel consumption per power plant as activity data, and fuel-specific NCV and emission factors.

3.2.4.2 Methodological issues

Emissions are calculated based on the Tier 1 methodology for heavy fuel oil and Tier 2 methodology for Diesel oil, with the development of country specific emission factors. Emissions from landfill gas has also been included using Tier 1 and default emission factors since the Naameh landfill generates electricity which is sold to an Electricite du Liban.

Activity data

The amounts of fuel consumed in power plants, and landfill gas as well as the annual stock has been provided by Electricité du Liban (EDL) for the years 2020-2022, disaggregated per power plant and per fuel type. Accordingly, Gas/Diesel oil consumption is estimated at 364,947 tonnes and Heavy Fuel oil at 68,320 tonnes in 2022, recording a drastic decrease of 71% and 96% respectively compared to 2019. This is a direct result of the economic crisis and financial constraints of the government to purchase fuel for the operation of the power plants. Consequently, the 2 main heavy-fuel oil-run plants were shut down and the remaining diesel-fueled plants operated at minimum load.

The amount of lubricants is provided by the Lebanese Customs database (HS Code 2170.19.90; by net weight of import). Since insignificant amounts of lubricants are used in industries and other facilities, it is assumed that all imported lubricants are consumed by EDL power plants in co-combustion processes.

Emission factors and other parameters

Lebanon initiated the calculation of a country-specific emission factor for energy industries for the first time under the GEF-funded CBIT project, to be used for the BTR1, as part of its improvement plan and in line with the IPCC guidelines. Calculating country-specific emission factors requires understanding the quality of different types of fuel, specifically the percent carbon content and the net calorific values. Initially, the calculation of country-specific emission factors for all types of fuel used in the energy sector was planned, including heavy fuel oil, diesel oil, and gasoline (95 and 98 octane). Despite several months of research and acquiring fuel test results from primary sources in Lebanon, only the emission factors for diesel oil used in energy industries were successfully calculated.

Through the review of fuel-specific laboratory reports and specification documents provided by EDL, the carbon content of diesel oil utilized in EDL power plants was calculated. Subsequently, the country specific Carbon Emission Factor was computed, yielding a value of 73,960 kg CO_2/TJ, closely approximating the IPCC's default emission factor of 74,100 kg CO_2/TJ. The country-specific emission factor was used to calculate emissions for the years 2020-2021 and 2022. Details of methodology and results are presented in annex V. The change of emission factor from default to country specific did not result in significant changes (-0.19%) in CO_2 emissions from 1.A.1 energy industries (difference of -0.19%).

Table 17 - CO_2, CH_4 and N_2O emission factors for 1.A.1 Energy industries

For all categories		Energy Industries	
Fuel type	CO_2 emission factor (kg/TJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)
Diesel oil	73,960*	3	0.6
Heavy fuel oil	77,400	3	0.6
Lubricants	73,300	3	0.6

*country-specific emission factor

Source I table 2.2 page 2.16 chapter 2 volume 2, IPCC 2006 guidelines

Table 18 - General parameters by fuel type

Fuel type	Net calorific value (TJ/ktonnes)	Description
Diesel oil	41.60	Specific NCV of diesel oil imported and consumed
Heavy fuel oil	40.83	Weighed average of specific NCV of heavy fuel oil grade A and Grade B consumed
Lubricants	40.19	Default
Landfill Gas	50.40	Default

3.2.4.3 Description of flexibility if applied

No flexibility provision was adopted.

3.2.4.4 Uncertainties and time series consistency

Uncertainty values used for the calculation of GHG emissions for Energy industries were adopted from the IPCC 2006 guidelines.

Uncertainties associated with EFs used to estimate CO_2 emissions were estimated at ±5%; while those pertaining to EFs used to estimate CH_4 and N_2O emissions reach up to ±30% and ±60% uncertainty respectively.

Uncertainties pertaining to AD regarding fuel consumption within Sector 1 'Energy' were estimated at ± 1%.

For the uncertainty analysis of the country specific emissions factor of diesel oil, the API Technical report 2572 (API, 2013), IPPC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPPC, 2000), API Addressing uncertainty in oil and gas industry greenhouse gas inventories (API, 2015) and ISO/IEC Guide 98-3 (GUM) (ISO/IEC, 2008) were used as guides. Accordingly, a value of +-5% was used for the CO_2 emission factor, which are in line with the IPCC default uncertainties.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

3.2.4.5 Category specific QA/QC

The calculation of emissions from electricity generation at power utilities in Lebanon relies on data provided by Electricité du Liban, the primary operator of power plants, ensuring that the data is sourced from official and authoritative channels and comparing it with various reference sources for fossil fuel consumption data. To enhance accuracy and minimize errors, the process incorporates several quality assurance and control (QA/QC) measures. These include automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies.

Other QA/QC procedures included involve updating and specifying Activity Data (AD) and Emission Factors (EFs) according to the 2006 IPCC Guidelines and integrating them into spreadsheets that align with the Common Reporting Tables. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

Energy-industries related fuel consumption was also compared to the total fuel imported into the country to align the reference and sectoral approaches.

The inventory process is continuously refined based on recommendations from international experts, addressing issues like data series restoration and the reallocation of fuel consumption categories. The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

3.2.4.6 Category-specific recalculations

Changes in emission factor of diesel oil from default to country specific is only used for the years of 2020-2022 as it reflects the quality of the fuel consumed during this period. The new emission factor has not been used for previous years; hence no recalculations were undertaken.

3.2.4.7 Category specific planned improvements

The main barriers and challenges to a consistent and reliable data collection and reporting for the energy sector in general are identified as follows:

- Information on fuel imported is available from the Directorate General of Petroleum, however fuel imported does not necessarily equal fuel consumed, because: 1) fuels can be stocked and combusted over subsequent years and 2) diesel can be smuggled to neighboring countries and not accounted for.
- Fuel received by powerplants are not necessarily consumed by the same powerplant. Zouk provides fuel for Hreishe, and Zahrani provides fuel for Sour and Baalbek (via trucks).
- Losses in the fuel storage systems are not considered. Jieh and Zouk fuel storage units are leaking.

By adopting country-specific emission factors for diesel oil in energy industries, Lebanon was able to adopt a Tier-2 approach for a key category, which is the main improvement to its reporting mechanism to the UNFCCC and in line with the Transparency, Accuracy, Consistency, Completeness, and Comparability (TACCC) approach of the reported information. However, more studies should be undertaken to complete the assessment and include other fuels such as Heavy fuel oil used in powerplants (although its use has been significantly decreasing).

In addition, through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the energy sector. The Energy task force, composed of the main stakeholders of the energy sector, will be responsible for the timely and reliable provision of information.

Table 19 - Implemented and planned improvements for Lebanon's GHG inventory for the energy sector – Energy industries

Planned improvement	Implemented	Short term	Long term
Obtain carbon content of diesel oil used in EDL power plants to use tier 2 methodologies	X		
Obtain carbon content of heavy fuel oil used in EDL power plants to use tier 2 methodologies		X	
Request from MoEW to include carbon content and NCV testing and reporting at the loading and discharge ports		X	
Request from LIBNOR to include carbon content and NCV the parameters of NCV and %C to be added to the fuel standards of Lebano.		X	
Derive more accurate oxidation factors			X
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X		

3.2.5 Manufacturing industries and construction (1.A.2 CRT 1.A.2)

3.2.5.1 Category description

This reporting category, which pertains to manufacturing industries and construction, covers emissions resulting from the combustion of various fuels, including gas/diesel oil, heavy fuel oil, petroleum coke, and Liquefied Petroleum Gas (LPG). Gas/diesel oil is considered to be used mainly for electricity production within the industrial facilities generators and in residential neighborhoods. Petroleum coke usage is confined to the cement industry. The emissions for this category are calculated using the tier 1 methodology, although this category has been identified as a key category (CO_2) in both level and trend assessments.

3.2.5.2 Methodological issues

Although this category is a key category under the level and trend assessments, a tier 1 methodology is used, and the emissions are reported under 1.A.2.m unspecified industries given the absence of disaggregated data per industry in Lebanon.

Activity data

With the absence of a national energy balance, assumptions have been made in order the estimate the quantities of diesel oil consumed at an industrial level and in neighborhood generators, as per the below:

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 recorded on these quantities.

2- Production of electricity by neighbourhood generators: due to the frequent power shortages, neighbourhood generators have flourished in Lebanon, supplying electricity to households during outages (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 with the main stakeholders (Ministry of Energy, Electricité du Liban, private distributers of fuel, and owners of generators) it was agreed to assume that 55% of the electricity demand is being met through private generators compared to 36% in 2019-2021 due to the significant shortage from public electricity supply.

The amounts of heavy fuel oil, and petroleum coke consumed by industries are provided by the Ministry of Energy and Water.

The amounts of LPG and gas/diesel oil consumed by Manufacturing Industries and Construction (MIC) are calculated based on the fuel imports database of the MoEW and the distribution of fuel per end use provided by IPT, one of the main fuel distributors in Lebanon.

Emission factors and other parameters

Country specific NCV have been used for Diesel oil and Heavy fuel oil, and default NCV for Petroleum coke, Bitumen and LPG, as presented in Table 19 Default emission factors from the 2006 IPCC guidelines are used for all fuels for all greenhouse gases.

Table 20 - Net Calorific Values by fuel type for MIC

Fuel type	Net calorific value (TJ/ktonnes)	Description
Diesel oil	41.6	Specific NCV of diesel oil imported and consumed
Heavy fuel oil	41.1	Specific NCV of diesel oil imported and consumed
LPG	47.3	Default
Bitumen	40.2	Default
Petroleum coke	35.3	Default

Table 21 - CO_2, CH_4 and N_2O emission factors for 1.A.2 Manufacturing industries and construction

For all categories		Manufacturing industries and construction	
Fuel type	CO_2 emission factor (kg/TJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)
Diesel oil	74,100	3	0.6
Heavy fuel oil	77,400	3	0.6
LPG	63,100	1	0.1
Bitumen	80,700	3	0.6
Petroleum coke	97,500	3	0.6

Source I table 2.3 page 2.18- 2.19 chapter 2 volume 2, IPCC 2006 guideline

3.2.5.3 Description of flexibility if applied

No flexibility provision was adopted.

3.2.5.4 Uncertainties and time series consistency

Uncertainty values used for the calculation of GHG emissions for 1.A.2 Manufacturing industries and construction were adopted from the IPCC 2006 guidelines default values for liquid fuels, with ±5% for activity data uncertainty and ±5 for CO_2 emission factor uncertainty, ±67.12% and ±288.79% for CH_4 and N_2O emission factor uncertainty.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

3.2.5.5 Category specific QA/QC

The same QA/QC measures implemented for all energy categories were also adopted for the manufacturing industries and construction category. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

MIC related fuel consumption was also compared to the total fuel imported into the country to align the reference and sectoral approaches.

For cement industries, activity data compiled from the files of the Ministry of Environment were shared with the 3 cement companies to complete missing month and validate petcoke consumption.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

3.2.5.6 Category-specific recalculations

No recalculations were made for this subcategory.

3.2.5.7 Category specific planned improvements

The main barriers and challenges to a consistent and reliable data collection and reporting for this category are identified as follows:

- There is no national energy balance in Lebanon to estimate energy consumption per sector (i.e., industrial, commercial, etc.)
- There is no data on the quantities and production capacity of private generators, as they operate illegally in the country.
- There is no clear methodology and unified number for estimating yearly demand of electricity. EDL takes spot measurements (not continuously recorded) on the transformers supplying electricity, which is assumed to be correlated to the demand. This approach of estimating electricity demand is inaccurate, since it cannot be assumed that the energy load is the same during the whole day and across the week.

- The estimation of the Energy Not Supplied (ENS) assumes that a specific percentage of ENS is provided by private electricity generators, which can be highly uncertain.
- Data on fuel consumption for electricity generation at an industrial level is not available.

Through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the energy sector. The Energy task force, composed of the main stakeholders of the energy sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

Table 22 - Short term and long term planned improvements for Lebanon's GHG inventory for 1.A.2 Manufacturing industries and construction

Planned improvement	Implemented	Short term	Long term
Update national industrial survey for the accurate identification of industries operating in Lebanon and estimate fuel consumption			X
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of fuel consumed at industrial and private generator levels		X	
Update the work to estimate the percentage of electricity generated by EDL and generated by industries for their own use. Include in this work an estimate of the fuel types used to generate the electricity			X
Conduct survey on fuel consumption for generators in main cities in Lebanon		X	
Improve accuracy in distribution of gas/diesel oil by end use category			X
Calculate country specific EFs for other fuels used in Lebanon		X	
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X		

3.2.6 Transport (1.A.3 CRT 1.A.3)

3.2.6.1 Category description

The categories included under the transport sector are 1.A.3.a civil aviation, 1.A.3.b road transport and 1.A.3.d navigation. The remaining categories such as 1.A.3.c railways and 1.A.3.e other transportation are reported as Not Occurring. Emissions related to military maritime transport were not considered due to the unavailability of the activity data.

Road transport (1.A.3.b) 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 Passenger Cars (PC), Light-Duty Vehicles (LDV), Heavy-Duty Vehicles (HDV) and motorcycles (Table 22). After the ban of the use of diesel for vehicles with gross weight lower than 3,500 kg in Law 341/2001 and Decree 341/2002, passenger cars, light-duty vehicles and motorcycles run only on gasoline, while heavy duty vehicles run on diesel.

Table 23 - Description of the vehicles categories used in the calculation of road transport emissions

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

3.2.6.2 Methodological issues

Methodology

For mobile combustion, CO_2 emissions from road transport, civil aviation and navigation are calculated using a Tier 1 methodology since no information on the specific carbon content of the fuel used in transportation is available. CO_2 emissions from gasoline and diesel fuel are calculated based on the quantities of fuel consumed per type of vehicle and by using default emission factors provided in 2006 IPCC Guidelines.

Tier 2 technology-specific emissions factors have been used for the calculation of CH_4 and N_2O emissions, which depend largely upon the combustion and emission control technology present in the vehicle.

Activity Data

The following activity data is considered:

- The number of registered vehicles in Lebanon for the year 2022 is estimated at 2,428,888 vehicles, of which 80% are passenger cars. The fleet characteristics are extrapolated from the 2019 fleet data since no data of 2022 has been made available from the Truck and Vehicle Management Authority. The 2019 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.
- The vehicle fleet is classified per vehicle type, category and European Union (EU) emission control technology taking 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 was obtained from a survey conducted in Lebanon in 2023 on a sample of 1,271 vehicle across 4 regions (MoE/UNDP/GEF, 2023). The precent of catalyst removed in presented in Table 24

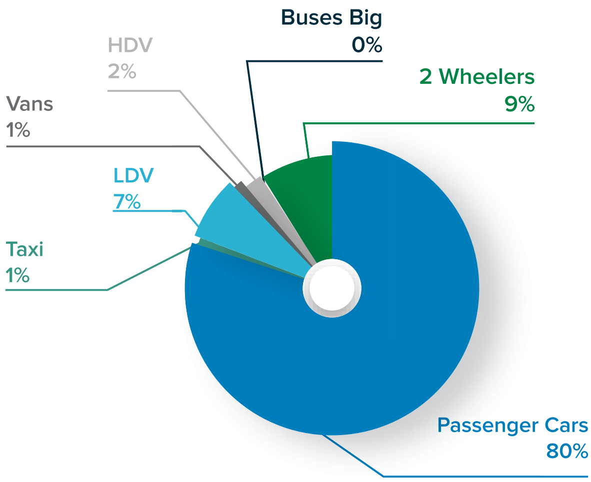


Figure 15: Vehicle Fleet Composition used for 2022 (based on 2019 data)

Table 24 - Catalyst available/installed in vehicles based on year of production

Vehicle type	Year of production	Number of vehicles with catalyst and percent
PC & Taxi	1988-1991	2 (7.40%)
	1992 - onwards	749 (78.10%)
LCV & Vans	1988-1991	4 (0.00%)
	1992 - onwards	24 (38.09%)
Trucks & Buses	1988-1991	0 (0.00%)
	1992 - onwards	14 (46.66%)
Motorcycles	1988-1991	1 (0.00%)
	1992 - onwards	43 (48.86%)

- In the 2006 IPCC guidelines, the tier 1 emission factors are shown as a function of kgemissions/ TJfuelused. Therefore, the required activity data is fuel consumption per vehicle type and technology (Table 25)

Table 25 - Activity data of fuel consumed per type of vehicle for 2022

Transport Sub-category	Fuel consumed in 2022 (Gg)
Passenger cars with 3-way catalysts	991.513
Passenger cars without 3-way catalysts	666.767
Light duty trucks with 3-way catalysts	81.432
Light duty trucks without 3-way catalysts	192.263
Heavy Duty vehicles (diesel)	202.249
Motorcycles	20.648

- Gasoline consumed by each type of car by type of fuel is estimated based on:
  - Number of gasoline vehicles (cars, light duty vehicles, motorcycles)
  - Number of diesel vehicles (assuming only heavy-duty vehicles)
  - Average travelled distance
  - Fuel economy
  - Fuel density
  - Net Calorific Value

- Gas/diesel oil is only used by heavy-duty vehicles. The amounts used per year are assumed based on average fuel economy (29.9 l/100km) and annual mileage (22,682 kms for buses and 12,372 for heavy trucks) based on the 2023 transport survey.
- HDV diesel consumption is assumed to be 29.9 litre of diesel/100km, based on the data collected in the field on their trucks fleet consumption, and double checked against the GREET Model default value (from Argonne National Laboratory) and 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.
- 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 (El-Hage, 2014). However, it is assumed that in 2022, this amount has been reduced to 1 ktonne due to increase in cost of the used fuel after the economic crisis.
- Activities related to domestic navigation are limited to fishing boats, which are reported under the category agriculture/forestry/fisheries (1.A.4.c.iii) and consequently, their emissions are not reported under transport.

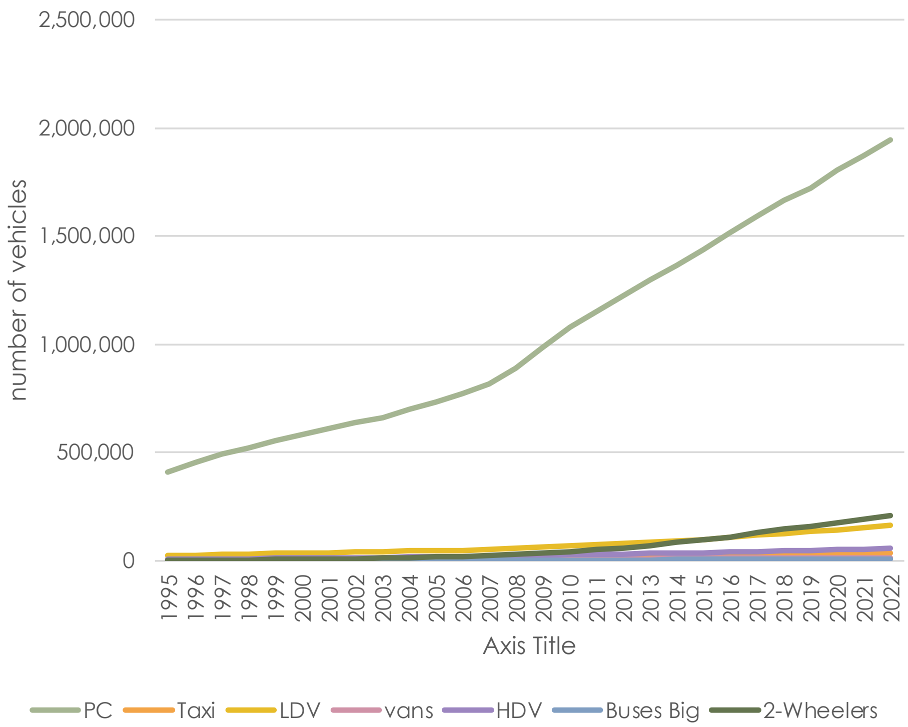


Figure 16: Classification of the Lebanese vehicle fleet per type

Emission factors and other parameters

- The annual travelled distance per vehicle category for the year 2022 is estimated based on the transport field survey conducted in 2023 to assess the new transport patterns in Lebanon following the economic crisis and the significant changes in socio-economic conditions (MoE/UNDP/GEF, 2023). Results show that only the PC and motorcycles returned to a business-as-usual scenario compared to 2019 in terms of kilometers driven per year (Median of 12,894 kms for private cars and 5,289 kms for motorcycles), while all other categories have decreased between 30% and 75% compared to 2019 (Table 26).
- Fuel consumption based on the conducted survey was determined for the PC & taxi, LCV & vans, trucks & buses, and motorcycles. The median value was 180 km/20L, 195 km/20L, 90 km/20L, and 440 km/20L for the PC & Taxi, LCV & Vans, Trucks & Buses, and Motorcycles respectively for 2022 (MoE/UNDP/GEF, 2023)

Table 26 - Comparison between 2019 and 2022 kilometers driven per year per vehicle category

	PC N=1012	Taxi N=36	LCV N=76	Vans N=12	Trucks N=35	Buses N=4	Motorcycles N=96
Km driven in 2019	12,000	50,000	25,000	50,000	50,000	50,000	5,000
Km driven in 2022	12,893.86	32,993.29	15,343.04	16,999.15	12,372.15	22,681.60	5,289.23
Percent change	+7.4%	-34.0%	-38.6%	-66.0%	-75.3%	-54.6%	+5.8%

Default CO_2 emission factors are used for each fuel type and each category of vehicle from the IPCC 2006 guidelines. For N_2O and CH_4 emissions, default EU emission factors per vehicle type and technology are considered since in Lebanon most of the vehicle fleet is constituted of European vehicles. Table 27 presents the parameters used to calculate fuel consumed by each vehicle type based on the below equation:

Fuel consumed /vehicle type = number of vehicles/type x average distance travelled/year x fuel economy/type x fuel density/fuel

Where:

Fuel consumed: amount of gasoline of diesel oil consumed per type of vehicle per year (ktonnes/year)

Number of vehicles: number of vehicles per type and emission control technology per year (number of vehicles/year) Data provided by Vehicle registration authority.

Average travelled distance: distance travelled per type pf vehicle per year (kms/year). Data based on field surveys on the ground.

Fuel economy: volume of fuel consumed per 100kms per type pf vehicle (L/100 kms). Data provided by literature review.

Fuel density: Density of fuel per type (kg/L). Data provided by Literature review.

Table 27 -Default CO_2 emission factors (kg/TJ) for Transport 1.A.3

Fuel type	CO_2 emission factor (kg/TJ)
Gasoline	69,300
Aviation gasoline	70, 000
Jet kerosene	71,500
Diesel oil	74,100

At Tier 1, the emission factors assume that 100 percent of the carbon present in fuel in oxidized during or immediately following the combustion process.

Source I table 3.6.4 page 3.64 and table 3.5.2 page 3.50 chapter 3, volume 2, IPCC 2006 guidelines

Table 28 - Parameters for road transport 1.A.3.b for 2022

	Average Travelled Distance (km)	Fuel Economy (L/100 km	Fuel Density (kg/L	Net Calorific Value (TJ/ktonnes)
Gasoline Passenger cars – Gasoline				
Uncontrolled	12,894	11.2	0.74	43.5
Early non-catalyst control	12,894	9.4	0.74	43.5
Non-catalyst control	12,894	8.3	0.74	43.5
Oxidation catalyst	12,894	8.1	0.74	43.5
Three-way catalyst	12,894	8.5	0.74	43.5
Taxi Passenger cars – Gasoline				
Uncontrolled	32,993	11.2	0.74	43.5
Early non-catalyst control	32,993	9.4	0.74	43.5
Non-catalyst control	32,993	8.3	0.74	43.5
Oxidation catalyst	32,993	8.1	0.74	43.5
Three-way catalyst	32,993	8.5	0.74	43.5
Light-duty trucks- Gasoline				
All types	15, 343	13.6	0.74	43.5
Light trucks Vans-Gasoline				
All types	16,999	13.6	0.74	43.5
Heavy trucks Diesel				
All types	12,372	29.9	0.83	41.6
Buses Diesel				
All types	22,682	29.9	0.83	41.6
Motorcycles Gasoline				
<50cc	5,289	2.4	0.74	43.5
2-strokes	5,289	4	0.74	43.5
4-strockes	5,289	5.1	0.74	43.5

Table 29 - Default emission factors for CH_4 and N_2O emissions for 1.A.3 transport

Type of vehicle	CH_4 emission factor (kg/TJ)	NO_2O emission factor (kg/TJ)
Gasoline Passenger cars		
Uncontrolled	33.00	3.20
Early non-catalyst control	33.00	3.20
Non-catalyst control	33.00	3.20
Oxidation catalyst	25.00	8.00
Three-way catalyst	3.80	5.70
Light trucks Gasoline cars		
Uncontrolled	33.00	3.20
Early non-catalyst control	33.00	3.20
Non-catalyst control	33.00	3.20
Oxidation catalyst	25.00	8.00
Three-way catalyst	3.80	5.70
Light trucks Gasoline cars	3.90	3.90
Motorcycles Gasoline cars		
<50cc	33.00	3.20
2-strokes	33.00	3.20
4-strockes	33.00	3.20

Source I table 3.2.2 page 3.21 chapter 3 volume 2, IPCC 2006 guidelines

Emissions from other international bunkers are calculated with default emission factors available in the 2006 IPCC guidelines for GHG emissions.

Table 30 - International bunkers default CH_4 and N_2O emission factors (kg/TJ)

For all categories		Manufacturing industries and construction	
Fuel type	CO_2 emission factor (kg/TJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)
Aviation gasoline	70,000	0.5	2
Jet kerosene	71,500	0.5	2

Source I table 3.6.5 page 3.64 and table 3.5.3 page 3.50 chapter 3 volume 2, IPCC 2006 guidelines

3.2.6.3 Description of flexibility if applied

No flexibility is applied under this category.

3.2.6.4 Uncertainties and time series consistency

For road transport, the IPCC Approach 2 using Monte Carlo simulations[1] was used for CO_2, CH_4, N_2O, and CO_2eq. to estimate the uncertainty levels for the year 2022 and Proper Probability Density Functions (PDF) were used. The number of iterations was reached at 1,100 when the estimate for the 95% confidence range was determined to be within ± 1% of the mean; then an adequately stable result was attained. The frequency plots obtained are presented in Figure 17.

1 This is a technique used to understand the impact of uncertainty and variability in a system. In this case, it's likely used to simulate different scenarios for gas emissions.

The statistics of the Monte Carlo analysis are presented in Table 30. The emission data fits a lognormal distribution. Additionally, the mode (most common value) of the data is closer to the 2.5th percentile[2] (lower end) than the 97.5th percentile (higher end). This suggests that a higher chance of observing lower emission values exists compared to higher ones. In simpler terms, it's more likely to see lower levels of gas emissions than higher levels based on the analysis.

Table 31 - Statistics of the Monte Carlo assessment for the year 2022 for road transport

Index	CO_2	CH_4	N_2O	CO_2eq.
Mean (tonnes)	7,640,276	2,230	623	7,868,587
Median (tonnes)	6,700,128	1,834	525	6,904,336
Standard deviation (tonnes)	3,972,583	1,510	368	4,094,757
Uncertainty (%)	-64%; +139%	-71%; +186%	-66%; 157%	-64%; +140%

Based on these results, the level of uncertainty related to CO_2eq. emissions are fairly similar to the level of uncertainty related to CO_2 emissions, which is expected since the major driver of CO_2eq. is CO_2 in the case of road transport with a fleet running on gasoline and diesel. This indicates that the observed CO_2 emissions uncertainty is mostly responsible for the uncertainty of CO_2eq., while CH_4 and N_2O contributions are minor.

The uncertainty assessment following Approach 1 is not applicable as per the 2006 IPCC guidelines since assumptions/conditions of Approach 1 would not be met.

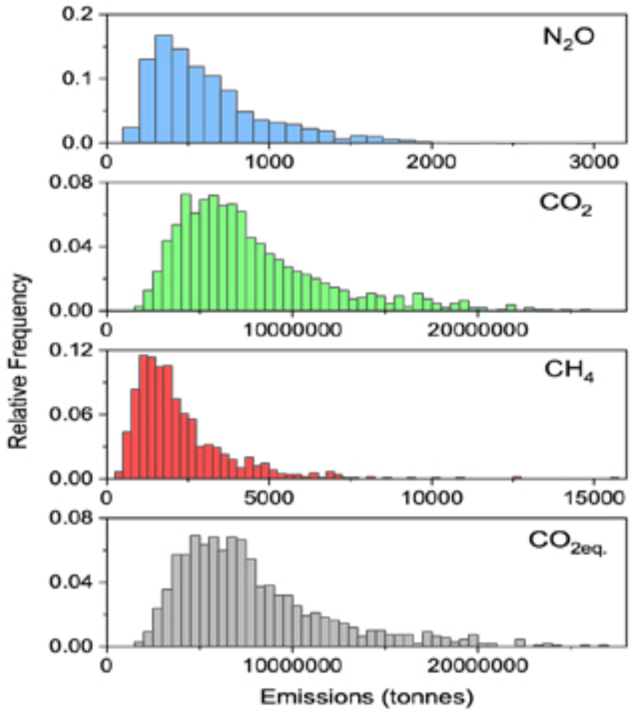


Figure 17: Frequency plots obtained following the Monte Carlo simulations

2 Values that divide a dataset into 100 equal parts. The 2.5th percentile represents the value below which 2.5% of the data falls, and the 97.5th percentile represents the value below which 97.5% of the data falls.

The most relevant parameters for the uncertainty of CO_2eq. emissions from road transport for the year 2022, measured by the rank correlation coefficient, have been individuated from the application of Monte Carlo. These are the Vehicle Kilometre Travelled for PC (VKT1) with a contribution of 88%, LCV (VKT3) and trucks (VKT5) each having a contribution of 2-3%. As far as feasibility is concerned, it is important to reduce the associated uncertainty of VKT1.

The trend uncertainty related to the transport sector for the period 1994-2022 is 30.39%. For CO_2 the uncertainty in the emission factor for liquid fuels is falls between -5% to +5% range, whereas for CH_4 and N_2O, uncertainties can reach -70% to + 210%. Although uncertainties in N_2O and CH_4 estimates are too high, their impact on total GHG inventory uncertainty is negligible.

Activity data are the primary source of uncertainty in the emission estimates mainly due to the lack of completeness. Activity data uncertainty for liquid fuel is estimated at 5%.

3.2.6.5 Category specific QA/QC

The same QA/QC measures implemented for the other energy categories were also adopted for the transport category. These measures include the verification and validation of activity data and parameters such as fleet characteristics, the fuel efficiency per type of vehicle and the vehicle kilometers travelled through expert consultation and comparison with other references. In addition, a field survey was conducted in 2023 to re-assess the annual kilometers driven during the 2020-2022 period, capturing any potential changes due to the socio-economic crisis and the COVID-19 pandemic.

Transport related fuel consumption was also compared to the total gasoline imported into the country to align the reference and sectoral approaches.

Special calculation worksheets and formulas were developed separately to the IPCC software to calculate disaggregate vehicle fleet by technology. Accordingly, fuel consumption data was estimated and used as input in the IPCC inventory for emission calculation and compilation.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied. Emission factors were compared to the IPCC guidelines and other years, to ensure and maintain consistency in calculation methods across all years covered by the inventory.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

3.2.6.6 Category-specific recalculations

No recalculations were made for this subcategory.

3.2.6.7 Category specific planned improvements

Emissions from the transport sector are dominated by passenger cars, followed by freight vehicles and motorcycle. The main challenges for the transport sector in relation to data collection and reporting process is related to the data availability that is usually shared in format not suitable to be easily used for GHGI compilation which required intensive data cleaning and re-categorization before using it in the IPCC software.

Within the frames of this NIR and in order to tackle the inaccuracy of information on kilometres driven that have been identified as accuracy barriers in previous inventories, improvements were made to the road transport sector GHG Inventory through the deployment of a survey in 2023 to re-assess the transport patterns in Lebanon during the period 2020-2022 and capture the changing socio-economic conditions in Lebanon. This was part of the improvement plans previously reported under Lebanon's BURs.

In addition, through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the transport sector. The Transport task force, composed of the main stakeholders of the transport sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

However, further improvements are planned to further ensure that the results and reporting are aligned with the MPGs and with the TACCC principles, as presented in Table 32.

Table 32 - Improvement plan for the transport sector

Tasks	Implemented	Short term	Long term
Improve accuracy of fuel economy estimations per vehicle type			X
Improve accuracy of travelled kilometers estimations per vehicle type	X		
Improve accuracy of diesel consumed for road transport through the development of an energy balance		X	
Obtain data on fuel consumed in road transport, navigation and aviation from the Lebanese army			X
Obtain data on fuel consumed in yacht clubs to improve accuracy of emissions from national navigation			X
Obtain data on fuel consumed by tankers in Beirut and Tripoli ports			X
Decrease discrepancy between fuel imports to Lebanon and fuel consumed by transport secto		X	
Calculate carbon content for gasoline and diesel used in transport		X	
Institutionalize collection of data from Car registration department			X
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X		

3.2.7 Other sectors (1.A.4 CRT category Number)

3.2.7.1 Category description

This category includes the greenhouse gases emitted by fuel combustion in the commercial/ institutional sector (1.A.4.a), residential sector (1.A.4.b) and agriculture/ forestry/ fisheries (1.A.4.c). 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.

3.2.7.2 Methodological issues

Tier 1 methodology is used since no country-specific emissions factors are available.

Activity Data

The LPG and gas/diesel oil consumed by 1.A.4 Other sectors are calculated based on the fuel imports database of the MoEW and the distribution of fuel per end use provided by IPT, one of the main fuel distributors in Lebanon.

- 10% of imported LPG is used in commercial and institutional sectors (1.A.4.a)
- 81% of imported LPG is used in the residential sector (1.A.4.b)
- 3% of imported GDO is used in the residential sector (1.A.4.b)
- 1% of imported GDO is used AFF-fishing (1.A.4.ciii)
- 1% of imported GDO is used AFF-off-road (1.A.4.ciii)
- The remaining GDO (after the amounts used in EI, transport, residential and AFF) are divided equally between MIC and Commercial/institutional to account for private generators

Emissions from burning of wood are allocated under the residential sector, 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, 2023). 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. 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.

Emission factors

The same parameters presented in Table 17 under 1.A.1 Energy industries are used for 1.A.4 Other sectors. Default emission factors from the 2006 IPCC guidelines are used.

Table 33 - CO_2 CH_4 and N_2O stationary sources

For all categories		Other sectors	
Fuel type	CO_2 emission factor (kg/TJ)	CH_4 emission factor (kg/TJ)	N_2O emission factor (kg/TJ)
Diesel oil	74,100	10	0.6
LPG	63,100	5	0.1
Biomass (wood waste)	112,000	300	4

Source I table 2.4-2.5 page 2.20-2.23 chapter 2 volume 2, IPCC 2006 guidelines

3.2.7.3 Description of flexibility if applied

No flexibility provision was adopted.

3.2.7.4 Uncertainties and time series consistency

Uncertainty values used for the calculation of GHG emissions for 1.A.4 Other sectors were adopted from the IPCC 2006 guidelines default values in addition to some expert judgment, and a value of ±15% was used as uncertainty value for activity data and ±5% for CO_2 emission factor, ±50% for CH_4 ±60% for N_2O emission factor.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

3.2.7.5 Category specific QA/QC

The same QA/QC measures implemented for all energy categories were also adopted for the other sector category. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Other sectors related fuel consumption was also compared to the total fuel imported into the country to align the reference and sectoral approaches.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

3.2.7.6 Category-specific recalculations

No recalculations were made for this subcategory.

3.2.7.7 Category specific planned improvements

The main barriers and challenges to a consistent and reliable data collection and reporting for this category are identified as follows:

- There is no national energy balance in Lebanon to estimate energy consumption for the commercial and residential sector
- There is no data on the quantities and production capacity of private generators, as they operate illegally in the country.
- There is no clear methodology and unified number for estimating yearly demand of electricity. EDL takes spot measurements (not continuously recorded) on the transformers supplying electricity, which is assumed to be correlated to the demand. This approach of estimating electricity demand is inaccurate, since it cannot be assumed that the energy load is the same during the whole day and across the week.
- The estimation of the Energy Not Supplied (ENS) assumes that a specific percentage of ENS is provided by private electricity generators, which can be highly uncertain.

Through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the energy sector. The Energy task force, composed of the main stakeholders of the energy sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

Table 34 - Short term and long term planned improvements for Lebanon's GHG inventory for 1.A.4 Other sectors

Tasks	Implemented	Short term	Long term
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of fuel consumed at industrial and private generator levels		X	
Update the work to estimate the percentage of electricity generated by EDL and generated by commercial and residential buildings for their own use. Include in this work an estimate of the fuel types used to generate the electricity.			X
Conduct survey on fuel consumption for generators in main cities in Lebanon		X	
Improve accuracy in distribution of gas/diesel oil by end use category			X
Calculate country specific EFs for other fuels used in Lebanon		X	
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X		

4. Industrial Processes and product use (CRT 2)

4.1 Overview of the sector

In 2022, Lebanon's industrial sector contributed around 2% to the country's GDP, decreasing from 12% in 2019 (World bank, 2024). Although the sector faced numerous challenges during the last period with a significant number of industries closing down permanently, it remained a significant part of the economy, employing a large portion of the workforce (up to 20%) and being a key source of hard currency, especially amid the economic crisis (ALI, 2021).

In terms of types of industries, the Association of Lebanese Industrialist (ALI) data indicates that food industries have the largest number of firms at around 19% followed by plastic and chemicals at 14% of the total count, then paper and packaging and minerals at around 11% of the count each.

In Lebanon, the lack of heavy industries such as steel manufacturing or chemical production means that Lebanon's industrial greenhouse gas emissions are relatively limited, with cement production being the most significant contributor, with other emissions from HFC uses for refrigeration and air conditioning and some processes that use CO_2 carbonates.

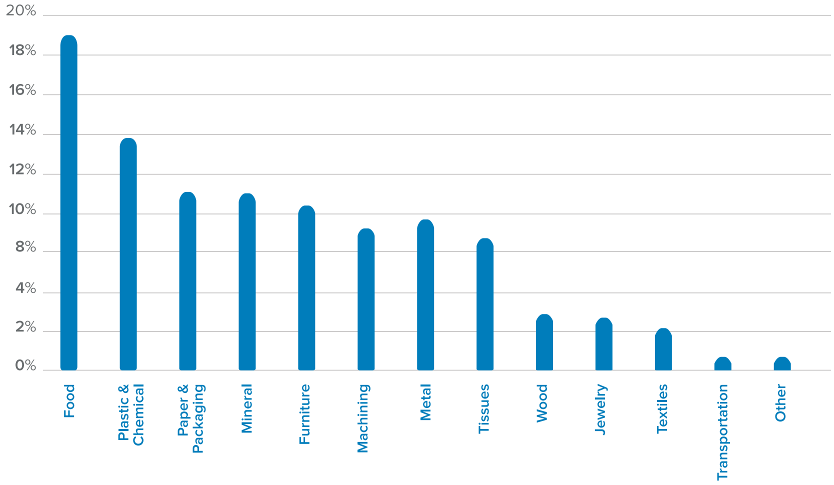


Figure 18: Percentage distribution of industries per type of manufacturing in Lebanon (LCPS, 2023)

The development of the complete inventory limits reporting of GHG emissions from some industrial categories as data collection remains a challenging task in Lebanon. The absence of an updated national industrial survey limits the identification of industrial processes taking place in Lebanon, which consequently hinders the complete calculation of some GHG emissions such as PFCs and SF_6 and some indirect emissions such as Non-Methane Volatile Organic Compounds (NMVOCs). Extensive efforts have been deployed during previous inventories to collect data to estimate emissions from a number of industries such as food and beverages, but the data quality remains highly uncertain. Therefore, due to limited capacity, emissions from some industries are not estimated and are reported as NE in the reporting tables with proposed planned improvements for later submissions.

GHG emissions in 2022

In 2022, the Industrial Processes and Product Use (IPPU) category in Lebanon contributed about 12.6% to the total national emissions, recording a decrease of 20% from 2019 due to significant decrease in production of cement during the 2020-2022 period amidst the crisis.

The share of F-gases from refrigeration and air conditioning also decreased by 12% compared to 2019 due to economic crisis where the purchase of new refrigerator and air conditioning systems decreased with the reduction of the purchase power of the population, reaching 1,656 Gg CO_2eq. in 2022. The use of HFC-134a and the mixtures of R404 A, R407C, R410A (HFC-125) in refrigeration result in most of the emissions in terms of CO_2eq., due to their high Global Warming Potential of HFC. It is estimated that 80% of emissions of F-gases are generated from stationary sources (residential and commercial refrigerators, air conditioning, condensing units and process chillers) and 20% from mobile sources (car air conditioning and refrigerated trucks). All other sources have minimal contribution to emissions in the sector.

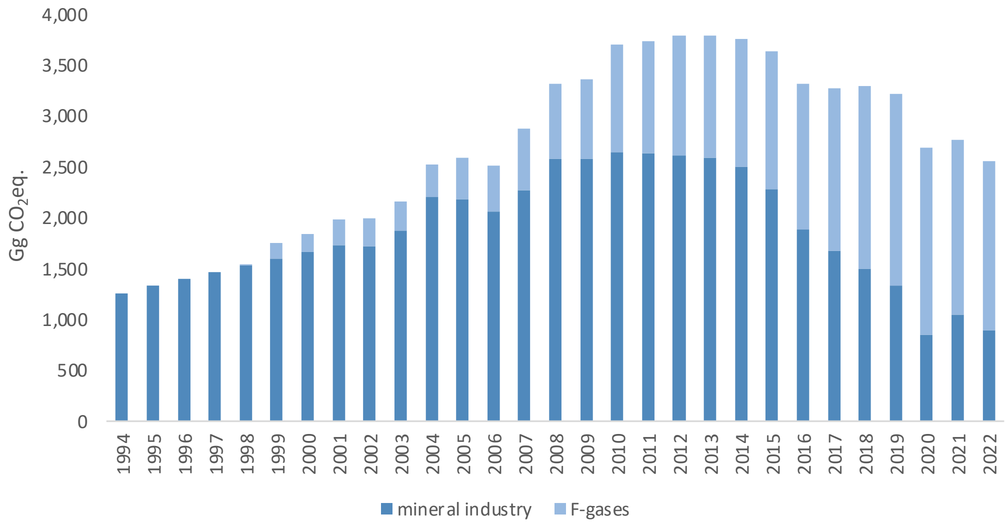


Figure 19: GHG emissions from IPPU for the time series 1994-2022

4.2 Mineral Industry (CRT 2.A)

4.2.1 Category description

The mineral industry category in the IPCC 2006 guidelines includes activities related to the production and processing of minerals, which involves the emissions of greenh ouse gases from chemical reactions during the production of materials such as cement, lime, glass, and ceramics. The primary emissions are usually CO_2 released from the calcination of limestone and other carbonates, and from the combustion of fossil fuels used in the production processes.

4.2.2 Methodological issues

The GHG inventory of industrial processes in Lebanon is carried out based on calculation methodologies of the 2006 IPCC Guidelines for national greenhouse gas inventories, using Tier 1 methodologies with national and default emission factors for the other categories. Cement production only adopted a Tier 2 methodology. Emissions from fuel combustion in the industrial sector for energy purpose is not included under the IPPU sector, but rather in the energy sector (1.A.2).

Table 35 - GHG emissions categories and activity data for 2022 for Mineral industry

Reporting categories	Methodology, description and remarks	Activity data for 2022
2.A Mineral industries		
2.A.1 Cement production	All 3 cement industries in Lebanon are covered in this calculation. Cement manufacturing is a key category in Lebanon; therefore Tier 2 is adopted to calculate emissions from this category as per equations 2.4 and 2.5 of the IPCC 2006 guidelines.	1,694,723 tonnes clinker
2.A.2 Lime production	The only lime production plant in Lebanon is covered in this calculation. As data was not made available during this period, extrapolation was used to estimate the quantities of lime produced. Lime is also produced in cement manufacturing; however, it is already accounted for in clinker production in cement industries. CO2 resulting from lime production is not a key category in Lebanon therefore the Tier 1 method is used.	1,004 tonnes lime
A.3 Glass production	The 2 glass producing factories in Lebanon shut down in the early 2000s. Glass is imported and manufactured into different shapes (containers, windows, etc.) using carbonates. Since there is no survey of the exact amount of carbonates used in glass production, related emissions are not estimated under this category.	NE
2.A.4 Other process Uses of Carbonates	Subcategories from which emissions occur in Lebanon include ceramics (2.A.4.a) and other uses of soda ash (2.A.4.b). Other subcategories do not occur and are reported as such. Data on ceramics is considered incomplete as it only includes the main ceramics production facilities in the country (sanitary and tile) and does not cover the entire time series considered in this inventory. Therefore, emissions from ceramics are Not Estimated in the current inventory. Note that category 2.A.4.a is not expected to be a key category. There is no soda ash production in Lebanon. National consumption is based on imported soda ash (HS code 28.36.20) and it is assumed that all imported soda ash is used during the year of import in the industrial sector. Percentages of soda ash used per type of industry (glass manufacturing, soap and detergents, water treatment etc.) are not available. Therefore, total national consumption is used as activity data.	1,584 tonnes of soda ash used

Emission factors

Except for the emission factor for cement production which was nationally developed, all other emission factors used in the calculation of emissions from the IPPU category are based on default values provided by the 2006 IPCC GL. Table 36 presents all the emission factors used in the IPPU category. Details on how the national emission factor was calculated are presented in Box 1.

Table 36 - Emission factors and other parameters for industrial processes

Reporting categories	Emission factor	Source
2.A.1 Cement production	0.52 t CO_2/t clinker produced Correction factor for cement kiln dust: 1.02	Nationally developed emission factor (MoE/UNDP/GEF, 2011)
2.A.2 Lime production	0.75 tonnes CO2/tonnes lime produced	IPCC 2006 guidelines
2.A.4 Other process Uses of Carbonates	0.415 tonnes Co2/tonnes carbonate	IPCC 2006 guidelines

Box 1: Details on the calculation of the national emission factor for cement production

Data on CaO (quicklime) content of the clincker (CaO_Clincker) and the fraction of this CaO from carbonate (CaO_Carbonate) is needed in order to generate a national emission factor for Tier 2 method for the calculation of emissions from cement. The values obtained from cements companies are:

CaO_Clinker = 66%

CaO_Carbonate = 99.8%

The carbonate $CaCO_3$ is 56.03 percent CaO and 43.97 percent CO_2 by weight as per table 2.1 of the 2006 IPCC GL.

The equation for the clinker emission factor when applying these parameters is:

EFcl = (0.66-(1-0.998))/0.5603*0.4397 = 0.52 tonnes CO_2/tonne clinker

A correction factor should be applied to this emission factor, the default value of 1.02 was applied.

4.2.3 Description of flexibility if applied

No flexibility provisions have been applied.

4.2.4 Uncertainties and time series consistency

Uncertainties has been calculated based on default uncertainties provided in the IPCC 2006 guidelines and in consultation with stakeholders, with ± 1% for activity data uncertainties for cement and ±10% for activity data for lime production and ±20% for activity data for soda ash used and paraffin wax use.

As for emission factors, the inventory has used the following default uncertainties: ±10% for CO_2 emission factor for cement production and ±2% for CO_2 emission factor for lime and ±1% for CO_2 emission factor for soda ash used.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

4.2.5 Category specific QA/QC

The calculation of emissions from mineral industries relied on activity data provided from the Ministry of Environment ensuring that the data is sourced from official and authoritative channels and comparing it with various reference sources. To enhance accuracy and minimize errors, the process incorporates several quality assurance and control (QA/QC) measures. These include automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies.

Other QA/QC procedures included involve updating and specifying Activity Data (AD) and Emission Factors (EFs) according to the 2006 IPCC Guidelines and integrating them into spreadsheets that align with CRF tables. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

The inventory process is continuously refined based on recommendations from international experts, addressing issues like data series restoration. The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

4.2.6 Category-specific recalculation

No recalculations have been done.

4.2.7 Category specific planned improvement

Industrial activities are limited in Lebanon. The Industrial Processes and Products Use sector includes mineral production (cement and lime production), HFC uses for refrigeration and air conditioning and some processes that use $COCO_2$ carbonates. The main challenges in relation to data collection and reporting process include the following:

- Around 7,000 businesses have been licensed, however, the Ministry of Industry (MoI) estimates that roughly the same amount of unlicensed, mostly smaller businesses exist. This poses substantial additional challenges in getting data from half of the county's industries/businesses.
- Since 2019, the MoI database is not being updated due to the lack of resources to fill in documents. Industries are hiring third party personnel to fill in the forms. Same info is being filled in for different industries. MoI does not have the capacity to validate the information, leading to poor accuracy of the data.
- Although cement industries are still sharing their data with MoE, when requested by MoE, other industries are small businesses therefore data is difficult to get and/or very inconsistent, such as lime industry.

Therefore, planned improvements to increase accuracy and completeness of emissions are presented in the below table.

Table 37 - Short term and long term planned improvements for Lebanon's 2.A Mineral industry

Planned improvement	Implemented	Short term	Long term
Update national industrial survey for the accurate identification of industries operating in Lebanon		X	
Improve data collection on lime production		X	
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X		

4.3 Non energy products from fuels and solvent use (CRT 2.D)

4.3.1 Category description

The category "Non-Energy Products from Fuels and Solvent Use" in the 2006 IPCC Guidelines covers emissions arising from the use of fuels and solvents that do not serve as energy sources. This includes the use of lubricants, paraffin waxes, bitumen, and solvents in various industrial processes. The emissions result from the transformation of these products rather than their combustion. Emissions are estimated considering factors such as product use, chemical transformations, and the potential release of NMVOCs.

4.3.2 Methodological issues

Emissions from this category have been calculated based on calculation methodologies of the 2006 IPCC Guidelines using Tier 1 methodologies with national and default emission factors for the other categories.

Table 38 - GHG emissions categories and activity data for 2022 for Non energy products from fuels and solvent use

2.D Non-Energy Products from Fuels and Solvent Use		Activity data for 2022
2.D.1 Lubricant Use	There is no disaggregated data on the use of lubricants in Lebanon. Therefore, it is assumed that all imported lubricants are used in the power generation plants. Emissions from this subcategory are therefore reported as Included Elsewhere (reported under 1.A.1 Energy Industries).	IE
2.D.2 Paraffin Wax Use	Consumption of paraffin wax is based on the quantities imported as per the customs database using the HS code 27.12. It is assumed that all imported quantities are consumed within one calendar year. Data was obtained in tonnes and converted to terajoules (TJ) using the NCV 40.2 TJ/Gg as per the 2006 IPCC GL (table 1.2 page 1.18 of chapter 1 of volume 2 on Energy).	22 TJ equivalent to 547 tonnes
2.D.3 Solvent use	Emissions from solvent use have not been estimated since no aggregated data is available on solvent use in Lebanon. This category is not a key category and is only responsible for emissions of NMVOCs	NE

Emission factors

Emission factors used are based on default values provided by the 2006 IPCC guidelines, with the carbon content in wax being 20 tonnes C/TJ and the oxidised factor being 0.2.

4.3.3 Description of flexibility if applied

No flexibility provisions have been applied.

4.3.4 Uncertainties and time series consistency

Uncertainties has been calculated based on default uncertainties provided in the IPCC 2006 guidelines, with ±20% for activity data uncertainties (paraffin wax used) and 5% for CO_2 emission factor.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

4.3.5 Category specific QA/QC

The same QA/QC measures implemented for Mineral industry were also adopted for the non-energy products category. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

4.3.6 Category-specific recalculations

No recalculations have been done.

4.3.7 Category specific planned improvements

In addition to the challenges specified in section 4.2.6, category specific improvements are presented in the below table.

Table 39 - Short term and long term planned improvements for Lebanon's 2.D Non energy products from fuels and solvent use

Planned improvement	Short term	Long term
Update national industrial survey for the accurate identification of industries operating in Lebanon	X	
Obtain disaggregated data on glass production		X
Obtain disaggregated data on lubricants		X
Obtain disaggregated data on ceramics		X
Obtain disaggregated data on solvent use		X
Include Bitumen under 2.D.3.C	X	

4.4 Product uses as substitutes for ODS (CRT 2.F)

4.4.1 Category description

The category "Product Uses as Substitutes for Ozone-Depleting Substances (ODS)" in the IPCC guidelines focuses on the emissions from products that use chemicals as substitutes for ODS. These include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and other fluorinated gases. Applications include refrigeration and air conditioning (RAC), foam blowing agents, and aerosols.

4.4.2 Methodological issues

In this category, emissions from production, banks (lifetime servicing) and end-of-life emissions (from disposal) were estimated using the Tier 2b approach of the IPCC 2006 Guidelines. A bottom-up approach was applied to gather the necessary data to build the RAC appliances inventory, enable historic inventory estimates and GHG emissions.

Refrigeration and air conditioning systems were divided into the sub-categories of commercial refrigeration, domestic refrigeration, transport refrigeration, mobile air conditioning systems and stationary air conditioning systems.

Table 40 - GHG emissions categories and activity data for 2022 for Product uses as substitutes for ODS

2.F Product uses as substitutes for ODS	
2.F.1 Refrigeration and A/C	HFC are mainly used in Lebanon under the Refrigeration and Air Conditioning (RAC) sector. The main HFC refrigerants are HFC-134a and the mixtures R404A, R407C, R410A resulting in emissions of HFC-125 (38% in 2018), HFC-32 and HFC-143a.
2.F.2 Foam blowing Agents	There are no HFC applications in the foam manufacturing sector. The notation key Not Occurring is therefore used.
2.F.3 Fire protection	There are limited applications of HFCs in fire suppression systems. Due to lack of activity data, emissions from this category have not been estimated. The notation key NE is therefore used.
2.F.4 Aerosols	There are limited applications of HFCs in aerosols. Due to lack of activity data, emissions from this category have not been estimated. The notation key NE is therefore used.
2.F.5 Solvents	It is assumed that there are no PFC emissions for this category in Lebanon. The notation key NO is therefore used.

Activity data

A survey was conducted in 2016 which provided an indication of the share of HFC consumption in refrigeration and air conditioning in Lebanon.

All Ozone Depleting Substances (ODS') consumed in Lebanon are imported, primarily from the USA, UK, Spain, United Arab Emirates, Japan and China. There are two companies in the country that import these substances and use them in manufacturing refrigeration and condensing units: 1) Lematic Industries (domestic refrigeration); 2) Leon Industries S.A.R.L (commercial refrigerators and condensing units). Consumption of HFCs was obtained from these producers.

Data on appliances sales was gathered through a detailed survey performed at local shops, sales points, and supermarkets. Twelve questionnaires were completed accounting for around 45% of the market share for each of the subsectors. Additional data were obtained from statistical outputs of government departments, previous surveys data, custom offices for imported equipment and refrigerants and expert opinions.

For each of the subsectors and their respective appliance types, the methodology estimates an inventory of historic and future unit sales and stocks. From this, refrigerant consumption and emissions were estimated using data on lifetime, charge, production and other parameters. According to the collected information HFC refrigerants used in Lebanon are HFC-134a and the mixtures of R404A (refrigeration), R407C (AC) and R410A (AC). The shares of the refrigerant mixtures out of total charge were also collected. Emissions of single refrigerants were estimated using data on blends' composition (table 7.8 2006 IPCC Guideline, V3, Chapter 7, p.44). Export of equipment have not been considered in this inventory as data was not readily available.

Emissions from production, banks (lifetime servicing) and end-of-life emissions (from disposal) were estimated using the Tier 2b approach of the IPCC 2006 Guidelines. A bottom-up approach was applied to gather the necessary data to build the RAC appliances inventory, enable historic inventory estimates and GHG emissions. For production, real consumption of HFC-134a and R404a were obtained from producers for 2014-2018 and extrapolated using domestic sales data for 1999-2013. Emissions from banks and disposal were estimated using equations 7.13 and 7.14 of the 2006 IPCC Guidelines.

Refrigeration and air conditioning systems were divided into the sub-categories of commercial refrigeration, domestic refrigeration, transport refrigeration, mobile air conditioning systems and stationary air conditioning systems (see Table 41). There is only one domestic refrigeration producer in Lebanon, Lematic Industries, that has been using HFCs in their manufacturing processes since 1999. Another company, Leon Industries, S.A.R.L., manufactures refrigerators and condensing units for supermarkets and commercial stores.

Table 41 - RAC subsectors and appliance types

Subsector	Appliance types
Air conditioning	
Unitary air conditioning	• Window-type air conditioners • Split residential air conditioners • Split commercial air conditioners • Duct split residential air conditioners • Commercial ducted splits • Rooftop ducted • Multi-splits
Chillers	Air conditioning chillers
Mobile air conditioning	• Car air conditioning • Large vehicle air conditioning
Refrigeration	
Domestic refrigeration	Domestic refrigerators
Commercial refrigeration	• Stand-alone equipment • Condensing units
Transport refrigeration	Transport refrigeration

Due to the lack of recent updates to the survey in Lebanon, an extrapolation method was employed. This method relied on GDP per capita data from 2020 to 2022 to estimate changes in socio-economic conditions, assuming that the decrease in the purchasing power of Lebanese citizens lead to a decrease in the sales of new residential and commercial RAC units. This approach reflects best the potential impact of economic factors on ODS-related equipment sales in the country.

In 2022, the assumed sales of refrigerants and air conditioning units decreased by 50% compared to 2019 in line with the decrease in GDP per capita (7,578 USD/cap in 2019 compared to 3, 823 USD/cap in 2022 according to World bank, 2023b). However, due the emissions from Bank, life and end, total emissions of HFC-134a (GWP=1300); HFC-125 (GWP=3170), HFC-32 (GWP=677), HFC-143a (GWP=4800) decreased by 13% compared to 2019.

In the CRT tables, and due to the difficulty of calculating Tier 2 HFC emissions using the IPCC software with imports to the ETF platform, emissions from refrigeration have been included under emissions from air conditioning. Efforts will be made to disaggregate the reporting of these emission in subsequent BTRs.

Emission factors

Emissions of single refrigerants were estimated using data on blends' composition (table 7.8 2006 IPCC Guideline, V3, Chapter 7, p.44)

Table 42 - Parameters for the HFCs emissions estimates

Equipment type	Lifetime (years)	Main refrigerants	Initial charge (IC) (kg)	Lifetime (years)	Service EF (% of IC)	Disposal EF (% of IC)
Split residential AC	9	R410A	0.09	9	10	95
Split commercial AC	9	R410A	1.80	9	10	80
Rooftop ducted	9	R407C, R410A, R134A	10	9	8	75
Multi-splits	9	R407C, R410A	15	9	10	80
Air conditioning chillers	20	R134A, R410A	35	20	22	95
Car air conditioning	15	R134A	0.60	15	20	100
Large vehicle air conditioning	15	R134A	8	15	30	100
Domestic refrigeration	8	R134A	0.170	10	2	80
Stand-alone equipment	15	R134A, R404A	0.40	15	3	80
Condensing units	20	R134A, R404A	5	9	30	100

4.4.3 Description of flexibility if applied

No flexibility provisions have been applied.

4.4.4 Uncertainties and time series consistency

Uncertainties associated with emission factors used to estimate HFC emissions from source category 2F1 'Refrigeration and Air Conditioning' reach up to ±30%. Uncertainties associated with activity data on the use of refrigeration and air conditioning equipment is considered to be ±40%, additional uncertainty is introduced by the need to extrapolate sales data for the later years of the time series.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

4.4.5 Category specific QA/QC

The same QA/QC measures implemented for Mineral industry were also adopted for the product use as substitute of ODS category. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

For F-gases, special calculation worksheets and formulas were developed outside the IPCC inventory software to enable the use of Tier 2 methodology. The overall emissions were then entered manually in the overall national inventory to be added in the total emissions.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

4.4.6 Category-specific recalculations

No recalculations have been done.

4.4.7 Category specific planned improvements

In addition to the challenges specified in section 4.2.6, category specific improvements are presented in the below table.

Table 43 - Short term and long term planned improvements for Lebanon's 2.F Product uses as substitutes for ODS

Planned improvement	Short term	Long term
Update national industrial survey for the accurate identification of industries operating in Lebanon	X	
Collect data on export of refrigeration and air conditioning equipment	X	
Develop and repeat a survey/assessment for Refrigeration/ Air Conditioning to understand the current use of RAC equipment.		X
Refrigeration/ Air Conditioning: Hold thematic meetings with all relevant data provides to review current AD assumptions and try to validate current assumptions	X	
Refrigeration/ Air Conditioning: Identify major gaps and uncertainties in AD. Check and see if these gaps can be filled through expert judgement or by newly identified data.		X
Improve data on appliances sales according to subsector. Additional data needed will include statistical outputs of government departments, previous surveys data, custom offices for imported equipment and refrigerants, expert opinions.		X
Collect data on gases used in fire propellants		X
Collect and report data on 2.F.4 Aerosols		X
Enter data in a disaggregated form in the ETF platform	X	
Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	X	

4.5 Other product manufacture and use (CRT 2.G)

4.5.1 Category description

This category includes emissions of Sulfur hexafluoride (SF_6), perfluorocarbons (PFCs) from the manufacture and use of electrical equipment and a number of other products and N_2O emissions from uses like anesthetics and propellants. In most of these applications, the SF_6, PFC, or N_2O is deliberately incorporated into the product to exploit one or more of the physical properties of the chemical, such as the high dielectric strength of SF_6, the stability PFCs, and the anaesthetic effect of N_2O

4.5.2 Methodological issues

The Tier 1 methodology has been used to estimate emissions of N_2O in Lebanon, since it is assumed that there are no SF_6 and PFC emissions currently occurring, Default emission factors combined with imports and exports of gas to Lebanon have been used.

Table 44 - GHG emissions categories and activity data for 2022 for other product manufacture and use

2.G. Other product manufacture and use		Activity data for 2022
2.G.1 Electrical Equipment	There is no data on the production and disposal of electrical equipment in Lebanon therefore emissions from this category have not been estimated. The notation key NE is therefore used.	NE
2.G.2 SF_6 and PFCs from other Product Uses	There are no known product uses of SF_6 and PFCs in Lebanon and therefore this category has been marked as “Not Occurring”.	NO
2.G.3 N_2O use for medical purposes	N_2O is used for medical applications in anesthetic use, analgesic use and veterinary use. Import and export data is collected from the customs database, assuming that the remining quantities are consumed in a calendar year.	121 tonnes

4.5.3 Description of flexibility if applied

No flexibility provisions have been applied.

4.5.4 Uncertainties and time series consistency

Uncertainties associated with the “Other Product Manufacture and Use” category is estimated a to ±10% for activity data and to ±0% for N_2O emission factor.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

4.5.5 Category specific QA/QC

The same QA/QC measures implemented for Mineral industry were also adopted for this category. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

4.5.6 Category-specific recalculations

No recalculations have been done.

4.5.7 Category specific planned improvements

In addition to the challenges and specified in section 4.2.6, category specific improvements include the collection of data on aerosols and electric equipment's.

5. Agriculture (CRT 3)

5.1 Overview of the sector

ILebanon offers a range of agroecological zones well-suited for diverse agricultural production. The most fertile lands are in the Bekaa Valley, the Plain of Akkar, and the coastal plains. Crop production accounts for 60% of agricultural output, with livestock contributing 40%, particularly in mountainous regions where smallholdings are prevalent.

Agriculture in coastal plains is dominated by permanent crops like citrus and banana, while the Bekaa Valley and Akkar focus on cash crops like potatoes and vegetables. The global rise in fertilizer and fuel prices, compounded by Lebanon's foreign exchange crisis, has severely impacted agricultural production. A 2022 FAO survey found that over 80% of crop producers faced difficulties, with access to fertilizers (72%) and pesticides (59%) being the most significant challenges. The high costs have led to reduced input application or substitution with lower quality alternatives, thereby decreasing marketable production and incomes. Fertilizer imports and consumption have decreased by around 50% between 2019 and 2022, notably impacting potato and vegetable crops.

Livestock, composed mainly of sheep, goats, poultry, and cows, did not see a significant change in population despite the increased cost of imported animal feed.

Despite the crisis, the agri-food sector in Lebanon has demonstrated resilience during the crises and continues to generate livelihoods and income for a large share of the poor. The primary agricultural production's contribution to GDP increased from 3.2% (USD 1.77 billion) in 2018 to 8.9% (USD 2.32 billion) in 2020. It is estimated that approximately 20 percent of Lebanese households generate primary or secondary income from the broader agri-food sector (World Bank, 2021).

GHG emissions of 2022

In terms of GHG emissions, the agricultural sector (excluding land) generated 777.9 Gg CO_2eq. in 2022, a decrease from 15% in 2019, with preserving a share of 3.8% of national emissions. The decrease is mainly due to the decrease in consumption of fertilizers. CH_4 emissions represented more than half of emissions from the agriculture sector, with 3.A.1 Enteric fermentation being the main source of emissions (387.21 Gg CO_2eq.). Nitrous oxide (N_2O) emissions were estimated at 196.66 Gg CO_2eq. with 3.C.4 direct N_2O from managed soils being the main source of emissions followed by 3.A.2 manure management.

In terms of trend patterns for the agriculture sector, emissions have increased at an average rate of 1% from 1994 to 2019, followed by a significant decrease after 2019 due to the economic crisis which impacted the import and the use of synthetic fertilizers.

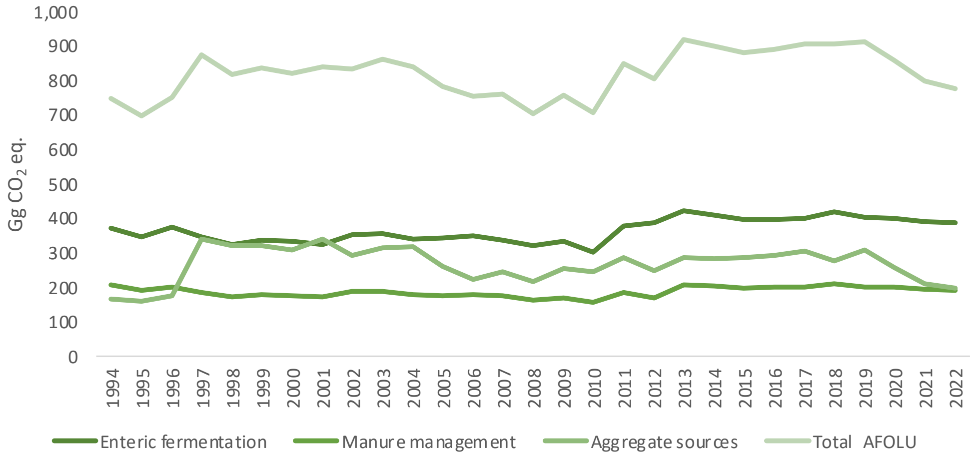


Figure 20: Trend analysis for net CO_2 emissions/removals from the AFOLU sector

5.2 Livestock (CRT 3.A, 3.B)

5.2.1 Category description

This category estimates CH_4 emissions from enteric fermentation in livestock, and CH_4 and N_2O emissions from manure management. As per the 2006 IPCC guidelines, CO_2 emissions from livestock are not estimated because annual net CO_2 emissions are assumed to be zero (the CO_2 photosynthesized by plants is returned to the atmosphere as respired CO_2). A portion of the C is returned as CH_4 and for this reason CH_4 requires separate consideration. Livestock is an important source of CH_4 emissions due to their ruminant digestive system and manure management is a source of N_2O emissions, which varies significantly between the types of management system used.

5.2.2 Methodological issues

Although this is a key category (excluding LULUCF), the Tier 1 methodology was adopted for the calculation of GHG emissions from enteric fermentation and manure management as information on dietary regimes, rate of pregnancy, rate of lactation and average amount of work done by livestock, manure characteristics and practices required for Tier 2 is not available. Basic characterization was therefore performed to assess the animal population in Lebanon. Population of some species was adjusted to number of days alive as appropriate using equation 10.1 (see footnotes Table 45). For non-dairy cattle, imported population was added to national population and adjusted to number of days alive.

Activity data

The livestock categories found in Lebanon are dairy cattle, non-dairy cattle, sheep, goats, poultry (laying hens, broilers and traditional), swine, horses, mules, asses, and camels. According to experts at the Ministry of Agriculture (MoA), some buffaloes exist in Lebanon in one farm in the country that produces mozzarella di buffala. However, statistics on buffaloes are not included in the MoA database nor in the FAOSTAT.

Data for dairy cattle, non-dairy cattle, sheep, goat, traditional poultry, laying hens, and broilers for the years 2011, 2020-2022 were obtained FAOSTAT. Data on imported beef was retrieved from previous inventories up until the year 2012 and was estimated by MoA expert judgement for the years 2013-2015 since published information could not be obtained. Populations of imported beef and broilers were adjusted to 60 and 30 days alive respectively.

Table 45 - Livestock population in Lebanon (heads) for the period 2011, 2020-2022

	Dairy cattle*	Non-dairy cattle*	Sheep	Goats	Camels	Horses	Mules	Asses	Swine	Poultry**
2011	55,000	31,674	450,000	550,000	200	2,634	5,000	15,000	7,650	13,363,013
2020	53,505	51,297	431,720	534,500	129	3,780	4,662	14,436	7,379	15,393,574
2021	53,634	45,021	442,883	537,181	129	3,667	4,662	14,393	7,257	15,855,381
2022	53,957	42,204	443,46	526,021	129	3,350	4,662	14,350	7,093	16,331,043

*Including imported beef adjusted to 30 days alive
**Including traditional chicken, hens and broilers adjusted to 60 days alive

As for activity data related to manure management, the attribution of fraction of total nitrogen excreted by species and managed in each manure management system was done through stakeholder consultation and expert judgement, as there is no published data on the matter. Therefore, the same assumptions used in previous inventories were adopted for this inventory.

Table 46 - Fraction of Manure Nitrogen per Manure Management System in Lebanon for the entire reporting period, based on expert judgement

	Dairy cattle*	Non-dairy cattle*	Sheep	Goats	Camels	Horses	Mules asses	Swine	Laying hens	Broiler	Traditional chicken
Anaerobic Lagoons	0.01										
Liquid systems	0.005										
Solid storage and drylot	0.955	1	0.33	0.33				0.90			
Daily spread	0.01							0.10			
Pasture range and paddock	0.02		0.67	0.67	1	1	1		0.04	0.04	1
Poultry manure without bedding									0.19	0.19	
Poultry manure with bedding									0.77	0.77	

Emission factors and other parameters

For enteric fermentation (3.A.1): Emission factors used for calculation of methane emissions from enteric fermentation are default values from 2006 IPCC guidelines and reported in Table 47. For non-cattle species, defaults proposed for developing countries were adopted. For cattle species, defaults proposed for Western Europe were adopted since the majority of cattle in Lebanon are imported from Western European countries, as per expert judgement.

Table 47 - Methane emission factors for enteric fermentation

Species	CH_4 Emission factor (kg/head/year)	Activity data for 2022
Sheep	5	Table 10.10 page 10.28 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10. Default for developing countries.
Goats	5	
Camels	46	
Horses	18	
Mules and asses	10	
Swine	1	

Species	CH_4 Emission factor (kg/head/year)	Activity data for 2022
Dairy cattle	117	Table 10.10 page 10.28 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10. Default for Western Europe as confirmed by expert consultation.
Non-dairy cattle	57	

For CH_4 emissions from manure management (3.A.2): Table 48 presents the emission factors used for calculating methane emission from manure management selected from the list of defaults provided in the 2006 IPCC guidelines. For cattle and swine, emission factors suitable for an average temperature of 24 degrees in Eastern Europe were chosen as they better reflect the conditions for manure management in Lebanon as per expert judgement (i.e. solid based systems are used for the majority of manure). For the other species, emission factors for temperate regions were chosen from the default factors proposed by the 2006 IPCC guidelines. The sum of each population subgroup multiplied by its corresponding emission factor was performed to calculate total CH_4 emissions form manure management as per equation 10.22.

Table 48 - Methane emission factors for manure management

Species	CH_4 Emission factor (kg/head/year)	Activity data for 2022
Sheep	0.15	Table 10.15 page 10.40 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10. Default for developing countries, temperate regions.
Goats	0.17	
Camels	1.92	
Horses	1.64	
Mules and asses	0.90	
Poultry	0.02	
Dairy cattle	35.00	Table 10.14 page 10.38 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10. Default for Eastern Europe, 24 °C average temperature.
Non-dairy cattle	18.00	
Swine (breeding)	11.00	

For direct N_2O emissions from manure management (3.A.2): Two parameters are needed for each livestock species to calculate nitrous oxide emissions from manure management: The Nitrogen excretion rate per head, and the typical animal mass. Default values are provided by region and were adopted as per the recommendation of national experts (Table 49).

In addition, 2 other parameters are needed per animal species and per manure management systems: the fraction of Nitrogen loss in the manure management system, and the amount of N in organic bedding. According to the 2006 IPCC guidelines, the amount of N bedding in manure management systems vary according to bedding materials. The following values are suggested: for dairy cattle, 7 kg N per animal per year, for non-dairy cattle, 4 kg N per animal per year, for breeding swine, 5.5 kg N per animal per year. The IPCC software mentions that N for organic bedding should be considered 0 unless for the following 2 manure management systems: deep bedding and solid storage. For sheep and goat in solid storage, the same value as non-dairy cattle were considered.

Emission factors for direct N_2O emissions from manure management systems are presented in Table 50. As per the 2006 IPCC guidelines, emissions from pasture range and paddock are not reported under manure management, but rather in category 3.C.

Table 49 - Nitrogen excretion rate for animal species (kg of N per 1,000 kg of animal mass per day) and typical animal mass for livestock categories (kg/animal)

	N excretion rate per head (kg of N per 1,000 kg of animal mass per day) *	Regional characteristics	Typical animal mass (kg/animal) **	Regional characteristics
Dairy cattle	0.48	Western Europe	600.00	Western Europe
Non-dairy cattle	0.36	Latin America	420.00	Western Europe
Sheep	1.17	Middle East	28.00	Developing countries
Goats	1.37	Middle East	30.00	Developing countries
Camels	0.46	Middle East	217.00	Developing countries
Horses	0.46	Middle East	238.00	Developing countries
Mules and asses	0.46	Middle East	130.00	Developing countries
Swine (breeding)	0.42	Western Europe	28.00	Western Europe
Laying hens	0.96	Western Europe	1.80	EFDB – IPCC software 2.54
Traditional chicken	0.83	Western Europe	1.80	EFDB – IPCC software 2.54
Broilers	1.10	Western Europe	0.90	EFDB – IPCC software 2.54

*Source: Table 10.19 page 10.59 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10
**Source: Tables 10 A-4 to 10 A-8 page 10.77 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10

Table 50 - Fraction of Nitrogen loss in manure management system ($Frac_{LossMS}$)

Animal type	Manure management system	$Frac_{LossMS}$	Source
Swine	Solid storage	0.50	Table 10.23 page 10.67 of IPCC 2006 volume 4 (part 2) chapter 10
Dairy cattle	Anaerobic lagoon	0.77	
	Liquid slurry	0.40	
	Solid storage	0.40	
	Daily spread	0.22	
Poultry	Poultry without litter	0.55	
	Poultry with litter	0.50	
Other Cattle	Solid storage	0.50	
Other	Solid storage	0.15	

Table 51 - Emission factors for Nitrous Oxide emissions for each utilized manure management system in Lebanon

Manure management system	Emission Factor (kg N_2O-N/kg N excreted)	Source
Anaerobic lagoons	0.000	Table 10.21 page 10.62 of 2006 IPCC guidelines, volume 4 (part 2) chapter 10
Liquid systems	0.000	
Solid storage and drylot	0.020	
Poultry with bedding	0.001	
Poultry without bedding	0.001	
Daily spread	0.000	

5.2.3 Description of flexibility if applied

Detailed information on flexibility provisions implemented within the current submission is presented in Table 5.

5.2.4 Uncertainties and time series consistency

Uncertainties for this category has been calculated based on default uncertainties provided in the IPCC 2006 guidelines (Table 52).

Table 52 - Emission factors for Nitrous Oxide emissions for each utilized manure management system in Lebanon

Category for uncertainty	Activity Data Uncertainty (+-)	Emission factors uncertainty (+-)
3.A - Livestock	62% dairy cows, other cattle, sheep, goats, camel, swine and poultry 20% for remaining livestock categories	For CH_4 20% all livestock categories For N_2O - 50% dairy cows, other cattle, sheep, goats, camel swine and poultry 20% for remaining livestock categories
3.C.1 Biomass burning	14%	70%
3.C.3 Urea Application	20%	60%
3.C.4 - Direct N_2O Emissions from managed soils	20%	60%
3.C.5 - Indirect N_2O Emissions from managed soils	20%	80%
3.C.6 - Indirect N_2O Emissions from manure management	20%	70%

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

5.2.5 Category specific QA/QC

The calculation of emissions from Livestock relied on activity data provided from the FAO statistics since no data was made available from official channels. To enhance accuracy and minimize errors, QA/QC measures included automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies.

Other QA/QC procedures included involve updating and specifying activity data (AD) and emission factors (EFs) according to the 2006 IPCC Guidelines and integrating them into spreadsheets that align with CRF tables. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

Specific QA/QC measures included verifying the accuracy of livestock population statistics with stakeholder consultations, and cross-checking emission factors used for enteric fermentation and manure management with other reports in the region. The dairy cattle emission factor is higher than the default for the region. The differences are due to the different manure management systems in these regions which impacts the MCF. The situation is similar for the emission factor for swine. The other cattle emission factor is much lower than the default value for the region.

The inventory process is continuously refined based on recommendations from international experts. The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

5.2.6 Category-specific recalculations

No recalculations were done under this category.

5.2.7 Category specific planned improvements

Although this is a key category, GHG emissions are relatively small with respect to the national total and therefore, limited improvements are planned at this stage, which include the improvement of consistency in livestock data series between MoA and FAOStat and the development and implementation of a survey on manure management systems.

In addition and based on the recommendations of the review exercise conducted under the BTR1, the EF for manure management should be revised to better reflect Lebanon's temperature- enteric and Nex rates – to ensure consistency and reflect national circumstances.

From an institutional side, through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the agriculture sector. The agriculture task force, composed of the main stakeholders of the agriculture sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

5.3 Aggregate sources and non-CO_2 emissions sources on land (3.C) (CRT 3.D, 3.F, 3.G-J and 4(IV))

5.3.1 Category description

There are significant emissions of non-CO_2 from biomass burning, livestock and manure management, or soils. Biomass burning (3.C.1) is treated as a disturbance that affects not only the biomass (in particular, above-ground), but also the dead organic matter (litter and dead wood). Emissions (CO_2 and non-CO_2) need to be reported for all fires (prescribed fires and wildfires) on managed lands, with the exception of CO_2 from grassland.

Emissions of N_2O from managed soils (3.C.4 and 3.C.5) 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 emissions of N_2O from soils are based on the amount of N applied to soils from the following sources:

- Managed soils: Synthetic Fertilizers F_{SN}
  - Organic N applied as fertilizer: F_{ON} (animal manure, sewage sludge, composting).
  - N in crop residues: F_{CR}
  - N mineralization: F_{SOM}
- Drainage/management of organic soils: F_{OS}. According to expert judgement, no organic soils exist in Lebanon as per the IPCC guidelines definition (i.e. 12 to 20% of organic matter content per mass). Soils in Lebanon do not contain more than 5% organic matter. Therefore, this category is reported as Not Occurring.
- Nitrogen contained in urine and manure deposited by grazing animals: F_{PRP}

Indirect nitrous oxide emissions also occur from all the categories above except the F_{OS}. Indirect emissions occur when nitrogen moves away from the site where it was deposited and is converted into N_2O somewhere else. This phenomenon is referred to as nitrogen loss by volatilization and/or leaching and runoff.

Finally, CO_2 emissions occur during application of fertilization of soils with Urea, due to a loss of CO_2 that was fixed in the industrial production process.

5.3.2 Methodological issues

For emissions from biomass burning (3.C.1): Under the Tier 1 approach, the Equation 2.27 was used to estimate CO_2 and non-CO_2 emissions from fire, using the default data. 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. Annual Sentinel 2-A imagery acquired in the post-fire season of the same year were employed to delineate burnt areas. Delineated areas are clipped to the land cover land use map of Lebanon to identify the type of forest cover, cropland and grassland affected by fires.

For CO_2 emissions from urea applications (3.C.3): Since this is not a key category, Tier 1 equation 11.13 was used where the amount of urea applied in tonnes was used with CO_2 default emission factor.

For direct N_2O emissions from managed soils (3.C.4): the Tier 1 methodology consists in estimating the amount of nitrogen added to soils from each source. Each group has a unique emission factor that is multiplied by the total amount of N applied. Then the three estimates of the three groups are added for the total direct N_2O emissions from soils as per equation 11.1. The Tier 1 methodology assumes that N_2O emissions occur the year the N is added to soils. Tier 2 methodology was not adopted since this is not a key category and information on conditions under which N is applied/deposited is not available.

- To calculate the amount of N in synthetic fertilizers applied to soils (F_{SN}): multiply amount of Nitrogenous fertilizers by the fraction of N content (p.11.12 of IPCC 2006 volume 4 (part 2) chapter 11)

- To calculate the amount of N from organic N additions applied to soils (F_{ON}): equation 11.3 and equation 11.4.

  - The amounts of N in sewage sludge (F_{SEW}) and composting (F_{COMP}) were not considered as there is no information on the Nitrogen content of the sludge and compost. According to expert judgements, the amounts of imported compost decrease over time as more local compost is used. The imported compost is often not fully rotted, so further rotting on the field might take place depending on conditions. Improvement on information related to F_{SEW} and F_{COMP} is needed and is included in the improvement plan in the subsequent section.

  - The IPCC guidelines do not provide a method for estimating other organic amendments which should be included in F_{ON}. the MoA does not have these figures either. Therefore, the emissions from this subcategory are Not Estimated.

  - Other than compost, the amount of N in animal waste that is intentionally applied to soils should also be included here (F_{AM}), and this figure does not include manure that is deposited by grazing animals. This value is calculated using the equation 10.34. In addition to data and parameters already used for calculating emissions from the manure management category (number of livestock, annual average excretion rate per animal, fraction of total annual N excretion for each livestock category that is managed in each manure management system), two additional parameters are needed: Fraction of managed N manure for livestock species that is lost in the manure management system ($Frac_{LOSS}$) and amount of nitrogen from bedding ($N_{beddingMS}$, to be applied only for solid storage and deep bedding systems)

- To calculate the amount of N from crop residues (F_{CR}): equation 11.6. the following parameters are needed for each crop type: dry weight correction of crop yield (equation 11.7), the area of the crop, the above ground residue (R_{AG}) and below ground residue (R_{BG}) (equations page 11.14, the N content of the above ground residue (N_{AG}) and below ground residue (N_{BG}), the fraction of crop area that is renewed ($Frac_{RENEW}$), the fraction of above-ground residue removed from field. No data is available on the practice of removing residues, therefore fractions were adopted by expert judgement.

- To calculate the amount of N in urine and dung deposited by grazing animals (F_{PRP}): equation 11.5. parameters needed for this equation have been determined in the manure management category.

For indirect N_2O emissions from managed soils (3.C.5): the same quantities of N calculated for direct N_2O emissions are used for indirect emissions (F_{SN}, F_{ON}, and F_{PRP} for volatilization, and F_{SN}, F_{ON}, and F_{PRP} F_{SOM} and F_{CR} for leaching and runoff). In addition, default values for the fractions of F_{SN} that volatizes ($Frac_{GASF}$) and of F_{ON} and F_{PRP} that volatizes ($Frac_{GASM}$) are needed to calculate indirect emissions of N volatilized as per equation 11.9. The fraction of N lost through leaching and runoff ($Frac_{LEACH}$) is needed to calculate indirect N_2O emissions from N leaching and runoff as per equation 11.10.

For indirect N_2O emissions from manure management (3.C.6): nitrogen losses due to volatilisation from manure management was calculated as per equation 10.26, using the values for the fraction of managed nitrogen manure that volatizes per species and per manure management species ($Frac_{GasMS}$) from the list of defaults provided in the 2006 IPCC guidelines, in addition to data identified for direct N_2O emissions. The default emission factor for N volatilisation and redeposition was adopted. Total indirect N_2O emissions from manure management was calculated as per equation 10.27.

Activity data

Biomass burning

Biomass burning in Lebanon is limited to Forestland and Grassland, where data is actually available. The biomass density (tonnes/m³) is taken as an average of biomass densities of the main tree species occurring in a Forest land subcategory. A weighted average of the biomass densities of all tree species constituting over 3% of the forest land subcategories were calculated to yield the final biomass density of Broadleaved and Coniferous forests, whereas the biomass density of the Mixed forests is the average of the biomass densities of the Broadleaved and Coniferous forests.

The percent of different tree species within the forest land subcategories is based on FAO (2005) and the biomass densities of the different species are taken from the IPCC 2006 Table 4.14, and Aksu et al., 2001. The land use classes in 1998 are subdivided into the Prometheus fuel type classes. The back mapping of the Prometheus fuel type classes is used to the Rothermel fuel models and fuel quantity.

Table 53 - Area of burned biomass (ha)

Year	Area of Forestland burned	Area of Grassland burned	Ares of Cropland burned
2011	148	182	585
2020	3,023	3,050	1,065
2021	2,102	520	215
2022	228	71	51

Amount of N in synthetic fertilizer applied to soils (F_{SN}):

The types of fertilizers applied to soils in Lebanon are: Urea, Ammonium Sulphate, Ammonium Nitrate, Calcium Nitrate, different combinations of NPK, Di-ammonium Phosphate, Mono-ammonium Phosphate. In addition, Urea Phosphate, Potassium Nitrate and Calcium Ammonium Nitrate are also applied although not reported in previous inventories due to lack of activity data. These have been added to the current inventory reported in BTR1.

It is believed that Sodium Nitrate was also used as a fertilizer in the past. However, since the adoption of Ministerial decision on fertilizer (decision number 507/1 of June 2012) which stipulates that any fertilizer that contains more than 3% of Sodium is forbidden of import, import of Sodium Nitrate has completely stopped since 2013, because Sodium Nitrate contains 26% of Sodium. Sodium is deteriorating to organic matter in the soil and destroys the clay-hummus complex in it.

In previous GHG inventories, emissions of Sodium Nitrate were estimated. This inventory reports emissions under Sodium Nitrate as Not Occurring starting the year 2013.

According to experts, there is no nitrogen fertilizer production in Lebanon. Therefore, all nitrogen fertilizer applied to soil is imported. It is assumed that the amount imported in a given year is entirely applied to soils in the same year.

Data for urea and synthetic fertilizer was retrieved from the customs online database. For fertilizers composed of several nitrogenous compounds, total imports were divided by 2 as per stakeholder recommendation since import quantities reported under HS code 31.02.80 include both ammonia and urea.

Table 54 - Types of fertilizers and their Nitrogen content used in Lebanon and corresponding HS code and adjustments applied to data

Type of fertilizer	HS code	Adjustments applied to data	N content
Urea	3102.10	Total imports	0.46
Ammonium sulphate	3102.21	Total imports	0.21
Ammonium nitrate	3102.60	Total imports divided by 2	0.35
	3102.80	Total imports divided by 2	
	3102.30	Total imports	
Sodium nitrate	3102.50	Total imports	0.16
Calcium nitrate	3102.60	Total imports divided by 2	0.16
NPK	3105.20	Total imports	0.17
di-ammonium phosphate	3105.30	Total imports	0.18
Mono ammonium phosphate	3105.40	Total imports	0.11
Urea phosphate	3105.59	Total imports	0.18
Calcium ammonium nitrate	3102.90	Total imports	0.26
Potassium nitrate	3105.90	Total imports	0.13

Table 55 - Breakdown of total amount of nitrogenous synthetic fertilizers used in Lebanon per type of fertilizer for selected years (in tonnes) and corresponding F_{SN}

Year	Urea	Ammonium Sulphate	Ammonium Nitrate	Sodium Nitrate	Calcium Nitrate	NPK	Di-ammonium
2011	7,937	26,954	3,475	10	3,095	40,000	1,817
2020	15,044	25,857	2,998	0	2,156	15,578	1,552
2021	4,664	16,626	998	0	987	15,884	176
2022	3,119	16,302	588	0	530	13,038	1,316

Table 56 - Breakdown of total amount of nitrogenous synthetic fertilizers

Year	Mono-ammonium	Calcium Ammonium Nitrate	Urea Phosphate	Potassium Nitrate	Amount of Synthetic Fertilizer applied to soil	Nitrogen content (F_{SN})
2011	546	-	-	-	83,833	18,3411
2020	1,512	2,178	145	470	67,490	17,570
2021	1,823	1,750	246	664	43,818	9,742
2022	417	2735	607	1,369	40,021	8,711

Amount of N in crop residues:

Production data for the different types of crops in Lebanon was collected on a wet matter basis and converted to dry matter as per the IPCC guidelines. Data on area cultivated per type of crop was completed using the FAOSTAT data base (under the domain Production\crops\ (name of crop)\production quantity), as data was not readily available at the MoA.

Table 57 - Crop production (in tonnes) per crop type and total amount of N in crop residues (F_{CR})

	Dry beans	Green beans	Broad horse beans	Chickpeas	Alfalfa	Lentils	Lupins	Dry peas	Green peas	Vetches	Barley
2011	743	25,000	126	3,547	30,000	1,893	132	2,500	4,371	720	30,000
2020	3,460	15,734	360	3,080	20,000	1,530	101	3,570	10,710	452	31,000
2021	3,771	15,414	362	1,978	20,000	1,424	100	3,509	10,644	453	30,000
2022	2,816	15,564	270	3,063	20,000	1,291	99	3,832	8,354	460	30,000

Table 58 - Crop production in tonnes per crop type and total amount of N

	Maize	Oats	Sorghum	Wheat	Carrots	Garlic	Onions	Potatoes	F_{CR} Total (kg N/year)
2011	3,000	183	450	125,000	5,106	2,837	86,657	275,000	2,605,036
2020	3,000	150	320	140,000	5,300	2,860	69,160	628,410	3,172,134
2021	3,000	140	322	100,000	4,388	2,389	61,535	659,480	2,942,759
2022	3,000	111	285	100,000	4,234	2,763	74,278	676,469	2,958,401

Emission factors and other parameters

For emissions from biomass burning (3.C.1):.

Table 59 - Emission Factors from biomass burning

Emission factors (g/kg dm burnt)		Reference
CH_4 Emission factor	4.70	Default value in IPCC 2006 table 2.5 for "extra tropical forest", Considering the note in table 2.5: the extra tropical forest includes all other forest types
N_2O Emission factor	0.26	

Table 60 - Parameters and assumptions from biomass burning

Parameter	Acronym	Value	Reference	Note
Mass of fuel available for combustion (Forestland)	MB	Broadleaf 9.5 (tonnes/ha)	The values for MB are derived from the back mapping of the Prometheus fuel type classes to the Rothermel fuel models and fuel quantity	
		Coniferous 30 (tonnes/ha)		
		Mixed 12.5 (tonnes/ha)		
Combustion factor (forest land)	C	0.74	Default IPCC 2006 table 2.6	for Other temperate forests, felled and burned
Mass of fuel available for combustion (Grassland)	MB	5 tonnes/ha		
Combustion factor (Grassland land)	Cf	0.74	Default IPCC 2006 table 2.6	for Shrublands

Parameter	Acronym	Value	Reference	Note
Mass of fuel available for combustion (cropland)	MB	4.6 tonnes/ha		All savannas woodland (mid/late dry season burn)
Combustion factor (Cropland)	Cf	0.74	Default IPCC 2006 table 2.6	All savannas woodland (mid/late dry season burn)

For CO_2 emissions from urea applications (3.C.3):

The emission factor for carbon emissions from Urea fertilization is 0.2 tonne of C per tonne of Urea (Source: 2006 IPCC guidelines, page 11.34).

For direct N_2O emissions from managed soils (3.C.4):

Parameters per crop type are presented below. In addition, the fraction of crop residue that is renewed annually was assumed to be 1 as recommended by the 2006 IPCC guidelines (page 11.14).

Table 61 - Type of crops in Lebanon and related parameters

Crop	Type as listed in Table 11.2 of 2006 IPCC guidelines	Fraction for dry matter	N_{AG}	N_{BG}	*$Frac_{REMOVE}$
Dry beans	Individual	0.90	0.010	0.010	0.90
Green beans	Beans and pulses	0.91	0.008	0.008	0.20
Broad, horse beans	Beans and pulses	0.91	0.008	0.008	0.80
Chickpeas	Beans and pulses	0.91	0.008	0.008	0.90
Alfalfa	Individual	0.90	0.027	0.019	0.70
Lentils	Beans and pulses	0.91	0.008	0.008	0.90
Lupins	Beans and pulses	0.91	0.008	0.008	0.90
Dry peas	Beans and pulses	0.91	0.008	0.008	0.90
Green peas	Beans and pulses	0.91	0.008	0.008	0.20
Vetches	Beans and pulses	0.91	0.008	0.008	0.80
Barley	Individual	0.89	0.007	0.014	0.80
Maize	Individual	0.87	0.006	0.007	0.70
Oats	Individual	0.89	0.007	0.008	0.70
Sorghum	Individual	0.89	0.007	0.006	0.70
Wheat	Individual	0.89	0.006	0.009	0.80
Carrots	Root crop	0.94	0.016	0.014	0.80
Garlic	Root crop	0.94	0.016	0.014	0.70
Onions	Tuberous	0.22	0.019	0.014	0.20
Potatoes	Individual	0.22	0.019	0.014	0.00

*Expert judgement as published in BUR1

Parameters related to calculations of direct N emissions from F_{ON} are presented in Table 62. The amount of N bedding in manure management systems vary according to bedding materials. N for organic bedding should be considered 0 unless for the following 2 manure management systems: deep bedding and solid storage.

Table 62 - Fraction of managed N manure lost and amount of N bedding per animal and manure management system

Species	Manure management system	Fraction of managed N manure lost ($Frac_{LossMS}$)	Amount of N bedding (Kg N per animal per year) **
Swine	Solid storage	0.50	5.50
Dairy cattle	anaerobic lagoon	0.77	0.00
	liquid slurry	0.40	0.00
	solid storage	0.40	7.00
	daily spread	0.22	0.00
Poultry	Poultry without litter	0.55	0.00
	Poultry with litter	0.50	0.00
Non-dairy cattle	Solid storage	0.50	4.00
Other	Solid storage	0.15	4.00

*Source: Table 10.23 page 10.65 of IPCC 2006 volume 4 (part 2) chapter 10
**Source: page 10.66 of 2006 IPCC guidelines volume 4 (part 2) chapter 10

Three emission factors are needed to calculate direct N_2O emissions from the different types on Nitrogen input to managed soils as presented in Table 63.

Table 63 - Emission factors for direct N_2O emissions from managed soils (kg N_2O-N per kg N)

	Emission Factor	Source
EF1 for N additions from mineral fertilizers. crop residues	0.01	Table 11.1 page 11.11 of IPCC 2006 volume 4 (part 2) chapter 11
$EF3_{PRP}$, CPP for cattle, poultry and pigs	0.02	
$EF3_{PRP}$, SO for sheep and “other animals”	0.01	

For indirect N_2O emissions from managed soils (3.C.5):

Table 64 - Factors and parameters used for the calculation of indirect N_2O emissions

Fraction of Synthetic Fertilizer Applied Emitted as NO_x and NH_3 ($Frac_{GASF}$)	0.1 kg of N /kg of N applied	Table 11.3 page 11.24 of IPCC 2006 volume 4 (part 2) chapter 11
Fraction of F_{ON} and F_{PRP} that volatizes ($Frac_{GASM}$)	0.2 kg of N /kg of N applied	
Fraction of N that is leached or runoff	0.3 kg of N /kg of N applied	
EF4 (N volatilization and redeposition)	0.010 kg of N /kg of N volatilized	
EF5 (leaching and runoff)	0.0075 kg of N /kg of N leached or runoff	

For indirect N_2O emissions from manure management:

In addition to $Frac_{GasMS}$ presented in the below table, EF_4 is used to calculate indirect N_2O emissions from manure management.

Table 65 - Fraction of managed manure nitrogen for livestock category T that volatizes as NH_3 and NO_x in the manure management system

Species	Manure management system	Fraction of livestock manure nitrogen that volatizes ($Frac_{GasMS}$)	Source
Swine	solid storage	0.45	Table 10.22 page 10.65 of IPCC 2006 volume 4 (part 2) chapter 10
Dairy cattle	anaerobic lagoon	0.35	
	liquid slurry	0.40	
	solid storage	0.30	
	daily spread	0.07	
Poultry	poultry without litter	0.55	
	poultry with litter	0.40	
Non-dairy cattle	solid storage	0.45	
Other	solid storage	0.12	

5.3.3 Description of flexibility if applied

No flexibility provision has been applied.

5.3.4 Uncertainties and time series consistency

Uncertainties related to biomass burning is estimated at ±14% and related to the CH_4 emission factor is estimated at ±70%.

Uncertainties related to urea application is ±20% for activity data and ±60% for CO_2 emission factor.

Uncertainties related to activity data for direct and indirect N_2O emissions are considered to be ±20% and uncertainties associated with the N_2O emission factors is estimated may reach up to ±60% for direct N_2O emissions and ±80% for indirect N_2O emissions.

Uncertainties related to activity data related to N_2O emissions from manure management are considered to be ±20% and for the emission factor, it may reach up to ±70%.

5.3.5 Category specific QA/QC

The same QA/QC measures implemented for livestock were also adopted for the aggregate sources of non-CO_2 emissions of solid waste. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

5.3.6 Category-specific recalculations

No recalculations have been undertaken under this category.

5.3.7 Category specific planned improvements

Although this is a key category, GHG emissions are relatively small with respect to the national total and therefore, limited improvements are planned at this stage. Potential improvements include obtaining more accurate data on nitrogen fertilizers imports though the homogenization of the MoA and Customs systems and data on the quantities of compost applied to soils.

In addition, through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the agriculture sector. The agriculture task force, composed of the main stakeholders of the agriculture sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

6. Land Use, Land Use Change and Forestry (CRT 4)

6.1 Overview of the sector

As of 2022, Lebanon's Land Use, Land Use Change, and Forestry (LULUCF) sector played a crucial role in sequestering CO_2, serving as a net sink with removals amounting to -3,245 Gg CO_2. This net removal is primarily associated with changes in vegetation cover within forest lands, croplands, and grasslands. Total GHG removals from the LULUCF increased from 2019 (6%) (Figure 21) mainly due to decrease in Land conversion to settlements and in forest fires during this period.

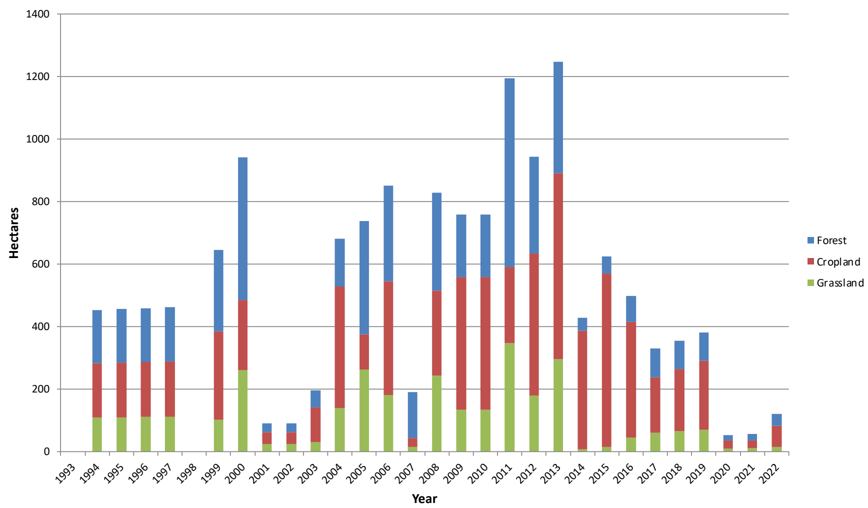


Figure 21: Land conversion to settlements during the 1994-2022 period

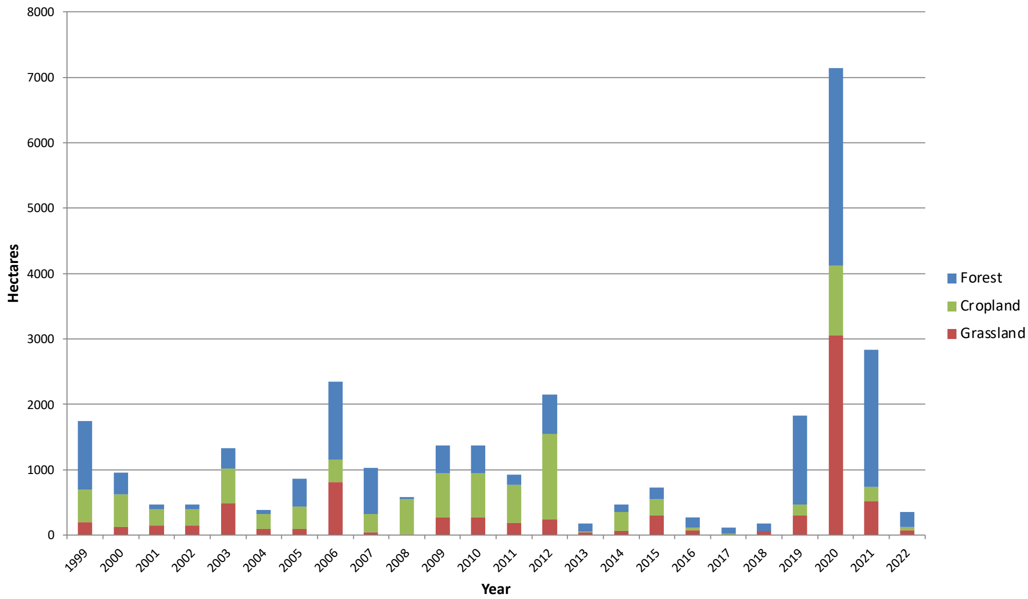


Figure 22: Burned areas during the 1994-2022 period

The forestry sector remains a vital component of Lebanon's carbon mitigation efforts, acting as a significant CO_2 sink. However, multi-temporal trends indicate a decline in sink capacities. This decline can be attributed to several key factors, including deforestation, forest fires, and notably, urbanization (even though a significant decrease in land conversion to settlement was observed between 2019 and 2022). The expansion of urban areas has led to the conversion of forest lands, croplands, and grasslands into settlements, contributing significantly to emissions and impacting the overall carbon balance.

The ongoing economic and monetary crisis in Lebanon has further exacerbated challenges in the LULUCF sector. Economic pressures may influence land-use decisions, potentially leading to increased deforestation and land-use changes. Additionally, the crisis may affect the capacity for sustainable forest management and conservation efforts.

One notable consequence of these challenges is the rise in fuelwood gathering, driven by economic hardships. As communities face difficulties accessing conventional energy sources, there is an increased reliance on wood for heating and cooking purposes. This shift in behavior poses additional pressures on forests and can contribute to further degradation and loss of forested areas.

In summary, while Lebanon's LULUCF sector continues to play a pivotal role as a carbon sink, the challenges stemming from deforestation, urbanization, and economic crises pose significant threats. Sustainable land management practices and conservation efforts are crucial to reversing the deteriorating trend in sink capacities and ensuring the resilience of Lebanon's ecosystems in the face of ongoing challenges.

Table 66 - Total inventory 3.B. LULUCF for 2022

Categories	Net CO_2 emissions / removals (Gg)
3.B - Land	-3,245.560
3.B.1 - Forest Land	-2,046.100

Categories	Net CO_2 emissions / removals (Gg)
3.B.1.a - Forest Land Remaining Forest Land	-2,015.400
3.B.1.b - Land Converted to Forest Land	-30.700
3.B.1.b.i - Cropland converted to Forest Land	NE
3.B.1.b.ii - Grassland converted to Forest Land	IE
3.B.1.b.iii - Wetlands converted to Forest Land	NO
3.B.1.b.iv - Settlements converted to Forest Land	NO
3.B.1.b.v - Other Land converted to Forest Land	-30.700
3.B.2 - Cropland	-1,218.680
3.B.2.a - Cropland Remaining Cropland	-1,218.680
3.B.2.b - Land Converted to Cropland	
3.B.2.b.i - Forest Land converted to Cropland	NO
3.B.2.b.ii - Grassland converted to Cropland	NE
3.B.2.b.iii - Wetlands converted to Cropland	NO
3.B.2.b.iv - Settlements converted to Cropland	NO
3.B.2.b.v - Other Land converted to Cropland	NE
3.B.3 - Grassland	-0.009
3.B.3.a - Grassland Remaining Grassland	0.000
3.B.3.b - Land Converted to Grassland	-0.009
3.B.3.b.i - Forest Land converted to Grassland	-0.009
3.B.3.b.ii - Cropland converted to Grassland	NE
3.B.3.b.iii - Wetlands converted to Grassland	NO
3.B.3.b.iv - Settlements converted to Grassland	NO
3.B.3.b.v - Other Land converted to Grassland	NE
3.B.4 - Wetlands	NO
3.B.4.a - Wetlands Remaining Wetlands	NO
3.B.4.a.i - Peatlands remaining peatlands	NO
3.B.4.a.ii - Flooded land remaining flooded land	
3.B.4.b - Land Converted to Wetlands	NO
3.B.4.b.i - Land converted for peat extraction	
3.B.4.b.ii - Land converted to flooded land	NO
3.B.4.b.iii - Land converted to other wetlands	
3.B.5 - Settlements	19.240
3.B.5.a - Settlements Remaining Settlements	0.000
3.B.5.b - Land Converted to Settlements	19.240
3.B.5.b.i - Forest Land converted to Settlements	9.610
3.B.5.b.ii - Cropland converted to Settlements	9.620
3.B.5.b.iii - Grassland converted to Settlements	0.005
3.B.5.b.iv - Wetlands converted to Settlements	NO
3.B.5.b.v - Other Land converted to Settlements	NE
3.B.6 - Other Land	0.000

Categories	Net CO_2 emissions / removals (Gg)
3.B.6.a - Other land Remaining Other Land	
3.B.6.b - Land Converted to Other Land	0.000
3.B.6.b.i - Forest Land converted to Other Land	NO
3.B.6.b.ii - Cropland converted to Other Land	NO
3.B.6.b.iii - Grassland converted to Other Land	NO
3.B.6.b.iv - Wetlands converted to Other Land	NO
3.B.6.b.v - Settlements converted to Other Land	NO

The present section covers the following FOLU subcategories:

- 3.B.1 Forest land
- 3.B.2 Cropland
- 3.B.3 Grassland
- 3.B.4 Wetland
- 3.B.5 Settlements
- 3.B.6 Other land

6.2 Land-use definitions and the land representation approach(es) used and their correspondence to the land use, land-use change and forestry categories (e.g. land use and land-use change matrix)

Information on the classification of land used is presented in Annex V

6.3 Country-specific approaches

6.3.1 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation.

In the preparation of land areas under the LULUCF sector, robust methodologies were adopted, and comprehensive land-use databases were leveraged. This approach ensured an accurate representation of land use and land-use changes, which are critical for estimating emissions and removals associated with land use.

The adopted approach for representing land areas is anchored in the use of advanced remote sensing techniques. The following strategies were employed:

- Landsat Satellite Imagery: Annual Landsat satellite images were utilized. This provided acceptable resolution data crucial for detailed land-use analysis at the national level. The temporal frequency of these images allowed for the monitoring of subtle changes in land cover and land use over time.
- Object-Based Image Analysis (OBIA): This advanced image analysis technique was used to process Landsat images. Unlike traditional pixel-based analysis, OBIA considers the shape, texture, and contextual relationship of objects (or groups of pixels), leading to a more accurate classification of land cover categories. This method is particularly effective in distinguishing between different land uses and detecting changes.

Primary databases for land-use information include:

- Land Cover Land Use Map of Lebanon (1998): This initially served as the baseline for the land-use analysis. The 1998 map provides a comprehensive overview of land-use distribution at the starting point, enabling us to track changes effectively.
- Annual Satellite Images: Supplementing the 1998 map, these images offer detailed, up-to-date information on land-use categories, changes, and spatial distribution. The integration of these datasets allowed the creation of a dynamic and accurate representation of land-use changes over time.

The integration of historical land-use data with annual satellite imagery in a Geographic Information System (GIS) formed the backbone of the LULUCF inventory. This combination allowed for:

- Tracking Land-Use Changes Over Time: By comparing historical data with contemporary satellite imagery, it was possible to assess the extent and nature of land-use changes.
- Ensuring Accuracy and Consistency: The use of consistent methodologies and data sources across different time periods enhanced the reliability of the conducted assessments.
- Spatial Analysis: The spatial resolution of employed data helped in conducting detailed analyses at various scales, from national down to local levels.

6.3.2 Information on approaches used for natural disturbances, if applicable

Recognizing the significant impact of natural disturbances, particularly wildfires, on land use and carbon stocks, the inventory methodology incorporated a comprehensive approach to monitor, assess, and integrate data on these events. The core of the adopted approach involved regular monitoring of natural disturbances, with a primary focus on wildfires. This monitoring was accomplished through regular mapping of events: regular mapping of land areas to promptly detect the occurrence and extent of wildfires was undertaken. This enabled to quickly assess the extent and severity of these disturbances.

To ensure comprehensive analysis, mapping results from satellite data were integrated into the inventory system:

- Sentinel 2-A Imagery: Satellite observations from Sentinel 2-A provided high-resolution imagery (10 m resolution), crucial for accurately delineating burnt areas. The impact on different vegetation types such as coniferous, broadleaf, mixed forests, croplands, and grasslands was assessed
- Application of Default Emission Factors: To quantify the emissions or removals resulting from natural disturbances default Emission Factors were mostly used.

6.3.3 Information on approaches used for reporting harvested wood products

Harvested wood products were not included in the calculation of this inventory since the weren’t automatically transferred from the previous version of the IPCC inventory, and due to time constraints, it wasn’t possible to transfer manually for the whole time series.

6.4 Land (CRT 4)

6.4.1 Category description

There are many factors governing emissions and removals of greenhouse gases that can be both natural and anthropogenic and it can be difficult to clearly distinguish between causal factors. Under the 2006

IPCC guidelines, only anthropogenic GHG emissions and removals are estimated, as all those occur on 'managed land', which is "land where human interventions and practices have been applied to perform production, ecological or social functions" (IPCC, 2007).

The estimation of GHG emissions and removals in 3.B land is divided into two broad categories:

1) methods that can be applied in a similar way for any of the types of land use (i.e., generic methods for Forest Land, Cropland, Grassland, Wetlands, Settlements and Other Land) for estimating ecosystem carbon stock changes as well as for estimating non-CO_2 fluxes from fire,

2) methods that only apply to a single land use or that are applied to aggregate data on a national level, without specifying land use.

6.4.2 Methodological issues

Methodology

The representation of most land-use areas and land conversions was done following the Approach 3 of the IPCC, 2006. The nationally adopted land-use classification system of the Land Cover / Land Use map of 1998 was employed for the inventory estimation. Each land category was further subdivided into lands remaining in the same land use (for example, forest lands remaining forest lands) and lands converted into another land-use category (for example, forest lands converted into croplands) during the inventory period.

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

- Approach 3/Tier 2 methodology within 2006 IPCC guidelines
- Surveys and personal communications
- Interpolations and extrapolation

The tier levels of the activity data acquired by surveys and personal communications depended on the accuracy and completeness of the nationally available estimates. The 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 Tier 1 approach, which employs the basic method, and the default emission factors provided in the IPCC Guidelines, was typically used in these inventory calculations. The Tier 3 approach, which uses higher order methods including models and inventory measurement systems was used for the representation of most land-use areas and land conversions. This allowed the generation of data about land use changes such as forest, croplands and grasslands conversions to settlements as well as the extent of burned areas in forest, croplands and grasslands. It is the most complex, accurate and spatially explicit method, provided by the IPCC guidelines, which ensured the consistency of the inventory calculations.

Multi-temporal satellite images were employed for mapping changes in land cover and land use changes. This included Landsat 8 imagery (1994-2022) The analysis of acquired data comprised mapping and comparing changes in land cover and land use using comparable satellite data of the same spatial resolution and spectral bands.

The global land cover map of 2021 with a resolution of 10 m was employed in combination with the land cover land use map of 2013 to assess changes in forest converted to cropland, forest converted to grassland, forest converted to wetland, cropland converted to wetland and grassland converted to wetland. Annual changes between 2013 and 2021 were calculated using interpolation. These changes remain not estimated for the year 2022 due to lack of updated global and national data.

Table 67 - 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 converted to cropland (2014-2021)	Forest land, Grassland and Other land converted to Cropland	No Settlements converted to Cropland
Grassland	Grassland remaining Grassland	Estimated		
	Land converted to Grassland	Forest converted to grassland (2014-2021)	Cropland, Forest land and other land converted to Grassland	No Settlements converted to Grassland
Wetland	Wetland remaining Wetland	Estimated	Cropland, Forest land and other land converted to wetland	Estimations not required for calculation[2]
	Land converted to Wetland	Grassland converted to wetland – Cropland converted to wetland – Forest converted to wetland		
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
	Land converted to other land	Estimated	Forest land, Grassland and Cropland converted to other land	NO

[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*

Activity data

Data collection was conducted using sources from satellite remote sensing imagery, literature reviews, and surveys. Table 68 represents the type of data sources and databases used in the data collection process. Table 69 represents the Activity Data for the years 2020-2022.

Table 68 - Type of data sources, databases and references used for data collection 1994-2022

Type of data source	Databases
Online database, Global databases	FAOSTAT, IPCC Emission Factor Database, Google Earth Engine
Satellite imagery	Sentinel 2-A imagery (2020-2022) (10 m) Landsat 8 images (2020-2022) (10 m)
Maps	Land Cover Land Use map of Lebanon of 1998 Land Cover Land Use map of Lebanon of 2013 Global Land Cover map of 2021 (10 m)
Surveys and personal communications	AFDC, LRI, Jouzour Loubnan, Oaks and Cedars, Ehden Nature Reserve, University of Balamand, FAO SALMA project, Akkar Trail, and the Souf Biosphere Reserve

Table 69 - Activity Data for selected years

	2011	2020	2021	2022
Forest Land remaining Forest Land (ha)	254,771.12	253,846.44	254,074.35	254,342.15
Coniferous	34,887.56	34,784.10	34,783.09	34,780.60
Broadleaf	193,467.06	192,190.36	192,115.97	192,084.38
Mixed	26,416.50	26,871.98	27,175.29	27,477.17
Annual volume of fuelwood gathering (m^3)		28,308.70	28,308.70	28,308.70
Non-Coniferous		22,810.15	22,810.15	22,810.15
Coniferous		5,498.55	5,498.55	5,498.55
Cropland remaining Cropland (ha)	329,415.12	326,736.70	326,754.55	326,686.84
Perennial	159,376.06	158,761.59	158,800.64	158,769.51
Annual	170,039.06	167,975.11	167,953.92	167,917.33
Forest converted to cropland	NE	52.00	52.00	NE*
Grassland remaining Grassland (ha)		314,880.02	314,864.85	314,849.19
Forest converted to Grassland	NE	3.49	3.49	NE
Wetland remaining Wetland (Ha)		638.97	656.43	656.43
Land converted to wetland	0	17.46	17.46	NE
Grassland converted to wetland	0	6.37	6.37	NE
Cropland converted to wetland	0	9.32	9.32	NE
Forest converted to wetland	0	1.77	1.77	NE
Other Land remaining Other Land (ha)	46127.28	44,160.27	43,798.71	43,334.60
Forest Land disturbances (forest fires) By forest type (ha)	161.13	3,023.78	2,102.71	228.10
Coniferous	14.63	322.28	631.87	37.39
Broadleaf	133.56	2,457.79	1,300.91	35.55
Mixed	12.94	243.71	169.93	155.16
Grassland burned (ha)	182.38	3,050.39	520.00	71.44
Cropland Burned (ha)	585.19	1,065.68	215.15	51.77
Land converted to Settlements	1,195.00	53.72	56.95	120.55
Forest Land to Settlements (ha)	603.94	18.04	19.83	37.19
Coniferous	55.88	0.27	1.01	2.48
Broadleaf	495.50	15.67	17.13	31.59
Mixed	52.56	2.11	1.69	3.11
Grassland to Settlements (ha)	348.25	9.83	12.29	15.65
Cropland to Settlements (ha)	242.88	25.85	24.83	67.71
Perennial	125.63	8.88	12.96	31.13
Annual	117.25	16.96	11.87	36.58
Other land to Forest (cumulative)	2,913.73	4,880.73	5,242.29	5,706.41

**NE: Activity data not estimated for 2022 as the global land cover map of 10 m resolution was available only for 2021*

GHG emissions and removals reported from the FOLU 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 70).

Table 70 - Causes of GHG emissions and removal reported for the land categories

Biomass losses	Biomass increments	Increase in soil carbon stocks and litter
Forest converted to settlement	Growth of forest lands	Afforestation
Grassland converted to settlement	Growth of croplands (Perennial crops)	
Cropland converted to settlement	Growth of lands converted to forests or plantations (Afforestation)	
Forest converted to wetland		
Grassland converted to wetland		
Cropland converted to wetland		
Forest converted to grassland		
Burned forest lands		
Burned croplands (perennial crops)		
Burned grasslands		
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 2006 default data or assumptions
- Tier 2: Country-specific data from global databases, literature or surveys, and personal communications

For CO_2 emissions and removals, complete list of the parameters investigated and reported for the period 1994-2022 as well as the assumptions made are presented in the below tables.

Table 71 - Main emission factors and parameters for 3.B land

Parameter	Symbol	Value(s) used	Reference	Notes
Carbon fraction of dry matter	CF	0.47 tonnes C/tonne dm	Default IPCC 2006 table 4.3	
Forestland				
Ratio of below-ground biomass to above-ground biomass	R	0.27 tonnes root/ tonne shoot	FAO 2005	

Parameter	Symbol	Value(s) used	Reference	Notes
Biomass conversion and expansion factor for conversion of removals in merchantable volume to biomass removals	BCEfr	1.33 coniferous 2.11 broadleaved 1.72 mixed	Table 4.5 IPCC 2006	
Average biomass in forest	B_W	130.00 tonnes dm/ha	Default IPCC 2006 table 4.7	
Aboveground biomass growth in forest	G_W	1.50 tonnes dm/ tonnes shoot	Default IPCC 2006 table 4.9	
Reference carbon stock	SOC_{REF}	38.00	Default IPCC 2006	
Litter carbon stocks of mature forests		20.30 coniferous	Default IPCC 2006 table 2.2	
Relative Stock change factor for land	FLU	0.82	Default IPCC 2006 table 5.5	Experts' surveys J. Stephan
Relative Stock change factor for management	FMG	1.00	Default IPCC 2006 table 5.5	Experts' surveys J. Stepha
Relative Stock change factor for input	FI	1.00	Default IPCC 2006 table 5.5	Experts' surveys J. Stephan
Biomass density	D	0.50 coniferous 0.58 broadleaved 0.54 mixed	FAO 2005 table 4.13 and 4.14	
Fraction of Biomass loss due to disturbance	Fd	0.41	Calculated	Derived from (1-fBl) from the IPCC GPG Table 3A.1.12 by first finding the average of 'All "other" temperate forests' and 'All shrublands' which is 0.585((0.45 + 0.72 / 2=0.585); and then finding Fraction of biomass loss in disturbance (fBl) by substitution (1-fBL=0.585 so fBL=0.415)
Cropland				
Above ground biomass (perennial)	B	134.00 tonnes dm/ha	IPCC 2006 default Model	
Above ground biomass (annual)	B	10.00 tonnes dm/ha	IPCC 2006 default Model	
Reference soil organic carbon stock	SOC	38.00 tonnes C/ha	IPCC 2006 default Model	For high activity clay mineral soil type
Harvest Maturity Cycle		30.00 years	IPCC 2006 default Model	
Biomass carbon loss	DCl	63.00 tonnes C/ha/yr	IPCC 2006 default table 5.1	Assuming climate region "temperate (all moisture regimes)"
Biomass accumulation rate	DCG	2.10 tonnes C/ha/yr		
Inventory time period	T	20.00	IPCC 2006 Default	Lebanon's croplands are long-term cultivated according to Experts' surveys J. Stephan

Parameter	Symbol	Value(s) used	Reference	Notes
Stock change factor for land-use in the last year of inventory time	FLU	0.82	Default IPCC 2006 table 5.5	Lebanon's level of tillage in its croplands is full according to Experts' surveys J. Stephan
Stock change factor for management regime in the last year of inventory time period	FMG	1.00	Default IPCC 2006 table 5.5	Lebanon's level of input of organic matter in its croplands is medium according to Experts' surveys J. Stephan
Stock change factor for input of organic matter in the last year of inventory	FI	1.00	Default IPCC 2006 table 5.5	No organic soils (Expert's surveys, T. Darwish)
Emission factor for climate type c	EF	0.00	IR	
Ratio of below-ground biomass to above-ground biomass after the conversion	R(a)	0.00	Default value	
Grassland				
Stock change factor for land-use in the last year of inventory time period	FLU	1.00	Default IPCC 2006 table 5.5	All levels, All climatic regimes
Stock change factor for management regime in the last year of inventory time period	FMG	0.95	Default IPCC 2006 table 5.5	Lebanon's grasslands are moderately degraded grasslands according to (Darwish and Faour, 2008)
Stock change factor for input of organic matter in the last year of inventory time period	FI	1.00	Default IPCC 2006 table 5.5	Lebanon's level of management inputs in its grasslands is nominal according to Experts' surveys J. Stephan
Ratio of below-ground biomass to above-ground biomass after the conversion	R(a)	0.00	Default value	
Settlements				
Carbon stock in living biomass immediately following conversion to settlements			Default values IPCC 2006	Tier 1 assumes that carbon stocks in living biomass following conversion are equal to zero
Biomass stocks before conversion		Annual crops 10 tonnes dm/ha Perrenial woody crops 134 tonnes dm/ha Gasslands 0 tonne dm/ha Forests 130 tonnes dm/ha	Default values IPCC 2006 Model	
Stock change factor for land-use in the last year of inventory time period	FLU	1.00	Default IPCC 2006 table 5.5	

Parameter	Symbol	Value(s) used	Reference	Notes
Stock change factor for management regime in the last year of inventory time period	FMG	1.00	Default IPCC 2006 table 5.5	
Stock change factor for input of organic matter in the last year of inventory time period	FI	1.00	Default IPCC 2006 table 5.5	
Dead wood/litter stock under the old category (cropland)		0.00	Default IPCC 2006	The Tier 1 method assumes that the dead wood and litter stocks are not present in Cropland or are at equilibrium as in agroforestry systems and orchards. Thus, there is no need to estimate the carbon stock changes for these pools
Dead wood/litter stock under the **new** category		0.00	Default IPCC 2006	The value is taken as a default from the IPCC 2006 as 0 tonne C/ha according to Tier 1 which assumes that carbon stocks in living biomass following conversion are equal to zero
Dead wood/litter stock under the **old** category (forestland)		130.00 tonnes dm/ha	Default IPCC 2006	

Table 72 - Main assumptions for AFOLU - Land Use Categories

Climate region	Warm temperate dry
Soil type	High activity clay mineral
Ecosystem type	Subtropical dry forest
Continent type	Continental
Species Age class	20 years
Growing stock level	Unspecified
Area of Forest remaining forest	The land use classes of 1998 are subdivided here into the three subcategories coniferous, broadleaved, and mixed forests. The class of shrublands is considered to be within the broadleaved forests subcategory since 52% of shrublands are broadleaves, 13% are mixed and only 1% are coniferous (FAO, 2005).
Annually extracted volume of roundwood	According to experts' surveys (Chneis, Stephan, May 2013), no roundwood is extracted from Lebanon. Because of the lack of official data, FAO provides an estimate of commercial roundwood in Lebanon based on the best information available however it was thought more accurate to take into account opinion of national experts.

Biomass density (average weighed)	The Biomass density (tonnes/m3) are taken as an average of biomass densities of the main tree species occurring in a Forest land subcategory. A weighted average of the biomass densities of all tree species constituting over 3% of the forest land subcategories were calculated to yield the final biomass density of Broadleaved and Coniferous forests, whereas the biomass density of the Mixed forests is the average of the biomass densities of the Broadleaved and Coniferous forests. The percent of different tree species within the forest land subcategories is based on FAO (2005) and the biomass densities of the different species are taken from the IPCC 2006 Table 4.14 and Aksu et al., 2001.

Broadleaved forest	Actual percentages in forests	Weighted percentage	**Biomass density of individual species** (tonnes d.m.m-3 fresh volume)	**Average weighted Biomass Density**
Quercus calliprinos	41.10%	46.08	**0.58**	0.26
Quercus infectoria	34.10%	38.22	**0.58**	0.22
Quercus cerris and var. pseudocerris	14.00%	15.70	**0.58**	0.09
Total	89.20	100.00		**0.58**
Coniferous forest	Actual percentages in forests	Weighted percentage	**Biomass density of individual species** (tonnes d.m.m-3 fresh volume)	**Average weighted Biomass Density**
Pinus brutia	43.70	44.86	**0.53**	0.23
Pinus pinea	35.80	36.75	**0.46**	0.18
Juniperus excelsa	9.70	9.95	**0.51**	0.05
Cedrus libani	4.50	4.62	**0.48**	0.02
Juniperus drupacea	3.70	3.79	**0.49**	0.02
Total	97.40	100		**0.50**
Mixed				**0.54**

Mineral soils	There is no data for the values carbon stocks in mineral soils in Lebanon therefore Tier 1 is used, and it assumes that the net change in carbon stocks in mineral soil is zero
Organic soils	There are no organic forest soils in Lebanon according to experts' surveys (Darwish, May 2013) therefore the value of area of drained organic forest soils is equals zero.
Disturbances (Forest fire)	The land use classes in 1998 are subdivided into the Prometheus fuel type classes. The back mapping of the Prometheus fuel type classes is used to the Rothermel fuel models and fuel quantity.

Prometheus fuel type class	Rothermel fuel models	Mass of available fuel (Rothermel averages)
1	1, 2, 3	5 tonnes/ha
2	5	6.5 tonnes/ha
3	6	12.5 tonnes/ha
4	4	30 tonnes/ha
5	8, 9	9.5 tonnes/ha
6, 7	7	12.5 tonnes/ha

No data exists on the amount of vegetation fires on lands converted to Forestlands, therefore they will not be calculated

Annual change in carbon stocks in living biomass	No data exist on losses in forest plantations or afforestation areas; therefore, it is assumed that value is equal to zero.

Other land converted to forest land	The values for area converted to forest land are taken from publications and personal communications with Association for forests, Development and Conservation (AFDC), Lebanese Reforestation Initiative (LRI), FAO-SALMA project, Shouf Biosphere Reserve, Oaks and Cedras, Akkar trail, Jouzour Loubnan, Herch Ehden Nature Reserve, the University of Balamand and reforestation project leaders in Lebanon. Afforestation and reforestation are both considered as Afforestation according to FAO (2010) especially that afforestation is happening on lands that haven't been forests in over 50 years. There is no exact data on the quantity and the type of tree species planted, however through personal communications, it is assumed that the trees planted are mostly coniferous (Chneis, May 2013)
Annual area of cropland with perennial woody biomass	The only sub-categories being accounted for here are the perennial woody crops that have and have not been burnt. Both burned and unburned perennial woody crops make up the total of perennial woody crops.
Land converted to cropland	Forest converted to cropland was assessed for the years 2014 throughout 2021 using interpolation of absolute change between baseline year 2013 and targeted year 2021 (using the global land cover map of 10 m) – Converted Forest land is assumed to be broadleaf and cropland type is assumed to be perennial given no cutting permit is given for conifer forest and no economic use is made from converting forest to annual cropland.
Land converted to grassland	Forest converted to grassland was assessed for the years 2014 throughout 2021 using interpolation of absolute change between baseline year 2013 and targeted year 2021 (using the global land cover map of 10 m) – Converted Forest land is assumed to be broadleaf and cropland type is assumed to be perennial given no cutting permit is given for conifer forest.
Area of grassland covered with grasses	The grasslands category includes only grasses. Grasslands covered with perennial woody biomass are considered shrublands and are included under Forestlands.
Settlements remaining settlements	No estimates will be made for the subcategory settlements remaining settlements due to lack of accurate data.
Land converted to settlements	Land converted to Settlements is calculated for Forest lands in addition to Croplands and Grasslands since enough data was available to do the calculation.
Land converted to wetland	Forest converted to wetland, cropland converted to wetland and grassland converted to wetland were assessed for the years 2014 throughout 2021 using interpolation of absolute change between baseline year 2013 and targeted year 2021 (using the global land cover map of 10 m). Type of forest converted is assumed as broadleaf given no cutting permit is given in conifer forests and cropland converted to wetland is reasonably assumed to be annual.

6.4.3 Description of flexibility if applied

No flexibility provision has been applied, as presented in Table 5.

6.4.4 Uncertainties and time series consistency

Uncertainties are influenced by several factors, primarily due to the need for updated data to accurately estimate GHG removals by forests. The uncertainties in different sections are also affected by the actual volumes of wood harvested by local public authorities and other forest owners. However, there is a lack of precise statistics on the amount of wood harvested, whether through authorized felling or illegal logging. General information in this area is available from authorities, municipalities, and NGOs, but it lacks the detail needed for accurate estimations.

Therefore, uncertainties have been estimated based on stakeholder consultations and expert judgements.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

Table 73 - Uncertainties used for LULUCF

Category for uncertainty	Activity Data Uncertainty (±)	Emission factors uncertainty (±)
4A1 'Forest Land Remaining Forest Land'	15%	5%
4A2 'Land Converted to Forest Land'	15%	5%
Forest land affected by fires	10%	30%
4.B1.1 'Cropland Remaining Cropland'		10%
4B1.2 'Annual Change in Carbon Stocks in Mineral Soils'		10%
4B2 'Land Converted to Cropland'		10% CO_2 30% Non-CO_2 emissions
4C1 'Grassland Remaining Grassland'	15%	10%
4D1 'Wetlands Remaining Wetlands'	10%	10%
4E2 'Land Converted to Settlements'	10%	10%
4G 'Harvested Wood Products'	30%	10%

6.4.5 Category specific QA/QC

The calculation of emissions and removals from LULUCF relied mainly on remote sensing tools and satellite images to assess the changes in land from year to year. and authoritative channels and comparing it with various reference sources. To enhance accuracy and minimize errors, the process incorporates several QA/QC measures including self-monitoring own protocols and data processing procedures.

Automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies.

Special worksheets were developed separately to the IPCC software to calculate land use and land use changes Activity data was then inputted in the IPCC software to calculate emissions and removals.

Other QA/QC procedures included involve updating and specifying activity data (AD) and emission factors (EFs) according to the 2006 IPCC Guidelines and integrating them into spreadsheets that align with CRF tables. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

The inventory process is continuously refined based on recommendations from international experts, addressing issues like data series restoration. The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

6.4.6 Category-specific recalculations

The use of the new IPCC Inventory model which relies on a new methodology, caused differences in yearly emissions at an average of 1.24% for the period 2020-2022. The main reason is the difference in removals from "other land converted to forest land" which takes into consideration the cumulative impact of afforested lands. Due to the technical challenges related to the import of LULUCF removals of the time-series 1994-2019 to the IPCC model version 2.930, recalculations for the complete period were not undertaken.

Table 74 - Difference in LULUCF emissions/removals between different versions of IPCC model

	Net CO2 emissions / removal (Gg CO_2)		
Categories	**IPCC software version 2.690**	**IPCC software version 2.930**	**Difference**
3.B - Land	-3,201.03	-3,245.55	44.52
3.B.1 - Forest land	-2,010.42	-2,046.11	35.69
3.B.1.a - Forest land Remaining Forest land	-2,005.18	-2,015.40	10.23
3.B.1.b - Land Converted to Forest land	-5.24	-30.71	25.47
3.B.1.b.v - Other Land converted to Forest Land	-5.24	-30.71	25.47
3.B.2 - Cropland	-1,210.57	-1,218.69	8.12
3.B.2.a - Cropland Remaining Cropland	-1,210.57	-1,218.69	8.12
3.B.3.b - Land Converted to Grassland		-0.01	0.01
3.B.3.b.i - Forest Land converted to Grassland		-0.01	0.01
3.B.4 - Wetlands			0.00
3.B.5 - Settlements	19.95	19.24	0.71
3.B.5.a - Settlements Remaining Settlements	0	0	0.00
3.B.5.b - Land Converted to Settlements	19.95	19.24	0.71
3.B.5.b.i - Forest Land converted to Settlements	12.01	9.61	2.40
3.B.5.b.ii - Cropland converted to Settlements	7.78	9.62	-1.84
3.B.5.b.iii - Grassland converted to Settlements	0.16	0.01	0.16

6.4.7 Category specific planned improvements

The updated methodology for calculating GHG emissions and removals in Lebanon's LULUCF sector introduced several improvements for more accurate reporting. These improvements included accounting for land conversion to wetlands from forest, grassland, and cropland, alongside new land conversion categories such as forest to cropland and forest to grassland. Additionally, a NO_x emission factor for cropland burning has been added. The assessment of fuelwood gathering now incorporates both FAOSTAT and field data for better accuracy. The adoption of the latest IPCC software (Version 2.871.8630.16234) facilitated these updates, along with accounting for cumulative reforestation activities over 20 years, ensuring a comprehensive representation of the sector's impact on Lebanon's GHG inventory.

Efforts will need to be put in the future to continuously feature new categories for mapping land use changes: specifically, the transitions from forest to cropland, forest to grassland and land to wetland. The continuous mapping of these categories will provide an up-to-date, detailed view of Lebanon’s changing landscapes. These mapping efforts, however, are inextricably linked to the availability and development of national land cover land use maps. These maps are essential for accurately tracking environmental changes. Additionally, the continued use of high-resolution global land cover maps, similar to the ones used in 2021, will ensure that Lebanon’ insights are grounded in the most current and comprehensive data available. Further leveraging of technologies such as Geographic Information System (GIS) and satellite remote sensing will enhance the accuracy and effectiveness of the mapping efforts. Needless to say, that many challenges lay ahead, including data availability (e.g., volume of illegal fuelwood gathering activities), technological needs, and resource allocation. Addressing these challenges head-on is essential for the success and reliability of future mapping initiatives.

The availability of accurate reforestation maps will also help in the identification of the different types of land conversion. A geospatial reforestation/afforestation database is needed.

The following additional improvements are recommended:

- Developing a National Soil Carbon database: Implement field studies and remote sensing techniques to gather data on carbon stocks in mineral soils across different land uses. This will allow for a move from Tier 1 to Tier 2 or Tier 3 methods, providing more accurate soil carbon change estimates.
- Monitoring forest plantations and afforestation areas: Establish a comprehensive monitoring system for newly planted forest areas, including the assessment of losses due to various factors. This system should include the recording of species planted, area coverage, and survival rates.
- Detailed inventory of tree species planted: Create a database that records the quantity and types of tree species planted in afforestation and reforestation projects. This database should be updated regularly through field surveys and collaboration with local forestry departments and NGOs.
- Assessing settlements in land use categories: Develop methodologies to estimate GHG emissions or removals in the settlements remaining settlements subcategory. This could involve using proxy data or conducting targeted studies to understand the carbon stock changes in these areas.

7. Waste (CRT 5)

7.1 Overview of the sector

Solid waste management

Many changes took place during the last 4 years as the country went through a difficult and delicate period starting with the economic crisis, followed by the COVID19 period that caused a series of lockdowns between 2020 and 2021 and the Beirut Port explosion. Despite the situation, some progress was achieved from a legal and institutional perspective which include:

1. The Solid Waste Management (SWM) Law 80 was issued in 2018, constituting the new backbone of the legal framework for the sector.

2. The National SWM Authority (as per article 13 of law 80/2018) was approved by the Council of Ministers (CoM) (decision No 28 dated 12/01/2024) but still needs the appointment of its members to make it operational.

3. The Cost recovery system: A draft law was approved by the CoM as per the decree No 12526 dated 2/11/2023 and sent to Parliament for endorsement. This is a very critical law that will allow to resolve one of the main weaknesses of the sector, namely the ability to provide sustainable financing of SWM solutions, on a national and subnational levels.

4. The National SWM strategy: The strategy document is being finalized and awaits final approval by the CoM. The strategy will put in place several strategic and realistic objectives which the government will aim to achieve in the short, medium and long term.

The Cost Recovery Law and the National SWM Strategy are urgently required in order to allow the implementation of the required reforms of the sector. These two regulations will organize the sector from the institutional and financial aspects where the authority will be responsible for controlling and monitoring SWM facilities. As for the municipalities, they will be able to sustainably finance the private sector for SWM services, allowing the government to take the sector to another level where many open dumps will be closed. In addition, these regulations will incentivize the private sector to invest and to upgrade the quality of the operation and maintenance of the sector.

In addition, Lebanon was divided into 17 service areas where local and regional master plans are under preparation at the moment by different international agencies as support to the MoE. These master plans will pave the road for the implementation plans in each service area once the necessary legal and institutional documents are issued.

The mandate for managing solid waste in Lebanon is spread over different administrations and ministries involved directly or indirectly in the sector, with the main ones being the Ministry of Environment (MoE), the Ministry of Interior and Municipalities (MoIM) and the Office of the Minister of Administrative Reform (OMSAR). In addition, the Council for Development and Reconstruction (CDR) is in charge of overseeing the waste management contracts of Greater Beirut and Tripoli areas. Also, municipalities and unions of municipalities are often involved in the management of the sector in their geographical area.

International Non-Government Organizations (NGO)s and international funding agencies such as UN agencies, the World Bank, the EU, smaller international and local NGOs are also active in certain geographical locations regarding sorting and composting small scale activities. Finally, the private sector (mainly industrial) has been investing in the sector in recent years developing sorting, recycling and composting programs.

After the 2019 economic crisis, most administrations and operators were faced with obstacles that had an impact on the operation of solid waste facilities, ranging from technical to financial aspects. Since all contracts were in Lebanese currency, the quality of operation was seriously affected with the hyper-inflation and the strong devaluation of the Lebanese Pound. Public administrations who were responsible for these contracts had major difficulties modifying the payment terms of these service contracts. Gradually, some contracts with the CDR, OMSAR and some municipalities have been amended to modify the payments terms and rate used. In the case of private companies, there was a decrease in the operation capacity during the last period where less waste was received and managed by treatment facilities such as IBC and SICOMO.

In addition, the economic crisis and the pandemic period had major impacts on the waste composition and quantities of recyclable materials sorted. The Beirut Port blast alone generated more than one million tonnes of demolition waste (rubbles mixed mainly with glass, plastics and asbestos) from the greater Beirut area which was collected and transported to landfills, open dumps and storage points (UNDP, 2020).

It was only in the beginning of 2022 that most solid waste projects were back to operating under normal conditions with the exception of Material Recovery Facilities (MRF) such as the Karantina sorting plant and the Coral composting plant that were destroyed during the Beirut Port blast. Other MRFs did not resume operation for financial reasons or because equipment was either stolen or needed major budgets for repair.

Despite the above situation, the changes in the socio-economic situation did lead to significant changes in the characteristics and management of solid waste in Lebanon, namely:

- A reduction in waste generation due to the reduced purchasing power and decrease in population.
- An increase in the informal sorting of the waste at the source by the population and informal waste pickers in an attempt to recover some money for the waste they have sorted, in addition to an increase in the number of NGOs active in waste sorting and recycling.
- An increase in the percentage of waste being landfilled, which consequently led to a decrease in open dumping and burning.
- A decrease in composting due to the destruction of the main composting facility in Beirut and the surge in the operational and maintenance cost of small facilities.

Wastewater management

In addition to the challenges faced in the solid waste management sector, Lebanon's wastewater management system has also suffered significant setbacks over the past four years. The combined effects of the economic crisis, the COVID-19 pandemic, and the Beirut Port explosion have severely impacted the operation and maintenance of wastewater infrastructure across the country. Wastewater Treatment Plants (WWTPs) and sewerage networks have struggled to function due to financial constraints, infrastructure damage, and a lack of proper resources. These issues have led to increased discharge of untreated wastewater into rivers, coastal areas, and the Mediterranean Sea, exacerbating environmental degradation and posing serious public health risks.

Despite these challenges, some progress has been made in terms of institutional and regulatory advancements. Notable achievements during this period include:

1. The National Wastewater Strategy (NWS): A strategy document was finalized in 2020 and approved by the Council of Ministers (CoM). This strategy provides a comprehensive roadmap for the rehabilitation and expansion of wastewater treatment infrastructure and aims to improve wastewater collection and treatment across Lebanon.

2. Service Area Master Plans: Lebanon was divided into several service areas, and wastewater master plans have been developed in each area, led by the Ministry of Energy and Water (MoEW), with support from international donors. These plans identify priority projects to rehabilitate and expand existing wastewater networks and treatment facilities.

3. Cost Recovery System: A draft law to establish a cost recovery mechanism for wastewater services was developed and approved by the CoM in 2023 (decree No 13156 dated 12/03/2023). This law, currently awaiting parliamentary endorsement, aims to introduce tariffs for wastewater services to ensure sustainable financing and improve the quality-of-service delivery across the country.

4. International Assistance: Several international agencies, such as the World Bank, UN agencies, and the EU, have been actively involved in financing and supporting wastewater infrastructure projects. Funds have been allocated to rehabilitate damaged wastewater treatment plants in the Beirut area following the explosion.

However, the wastewater sector still faces critical challenges, including:

- Infrastructure Damage and Operational Deficiencies: Several wastewater treatment plants, especially in Beirut and surrounding areas, were severely damaged during the Beirut Port explosion. Key facilities such as the Ghadir WWTP and the Dora pumping station require significant repairs. Meanwhile, financial and technical constraints continue to limit the operational capacity of other plants across the country.
- Weak Institutional Coordination: The mandate for managing wastewater infrastructure is divided among multiple agencies, including the Ministry of Energy and Water (MoEW), the Council for Development and Reconstruction (CDR), and local municipalities. This has led to fragmented planning and poor coordination between stakeholders, impeding effective implementation of wastewater projects.
- Lack of Sustainable Financing: Hyperinflation and the devaluation of the Lebanese Pound have rendered it difficult to maintain and operate existing infrastructure. Contracts with service providers, which were originally in the Lebanese currency, are no longer viable due to the significant rise in operational costs. As a result, many wastewater projects have stalled, and there has been a notable increase in untreated wastewater being discharged into the environment.

Despite these challenges, there have been some notable shifts in wastewater management in Lebanon during this period:

- A reduction in wastewater generation: Due to the economic crisis, reduced industrial activity, and a decrease in population, the volume of wastewater generated in urban areas has dropped. This has somewhat alleviated pressure on the overburdened wastewater infrastructure.
- Increased reliance on international support: Many wastewater projects now rely heavily on international funding and technical assistance. Several donor agencies have stepped in to fill the financing gap, supporting the repair and upgrading of wastewater treatment facilities and networks.
- Public engagement in wastewater management: Civil society organizations and NGOs have become more involved in raising awareness about the importance of proper wastewater management. In some areas, local initiatives have been launched to promote the safe reuse of treated wastewater for agricultural purposes, particularly in water-scarce regions like the Beqaa Valley.

GHG emissions in 2022

In 2022, activities related to the generation and treatment of solid waste and wastewater emitted 1,348 Gg CO_2eq., thus contributing to 6.6% of Lebanon's total GHG emissions. CH_4 and N_2O emissions are mainly generated from the discharge of wastewater effluents into aquatic environments, while CO_2gases are mainly emitted from open burning of waste. Landfills and dumpsites are the largest source of GHG emissions in this category, being responsible of 49% of GHG emissions, followed by wastewater treatment and discharge with 44% of emissions.

In general, emissions have significantly dropped since 2019 (-25%), mainly due to the economic crisis that changed many characteristics of waste generation and management:

- Waste generation per capita decreased from 1.20 to 0.95 in urban areas and to 0.85 in rural areas, hence affecting total Municipal solid waste generated in Lebanon, which decreased from 2.3 million tonnes in 2019 to 1.6 million in 2022.
- Decrease of 55% in industrial waste after the closure of many industries in Lebanon that could not maintain their operations after the economic crisis and the consecutive COVID-19 lockdowns.
- Changes in composition of waste where less food was being wasted due to the economic crisis and more plastic waste was generated from the masks and gloves used during the COVID-19 pandemic, in addition to the surge of demolition waste after the Beirut port explosion in 2020.
- Significant reduction in composting activities (-75%) after the destruction of the main MRF in Beirut area after the Beirut Port Explosion and the closure of many small-scale facilities due to the increase in cost of transport and facility operations after the surge in fuel prices post 2019.
- Significant reduction in open dumping and open burning due to the increased capacities of some landfills (Tripoli and Zahleh) and the closure of some open dumpsites from 2019.
- Significant reduction in biological treatment of waste and treatment of wastewater due to the high operational costs of such plants amidst the surge in fuel and electricity prices after 2019

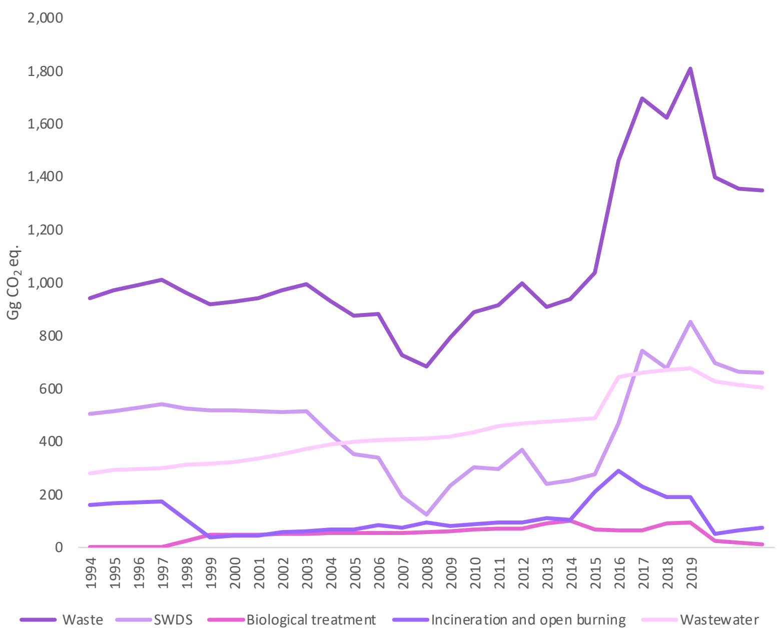


Figure 23: Trend in emissions in waste and wastewater sectors

Table 75 - GHG emissions from the waste sector in 2022

	Emissions CO_2eq. [Gg]			
	CO_2	CH_4	N_2O	Total
4 - Waste	12.874	1,245.882	90.034	1,348.790
A - Solid Waste Disposal	0.000	661.360	0.000	661.360
4.A.1 - Managed Waste Disposal Sites		120.988	0.000	120.988
4.A.2 - Unmanaged Waste Disposal Sites		297.388	0.000	297.388
4.A.3 - Uncategorised Waste Disposal Sites		242.984	0.000	242.984
B - Biological Treatment of Solid Waste		7.375	4.070	11.446
Composting		7.280	4.070	11.350
Anaerobic digestion		0.095	0.000	0.095
other		0.000	0.000	0.000
C - Incineration and Open Burning of Waste	12.874	51.951	8.848	73.673
4.C.1 - Waste Incineration		0.011	0.103	0.114
4.C.2 - Open Burning of Waste	12.874	51.940	8.745	73.559
4.D - Wastewater Treatment and Discharge		525.196	77.115	602.311
4.D.1 - Domestic Wastewater Treatment and Discharge		495.404	77.115	572.519
4.D.2 - Industrial Wastewater Treatment and Discharge		29.792	0.000	29.792
4.E - Other (please specify)		0.000	0.000	0.000

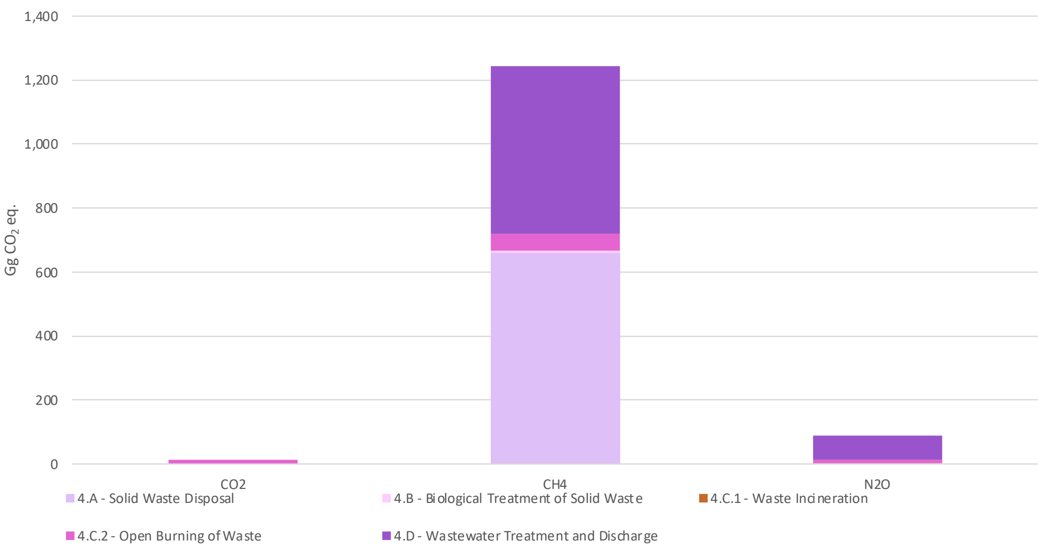


Figure 24: GHG emissions in the waste sector for 2022

7.2 Solid Waste Disposal (CRT 5.A)

7.2.1 Category description

The Solid Waste Disposal category, as defined by the IPCC guidelines, includes the long-term containment of solid waste in landfills or other disposal sites. This process generates greenhouse gas emissions primarily through the anaerobic decomposition of organic matter, resulting in methane (CH_4) and carbon dioxide (CO_2) emissions.

7.2.2 Methodological issues

Since solid waste disposal sites (SWDS) on land has been identified as a key category (CH_4 emissions) in previous inventories, and following the guidance of the IPCC 2006 guidelines, the tier 2 methodology has been used to calculate emissions from this category. Accordingly, the IPCC FOD method has been used with defaults parameters and country specific activity data, especially that CH_4 emissions from SWDS is a key category under the trend assessment.

The FOD method assumes that the transformation of degradable material in the SWDS to CH_4 and CO_2 is by a chain of reactions and parallel reactions, in turn governed by different half-lives for different types of waste. The CH_4 generation potential of the waste that is disposed in a certain year will decrease gradually throughout the following decades. In this process, the release of CH_4 from this specific amount of waste decreases gradually. Therefore, the FOD model is built on an exponential factor that describes the fraction of degradable material which each year is degraded into CH_4 and CO_2. Hence, the FOD method requires data to be collected or estimated for historical disposals of waste over a time period of 3 to 5 half-lives (or at least 50 years) in order to achieve an acceptably accurate result. Therefore, Lebanon starts the estimate in year 1972, i.e. 50 years from the reporting year 2022.

Activity data

Detailed data on solid waste generation is not readily available for all regions in Lebanon 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. Therefore, solid waste amounts are generally estimated based on population and generation rate per capita estimations. Surveys and assessment recently conducted were used to estimate waste generation rates, collection rate and disposal pathways for the period 2020-2022, especially that that waste parameters have significantly changed with the economic and social crisis that Lebanon is currently facing.

Population: Population in Lebanon was always estimated as no surveys or censuses have been done since the 1950's. As such, the estimations made by the United Nations and other international organizations are considered to be the most representative and are the most commonly used in reports and studies. As per Table 76, the population estimate is divided into different nationalities (Syrians residents, Syrian refugees, Palestinian refugees, resident foreign workers), based on the significant number of such population groups and the likely different waste generation rate for each category.

Table 76 - Population estimates

Year	Total Population[1]	Population Lebanese	Residents Syrian Workers	Syrian refugees Registered	Palestinian refugees[2]	Residents Foreign workers[3]
2020	5,662,923	3,747,923	612,185	887,815	270,000	145,000
2021	5,592,631	3,687,631	631,081	868,919	270,000	135,000
2022	5,489,739	3,584,739	649,548	850,452	270,000	135,000

1 Data Source: United Nations - World Population Prospects

2 Registered refugees including 30,000 from Syria: https://www.unrwa.org/where-we-work/lebanon

3 Ethiopia (37% or 58,772 individuals), Bangladesh (22% or 36,145 individuals), Sudan (9% or 14,613 individuals), Egypt (8% or 12,630 individuals), and the Philippines (6% or 9,252 individuals).

Waste generation: In terms of waste generation per capita, it is estimated that the rate has decreased at the beginning of 2020 as a result of the economic crisis compounded by the COVID-19 pandemic. Some unpublished surveys and records submitted to MoE, showed that waste generation per capita reached 0.75 kg/day in urban areas and 0.55 kg/day in rural areas and refugees camps after 2019. However, cross referencing these numbers with waste quantities delivered to landfills in Bekaa area where Syrian refugee camps are concentrated shows that waste generated per capita is higher that the reported values. Indeed, records obtained from the Zahleh landfill show that the percentage of waste generated from camps in the area did not decrease as much as outside the camps, mainly due to the financial support that only the Syrian refugees were receiving which did not significantly affect their socio-economic situation and purchasing power.

Therefore, an estimation of 0.95 kg/day in urban areas and between 0.80 and 0.85 kg/day in rural areas and refugee camps was used for the year 2022. The split between urban and rural areas is reported in many references as 90% urban and 10% rural areas.

Table 77 - Waste generation in Lebanon for the period 2019-2022 and baseline 2011

Year	2019	2020	2021	2022
Total Lebanese Population	5,108,670	3,747,923	3,687,631	3,584,739
Waste generation Rate (Lebanese – Urban areas) (kg/capita/day)	1.16	1.00	0.90	0.95
Waste generation Rate (Lebanese – Rural areas) (kg/capita/day)	1.16	0.85	0.85	0.85
Total Waste generated (Lebanese) (tonnes/day)*	5,926	3,692	3,300	3,370
Total population Non-Lebanese (Refugees/workers)	932,619	1,915,000	1,905,000	1,905,000
Waste generation rate (Refugees/ workers) (kg/capita/day)	0.50	0.80	0.80	0.80
Total Waste generated (Refugees/ Workers) (tonnes/day)	466	1,532	1,524	1,524
Total Municipal Waste (tonnes/day)	6,392	5,224	4,824	4,894
Total Municipal Waste (tonnes/year)	2,333,340	1,906,652	1,760,917	1,786,184

Waste composition: the Municipal waste composition in Lebanon has also changed during the 2019-2022 period, where less food was being wasted due to the economic crisis (45% of waste stream versus 54% in 2019) and more plastic waste was generated from the masks and gloves used during the COVID-19 pandemic (15-18% compared to 11.5% in 2019). In addition, despite the shut-down of the main sorting facilities, the informal waste picking has maintained the rate of sorting of recyclables due to the value of specific streams and the availability of more NGOs and private companies interested in purchasing such recyclables even in small quantities. Overall, it is considered that the waste composition is now back to pre-2020 values as the impact of the socio-economic crisis is no longer reflected in the waste composition and the waste stream. The adopted waste composition for the past four years is presented in the following table and chart.

Due to a change in waste categorization in the national waste dataset, there is a change in waste allocation from 2020 onwards. However, as nappies and garden/green waste have very similar IPCC default DOC values, the change in emissions will be very negligible and we've opted to retain the historic waste categorization.

Table 78 - Waste composition

Year	2019	2020	2021	2022
Organic Household Waste	54%	45%	49%	51%
Green Municipal Waste	-	3%	3%	4%
Paper & Cardboards	16%	16%	16%	15%
Plastics	11.5%	18%	17%	15%
Wood	1.5%	1%	1%	1%
Textiles	3.5%	3%	2%	2%
Metal	4%	4%	4%	4%
Glass	3.5%	4%	3%	3%
Others	6%	6%	5%	5%

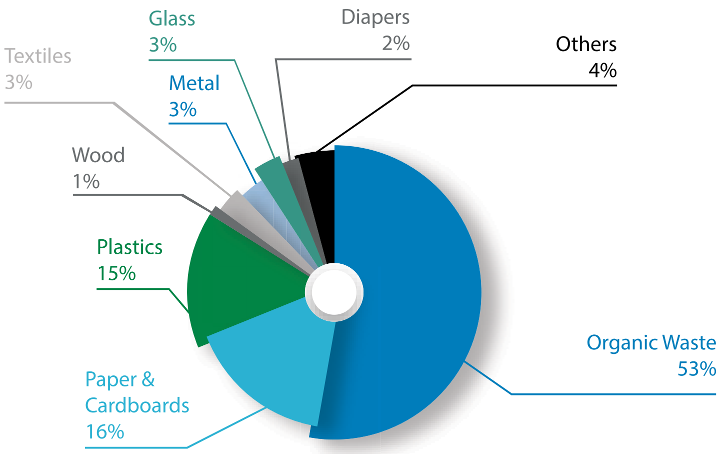


Figure 25: Waste composition for 2022

Industrial waste consists of non-hazardous streams such as paper, plastic, wood, textile, glass, food and organic waste, as well as metal scrap which are usually disposed of with municipal waste, in addition to some hazardous waste which contains chemicals and heavy metals, such as industrial sludge and waste generated from painting and chemicals industries. A small part of the industrial hazardous waste produced is being treated, although treatment was not considered during 2020 and 2021. Some were incinerated in cement kilns (sludge), some were being transported to sanitary landfills, others were sold as scrap or recyclable materials even though they were toxic. No export activities for this type of waste were considered.

The quantity of industrial waste has decreased by more than 50% between 2019 and 2022 due to the closure of many industries that could not sustain their operation costs amidst the increase of fuel costs, survive the economic crisis and the increase of fuel prices and maintain production during consecutive COVID lockdowns. Table 79 below shows an estimation of the quantities of industrial waste produced.n.

Table 79 - Industrial waste generation

Year	Total Hazardous Waste generated (tonnes/year)	Hazardous Waste treated (tonnes/year)
2019	75,510	
2020	55,000	3,000
2021	60,000	5,000
2022	90,000	21,000

Healthcare waste was considered the most critical issue to handle during the pandemic period between the years 2020 and 2021, and the government found itself incapable of managing the large quantities of such waste generated. Therefore, most of such waste went to sanitary landfills and open dumps while some was burned in open air including cytotoxic waste. The only operator working in healthcare waste management is Arc En Ciel, an NGO that treats infectious waste through autoclaving for some hospitals in Beirut, Mount Lebanon and Zahleh. For cytotoxic waste, some hospitals are exporting it according to BASEL Convention, others were using their own incinerators to burn it despite them being not yet environmentally compliant with the national standards and not approved by the MoE. As for other medical facilities, their healthcare waste is being collected and transported to open dumps and landfills. The following table shows the categories and an estimation of the quantities of healthcare waste produced.

Table 80 - Healthcare waste generation

Year	Infectious Waste Generated (tonnes/year)	Cytotoxic Waste Generated (tonnes/year)	Cytotoxic Waste Exported (tonnes/year)	Healthcare Waste Dumped (tonnes/year)	Cytotoxic Waste Incinerated (tonnes/year)
2019	-	-	-	-	**60**
2020	9,100	310	0	9,410	30
2021	8,000	275	40	8,235	30
2022	8,500	330	110	8,720	30

Waste management and disposal: During the last period, recycling rates have increased due to the increased sorting of recyclables by the population and the informal waste pickers. The main items collected are plastic (mainly PET), paper and cardboard, and metals/aluminum. Some studies indicated that 40,800 tonnes of paper and cardboard waste were recycled locally, and 16,500 tonnes were exported for recycling internationally in 2022 (UNDP, 2023).

The Ministry of Environment also played a major role in this process in 2019 by issuing Decree 5605 on sorting at source with its ministerial Decision trying to set the standard in defining the technical specifications for this process in term of number of bins, color of bins, types of bins, etc. The MoE was also assisting waste sorting initiatives with the environmental studies and awareness campaigns.

In addition, during the past two years, and backed up by the Ministry of Environment, many companies and industries launched drop-off center initiatives, which led waste generators to bring recyclable materials to these centers and get paid for it in cash on delivery. Some municipalities even introduced incentives for the waste producers who would sort their waste.

Since 2021, such initiatives have been growing very fast, people are aware of the importance of such initiatives, and this will be part of the SWM system and strategy in the coming years. One of the best examples is Lebanon Waste Management initiative which collected around 10,000 tonnes in 2023 and is expecting to double the quantity in 2024.

In addition, the activities of the informal waste pickers have started getting organized over the past four years through waste brokers and companies that have established networks of informal waste pickers all across Lebanon. Nevertheless, significant improvement in this sector is required from a social, health and safety point of view. Waste picking is not restricted to sorting the waste in communal bins. Waste picking is also organized in street bins, landfills and open dumps. In 2022 over 80,000 tonnes/year of recyclables (around 5% of the total waste generated) has been reported as diverted from disposal in landfills and open dumps through informal waste pickers. This number is expected to increase in the coming years, as the Ministry of Environment is trying to create a legal and institutional framework for this informal sector.

Even though the quantities of recyclable materials collected by the informal sector have been increased every year since 2020 as a result of the economic crisis, it was noticed that the quantities of recyclable materials sorted at the source did not increase in absolute terms (it was around 147,000 tonnes in 2019). In fact, informal waste pickers filled the gap left by the complete destruction of 2 major sorting plants in Greater Beirut area (Karantina & Aaamrousieh with a total capacity of around 2,500 tonnes/day). These 2 plants were generating around 55,000 tonnes/year of plastics, cardboard, metals and glass. This helped maintain the flow of recyclables despite the significant disruption caused by the explosion.

Table 81 - Summary of waste sorted at sorting facilities

Category	2019	2020	2021	2022
Total waste sorted (for recycling) (tonnes per year)		102,241	76,559	82,330
Percentage		5%	4%	4%
Total Waste sorted by the informal sector (not included in waste stream) (tonnes per year)		39,421	54,875	75,396
Percentage		2%	3%	4%
Total recyclables	145,596	141,662	131,434	157,726
Total recycles percentage	6%	7%	7%	8%

Waste disposal in solid waste sites is by far the most common fate of Municipal Solid Waste disposal in Lebanon. Indeed about 89-93% of the waste generated is collected and taken to landfills or dump sites. The National SWM strategy prepared by the MoE aims to reduce the reliance on open dumps in the next 5 years by constructing more sanitary landfills in most regions and service areas.

According to the IPCC 2006 guidelines, landfills used in Lebanon fall under 2 categories:

- Anaerobic managed solid waste disposal sites which must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste. Baalbeck, Bar Elias (previously), Jeb Jannine, Hbaline and Tripoli landfills are considered in this category.
- Semi-aerobic managed solid waste disposal sites must have controlled placement of waste and include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system. Naameh (before 2015), Costa Brava, Jdeideh/Bourj Hammoud and Zahleh are considered in this category.
- The remaining amounts (around 20-25%) are being disposed in open dumps every year (around 500,000 tonnes/year). Most of these open dumps are categorized as shallow (69% of total open dumps) and are frequently burned.

Table 82 - Waste quantities disposed in landfills

Category	2019	2020	2021	2022
Quantities of waste in **Anaerobic** landfills (tonnes per year) Baalbeck, Bar Elias (previously), Jeb Jannine, Hbaline and Tripoli landfills	169,072	228,829	146,846	217,645
Quantities of waste in **Semi-Aerobic** landfills (tonnes per year) Jdeideh, Bourj Hammoud, Costa Brava, Zahleh	852,982	821,700	789,678	815,707
Quantities of waste in **Open Dumpsites** (tonnes per year)	844,320	660,280	685,354	634,058
Percentage	80%	89%	92%	93%

The main landfill that recovers methane is the Naameh landfill, which is the biggest landfill in Lebanon and was closed in 2015. The methane still being extracted from the gas management system is conveyed to a nearby power plant managed by EDL where electricity is generated and distributed to the villages surrounding the landfill. Recent surveys showed that more than 5 MW of electricity is being generated from the Naameh landfill. Some minor flaring is also taking place at the Costa Brava landfills, which is a relatively young landfill.

Emission factors and other parameters

The calculation of methane generated from solid waste disposal sites is based on the use of the Methane Correction Factor (MCF) available by the IPCC 2006 GL taking into account the different SWDS categories. The CH_4 correction factor accounts for the fact that unmanaged SWDS produce less CH_4 from a given amount of waste than anaerobic managed SWDS. In unmanaged SWDS such as open dumpsites, a larger fraction of waste decomposes aerobically in the top layer. In unmanaged SWDS with deep disposal and/or with high water table, the fraction of waste that degrades aerobically should be smaller than in shallow SWDS. Semi-aerobic managed SWDS such as the Jdeideh, Bourj Hammoud, Costa Brava, Zahleh and Naameh (previously) are managed passively to introduce air to the waste layer to create a semi-aerobic environment within the SWDS. The anaerobic SWDS such as the Baalbeck, Bar Elias (previously), Jeb Jannine, Hbaline and Tripoli sites are closed landfill with no active or passive aeration. The MCF in relation to solid waste management is specific to that area and should be interpreted as the waste management correction factor that reflects the management aspect it encompasses.

Total amounts of waste received by the different managed and unmanaged classes are presented in Table 83.

Table 83 - Description of solid waste disposal sites categories

SWDS Category	MCF 2006 GL	Description
Managed anaerobic	1	Anaerobic managed solid waste disposal sites: These must have controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and will include at least one of the following: (i)cover material; (ii) mechanical compacting; (iii) levelling of the waste.
Managed – semi-aerobic	0.5	Semi-aerobic managed solid waste disposal sites: These must have controlled placement of waste and will include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.
Unmanaged 3 – deep (>5 m waste) and /or high-water table	0.8	Unmanaged solid waste disposal sites – deep and/or with high water table: All SWDS not meeting the criteria of managed SWDS and which have depths of greater than or equal to 5 metres and/or high-water table at near ground level. Latter situation corresponds to filling inland water, such as pond, river or wetland, by waste.
Unmanaged 4 – shallow	0.4	Unmanaged shallow solid waste disposal sites; All SWDS not meeting the criteria of managed SWDS and which have depths of less than 5 metres.
Uncategorised SWDS	0.6	Uncategorised solid waste disposal sites: Only if countries cannot categorise their SWDS into above four categories of managed and unmanaged SWDS, the MCF for this category can be used.

Source IPCC, 2006

7.2.3 Uncertainties and time series consistency

The 2006 IPCC Guidelines suggest that, for countries with efficient statistical systems, uncertainty levels associated with A ctivity Data (AD) should typically range between 10-30%. Therefore, it was considered appropriate to use a ±30% uncertainty level for both managed and unmanaged solid waste management (SWM) data.

For emission factors, a factor of ±30% was used for DOC and DOCf, based on stakeholder consultations and expert judgements.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

7.2.4 Description of flexibility if applied

No flexibility provision has been applied.

7.2.5 Category specific QA/QC

The data used for the calculation of emissions from the waste sector, specifically in terms of solid waste disposal sites, were provided through official communications with the main waste operators and landfill facilities, in addition to OMSAR projects and some municipalities that operate other facilities.

In line with the general QA/QC plan, all data used in the inventory were validated through desk review of other reports, publications and other data sources available and were endorsed by key stakeholders. Additional QA/QC measures were conducted including automating calculations to reduce manual entry errors, ensuring correct unit labelling and conversion throughout the process, and validating country-specific emission factors against IPCC defaults, documenting any significant discrepancies. The consistency of estimation methods across the entire reporting period is maintained, with results visualized through automatic trend charts.

The inventory process is continuously refined based on recommendations from international experts, addressing issues like data series restoration. The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

7.2.6 Category-specific recalculations

No recalculations were undertaken.

7.2.7 Category specific planned improvements

The main challenges in relation to data collection and reporting process of the solid waste disposal category are as follows:

- Data on waste generation and characterization is not regularly collected by the MoE.
- The “per capita waste generation rate” (tonnes/ capita/year) does not differentiate between urban and rural populations.
- Most recent data used on dumpsites dates to 2018 – conditions have changed a lot since then.
- The exact amount of industrial waste is not available.

For the BTR1, the Ministry of Environment conducted a comprehensive assessment of the solid waste sector to enhance the completeness and accuracy of the activity data and parameters used in calculating the GHG inventory. The improvements primarily focused on the distribution of waste streams across various treatment and disposal channels, as well as obtaining more precise data on composting and anaerobic digestion, methane flaring, and energy generation from waste. Direct contact was established with waste operators and data was collected from primary sources with minimal assumptions and estimations made.

In addition, through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the waste sector. The Waste task force, composed of the main stakeholders of the waste sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

Table 84 - Short-term and long-term planned improvements for the 4.A solid waste disposal

Planned improvement	Implemented	Short term	Long term
Conduct study on waste composition in Lebanon, taking in consideration rural and urban areas as well as seasonal changes in waste characterization		x	
Improve accuracy of municipal waste generation quantities	x		
Improve accuracy of municipal distribution of waste management methods	x		
Produce statistical data on industrial waste generation waste composition and management practices per industry type and region Create and use effective and implementable legal instruments to ensure the timely and reliable provision of AD	x		x

7.3 Biological treatment of solid waste (CRT 5.B)

7.3.1 Category description

Composting and anaerobic digestion of organic waste, such as food waste, garden (yard) and park waste and sludge are a new category under the 2006 IPCC guidelines, and it is considered for the first time as a separate activity in Lebanon. Composting is an aerobic process and a large fraction of the Degradable Organic Carbon (DOC) in the waste material is converted into carbon dioxide (CO_2). CH_4 is formed in anaerobic sections of the compost, but it is oxidised to a large extent in the aerobic sections of the compost. Composting can also produce emissions of N_2O, at range of 0.5 to 5% of the initial nitrogen content of the material.

Biological treatment of waste is usually linked to N_2O and CH_4 emissions, with a potential for recovery and combustion for energy under anaerobic digestion, where greenhouse gas emissions from the process are to be reported in the energy sector.

Anaerobic digestion of organic waste expedites the natural decomposition of organic material without oxygen by maintaining the temperature, moisture content and pH close to their optimum values. Generated CH_4 can be used to produce heat and/or electricity, with a small amount being emitted as leakage. The CO_2 emissions are of biogenic origin and should be reported only as an information item in the Energy Sector. N_2O emissions from the process are assumed to be negligible.

7.3.2 Methodological issues

Methodology

The CH_4 and N_2O emissions of biological treatment are estimated using the default method, Tier 1 using the IPCC default emission factors.

Activity data

Activity data on biological treatment is mainly based on the period reports submitted by the waste operators to the Ministry of Environment. In terms of composting, quantities that are being treated aerobically are not significant mainly due to the absence of sorting at the source. The separation of the organic fraction for composting is done in a number of MRFs in Lebanon by sorting commingled waste collected in compactor trucks. This results in major challenges to extract compostable organic material, characterized by a very high percentage of impurities in the raw material and the end product and a very low quality compost. Furthermore, the maturation step of the compost is often neglected resulting in the produced compost having no market (even if given away free of charge). Most of such material ends up back in landfills or open dumps, especially as a cover at the Naameh landfill.

In addition, the main composting plant in Beirut that used to treat about 300 tonnes per day was completely destroyed during the Beirut Port Blast along with the Karantina sorting plant. These two facilities were never rebuilt. As such, organic MSW was no longer sorted and compost production ceased at that time resulting in all collected waste going unsorted to the Greater Beirut landfills.

Except for compost produced from the anaerobic digestion at IBC in Saida, most composting in Lebanon consisted of aerobic windrow composting. Other aerobic composting technologies consist of in-vessel and tunnel composting. International studies have shown that aerobic composting technologies should be used for green waste in order to get good quality compost. In Lebanon, most facilities are composting organic waste extracted from MSW resulting in low quality compost that often has no market.

Anaerobic digestion is not a common practice in Lebanon as this technology requires specialized expertise and higher financial CAPEX and OPEX. The IBC plant in Saida is the only plant that uses this technology. Similarly to aerobic composting plants, producing good quality compost in anaerobic digestors from organic waste extracted from comingled waste is also a major challenge. In addition, with the onset of the socio-economic crisis and based on other administrative challenges that resulted the quality of the compost produced was also affected.

Table 85 - Waste quantities composted aerobically and anaerobically

Category	2020	2021	2022
Total waste composted (Aerobic) (tonnes per year)	42,331	30,370	27,578
Total waste composted (Anaerobic) (tonnes per year)	68,200	38,300	25,700
Total waste composted (tonnes per year)	110,531	68,670	53,278
Percentage	6%	4%	3%

The IBC plant in Saida uses anaerobic digestion to produce energy from the gas emitted from the fermentation of organic waste, which has been decreasing during the last period due to the high cost of operation and the decreasing quantities being received at the sorting plant.

Emission factors

The emissions from composting and anaerobic digestion in biogas facilities depend on factors such as type of waste composted, amount and type of supporting material (such as wood chips and peat) used, temperature, moisture content and aeration during the process. However, since no national data is available to develop country-specific emission factors, default factors for CH_4 and N_2O emissions from biological treatment for Tier 1 method are used for this inventory.

It is assumed that that the waste is weighed at dry basis. As per the IPCC 2006 guidelines, it is considered to have 25-50% DOC in dry matter, 2% N in dry matter, and moisture content 60%. The emission factors for dry waste are estimated from those for wet waste assuming a moisture content of 60% in wet waste.

Table 86 - Default emission factors for CH4 and N2O from biological treatment of waste

Year	CH_4 Emission Factor (g CH_4 /kg waste treated)	N_2O Emission Factor (g N_2O /kg waste treated)
Composting	10	0.6
Anaerobic digestion	2	0

7.3.3 Description of flexibility if applied

No flexibility provision has been applied.

7.3.4 Uncertainties and time series consistency

The composted waste is weighted, and uncertainty is 50%. Uncertainties in the default emission factors can be estimated using the ranges given in Table 4.1 in the Waste chapter of 2006 IPCC GL. The highest value was used; it is 100% for CH_4 EF and 150% for N_2O EF.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

7.3.5 Category specific QA/QC

The same QA/QC measures implemented for solid waste disposal were also adopted for the biological treatment of solid waste, especially that same operators are usually responsible for both activities. These measures include the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

7.3.6 Category-specific recalculations

No recalculations were undertaken.

7.3.7 Category specific planned improvements

The accuracy of the data used for calculation of emissions from biological treatment of waste has been improved for the BTR1 through the assessment study conducted by MoE on activity data and parameters of the sector. No additional further improvements are planned for this subcategory.

7.4 Incineration and open burning of waste (CRT 5.C)

7.4.1 Category description

Incineration and open burning of waste containing fossil carbon, e.g., plastics, are the most important sources of CO_2 emissions in the Waste Sector. Waste incineration is defined as the combustion of solid and liquid waste in controlled incineration facilities, while open burning of waste is defined as the combustion of unwanted combustible materials in nature (open-air) or in open dumps, where smoke and other emissions are released directly into the air without passing through a chimney or stack.

Incineration and open burning of waste are sources of greenhouse gas emissions, like other types of combustion. Relevant gases emitted include CO_2, methane (CH_4) and nitrous oxide (N_2O). Only CO_2 emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national CO_2 emissions estimate. The CO_2 emissions from combustion of biomass materials (e.g., paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates.

7.4.2 Methodological issues

The Tier 1 method is used for the calculation of CO_2 emissions from incineration/open burning, specially that this is not a key category. Data on the amount of waste incinerated/open-burned are collected and default data on characteristic parameters (such as dry matter content, carbon content and fossil carbon fraction) for different types of waste (MSW, sewage sludge, industrial waste and other waste such as hazardous and clinical waste) are used from the IPCC guidelines.

Activity data

The data used for the calculation of GHG emissions from this category has been estimated through research, stakeholder consultations and published reports, as no accurate data is available on incineration and open burned quantities of waste.

Around 40% of the total waste generated is being disposed in open dumps every year (around 600,000 tonnes/year), and 30-45% of these dump sites are reported to be subject to regular open burning either intentionally to reduce the volume of the waste and make space for more waste or by catching fire in periods of high heat. In both cases, the burning of waste in such dump sites is generating even more air pollution and GHG emissions.

The fraction of **open burning** is estimated based the records of the complaints registered in MoE related to open burning activities, and records of open burning accidents that happened in major open dumps such as Bar Elias, Hbaline, Deir Ammar and many others in the south region of Lebanon. These records show a decreasing trend in open burning from 2019-2020 due to public opposition on such practices then increase in 2021 to burn the COVID-19 related waste and another increase in 2022 as waste collection and treatment services were halted outside the greater Beirut areas due to lack of payments from the government.

Table 87 - Waste quantities burnt in open air dump sites

Category	2020	2021	2022
Total waste burned in open air	198,084	239,874	285,326
Percentage	30%	35%	45%

Incineration is used either to treat cytotoxic waste generated by hospitals, or to produce energy and electricity from municipal solid waste that has a high calorific value (more than 14 MJ/kg).

Recent inspections by the MoE showed that small illegal incineration activities (around 30-40 tonnes per year) have been undertaken by some private hospitals to get rid of cytotoxic waste especially during the COVID-19 pandemic period.

In addition, a paper and cardboard recycling company (SICOMO), has an incinerator to treat plastic rejects and paper and cardboard unfit for recycling. This operation is undertaken under the supervision of the Ministry of Environment, and it generates electricity for its own use.

Table 88 - Waste quantities incinerated

Category	2020	2021	2022
Clinical waste incinerated (tonnes per year)	30	30	30
Plastic waste incinerated (tonnes per year)	8,030	7,140	6,460
Total waste incinerated (tonnes per year)	8,060	7,170	6,490
Percentage	0.47%	0.44%	0.39%

Emission factors

The Tier 1 methodology is used for calculating CO_2 emissions from incineration/open burning, default data on characteristic parameters (such as dry matter content, carbon content and fossil carbon fraction) for different types of waste are used from the 2006 IPCC guidelines. The calculation of the CO_2 emissions is based on an estimate of the amount of waste (wet weight) incinerated or open-burned taking into account the dry matter content, the total carbon content, the fraction of fossil carbon and the oxidation factor. Default emissions factor is also used for CH_4 and N_2O emissions, based on incomplete combustion parameters during open burning.

Table 89 - Parameters for incineration and open burning

	Clinical waste incineration	Open burning MSW
Dry matter content in % of wet weight	-	78%
Total carbon content in % of dry weight	60%	34%
Fossil carbon fraction in % of total carbon content	40%	8%
Oxidation factor in % of carbon input	100%	58%

Nitrous oxide emissions from waste incineration are determined by a function of the type of technology and combustion conditions, the technology applied for NO_x reduction as well as the contents of the waste stream. Since this information is not available in Lebanon, a default emission factor is used according the 2006 IPCC guidelines. Since no specific emission factor is available for clinical waste incineration, it is assumed that clinical waste has the same characteristic of industrial waste, accordingly the emission factor for industrial waste incineration is used.

Table 90 - Emission factors for incineration and open burning

	Clinical waste incineration (g/ t waste)	Open burning MSW (g/ t MSW)
CH_4 emission factor	0[1]	6,500
N_2O emission factor	100	150
[1] For clinical waste, because of low concentrations and high uncertainties, it is good practice to apply an emission factor of 0		

7.4.3 Description of flexibility if applied

No flexibility provision has been applied.

7.4.4 Uncertainties and time series consistency

Since the primary factors influencing the uncertainty assessment for category 5C 'Incineration and Open Burning of Waste' relate to the quality of available Activity Data, the uncertainties related to estimated amount of waste burned by rural and urban populations is estimated at ±40%.

The uncertainties associated with the default emission factors used to estimate are estimated at ±25% for CO_2, around ±50% for CH_4, and up to ±100% for N_2O, according to expert judgment.

Since the same data sources and methodologies have been used in previous inventories, the time series is estimated to be consistent.

7.4.5 Category specific QA/QC

The same QA/QC measures implemented for solid waste disposal were also adopted for the incineration of solid waste, including the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

7.4.6 Category-specific recalculations

No recalculations were undertaken.

7.4.7 Category specific planned improvements

In addition to the improvements described in section 7.2.7, category specific improvements include the assessment of clinical waste incineration and the update of the survey of open dumpsites in Lebanon. No additional further improvements are planned for this subcategory.

7.5 Wastewater treatment and discharge (CRT 5.D)

7.5.1 Category description

Wastewater originates from a variety of domestic, commercial and industrial sources and may be treated on site (uncollected), sewered to a centralized plant (collected) or disposed untreated nearby or via an outfall.

Wastewater can be a source of methane (CH_4) and nitrous oxide (N_2O) emissions when treated or disposed anaerobically. The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Usually, BOD is more frequently reported for domestic wastewater, while COD is predominantly used for industrial wastewater. N_2O is associated with the degradation of nitrogen components in the wastewater, e.g., urea, nitrate and protein included in human sewage.

7.5.2 Methodological issues

Methodology

In Lebanon, there is no large-size Wastewater Treatment Plant (WWTP) that is currently operational. Some small size rural WWTPs are reported to be partially operational and/or their efficiency questioned. Although this is a key category, no accurate data is available to adopt country and technology specific methodologies. For this inventory, the IPCC 2006 IPCC guidelines, Tier 1 methodology is used since no country specific emission factors and measurements on wastewater treatment pathways are not available in Lebanon. Data is collected on the share of wastewater treatment in each pathway and emissions are estimated using default emission factors.

Activity data

Detailed and comprehensive information on wastewater generation rates, treatment percentages, and discharge media is limited in Lebanon. Consequently, much of the activity data relies on assumptions and estimations made specifically for this inventory or adopted from other publications. According to the National Water Strategy 2020-2035, about 60% of the population is connected to a wastewater network, but only 30% of wastewater is treated, from which 8% is treated to secondary levels in 2019. This percentage has significantly decreased to 1-2% of secondary treatment during the period of 2020-2022 due to the increase in fuel and electricity prices which made the operation of wastewater treatment plants not feasible anymore. Given that most of Lebanon's population resides in urban and peri-urban areas, the differences in wastewater degradable organic content between urban and rural areas are considered minor. Therefore, the population served by each treatment pathway is estimated at the national level.

Domestic Wastewater quantities are estimated based on the resident population in Lebanon. Calculations take into account Syrian displaced, refugees and foreign workers residing in Lebanon, where it is assumed that the same wastewater discharge practices are adopted. In 2022, the population has been estimated at 5.489 million.

In terms of **discharge pathways**, domestic wastewater in Lebanon is partly collected and treated in centralized plants or disposed of in waterways, lakes or the sea, via closed sewers. Uncollected wastewater is either discharged in sea/rivers (57% on 2022) or disposed in septic tanks (28% in 2022) that are lined or unlined holes of up to several meters deep. As for collected wastewater, percentages of **treated wastewater** were computed based on the received and treated volumes of wastewater by each wastewater treatment plant and by level of treatment. Accordingly, 13% is estimated to be treated at primary level and 2% and secondary levels at wastewater plants.

Sludge removal was calculated based on the assumption that typical primary and secondary wastewater treatment produce a total of about 0.94 kg of dry solids per 3.78 m^3 of wastewater treated, which is equal to 0.249 kg/m^3 (Metcalf and Eddy, 1991). Based on a rate of 50 m^3 wastewater generated per person per year in Lebanon [=0.8 (coefficient)*0.17(water consumption 170 liter/cap/day) *365], primary and secondary wastewater treatment is estimated to remove 12.43 kg/cap/year of organic sludge.

As for **industrial wastewater** generated in Lebanon, and given the lack of complete data, the values of the gross domestic product in USD were used to estimate volume of industrial wastewater generated 19.58 m^3/tonne of industrial production (mainly dominated by food and beverage manufacturing). Industrial wastewater is discharged directly into bodies of water, while very limited industrial facilities may have treatment plants.

Table 91 - Types of discharge systems in Lebanon

Collected	Untreated	River/sea discharge	Stagnant, oxygen-deficient rivers and lakes may allow for anaerobic decomposition to produce CH_4. Rivers, lakes and estuaries are likely sources of N_2O.
	Treated	Centralized aerobic wastewater treatment plants	May produce limited CH_4 from anaerobic pockets. Poorly designed or managed aerobic treatment systems produce CH_4. Advanced plants with nutrient removal (nitrification and denitrification) are small but distinct sources of N_2O.
Uncollected	Untreated	Septic tanks	A septic tank is an underground chamber made of concrete, fiberglass, or plastic through which domestic wastewater (sewage) flows for basic treatment. Organic solids float to the top and inorganic solids sink to the bottom of the tank. The clear liquid flows out the sides of the tank and into the surrounding soil. Settling and anaerobic processes reduce solids and organics, but the treatment efficiency is only moderate.
		River discharge	Stagnant, oxygen-deficient rivers and lakes may allow for anaerobic decomposition to produce CH_4. Rivers, lakes and estuaries are likely sources of N_2O.

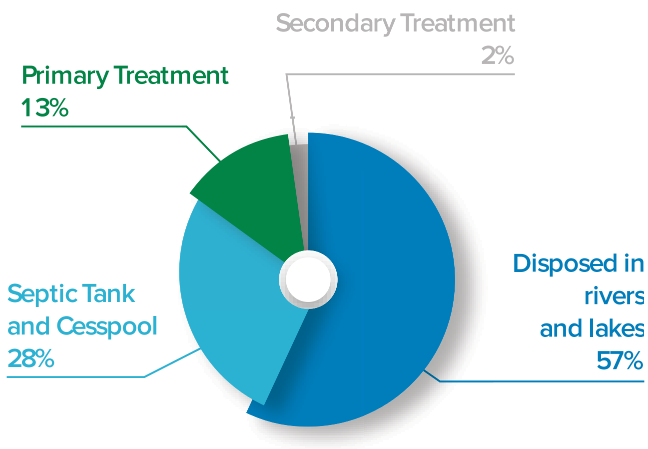


Figure 26: Percentages of the wastewater treatment systems and discharge pathways

Emission factors

The emission factor for a wastewater treatment and discharge pathway is a function of the maximum CH_4 producing potential (Bo) and the MCF for the wastewater treatment and discharge system. The Bo is the maximum amount of CH_4 that can be produced from a given quantity of organics, based on the BOD of wastewater. The MCF indicates the extent to which the CH_4 producing capacity (Bo) is realised in each type of discharge pathway and system. Expert judgment was used to estimate some of the below parameters.

The average degradable organic component (kg Biological Oxygen Demand (BOD)/cap/yr) for the Lebanese population is estimated at 23.7 kg BOD/cap/yr (MoE/UNDP/GEF, 2019; World Bank, 2011). However, based on the Lebanon Environmental Assessment of the Syrian Conflict and Priority Interventions study (MoE/UNDP/EU, 2014), the incremental pollution load of wastewater generated by displaced is estimated to produce around additional 40,000 tonnes of BOD5 per year (2014), reflecting a significant increase of organic biodegradable load in the environment. Based on the number of Syrian displaced to Lebanon, the degradable organic component is estimated at 34.5 kg Biological Oxygen Demand (BOD) kg/cap/yr. Therefore, a weighted average degradable organic component that take into consideration Lebanese population and Syria refugees is calculated, to reflect the different weights of population and BOD between both categories. Therefore, the value of 26.65 kg BOD/cap/year (equivalent to 73 kg/cap/day) is used to estimate the total BOD for domestic wastewater.

Table 92 - Wastewater parameters and conversion factors for CH_4 emissions for 2022

Parameters	Value	Source
Degradable organic component (kg Biological Oxygen Demand (BOD)/cap/yr)	26.65	Calculation
Chemical Oxygen Demand (COD) (kg COD/m^3)	2.05	Calculation
Correction factor for industrial BOD discharge in sewers (uncollected)	1.00	IPCC, 2006
Maximum CH_4 producing capacity (kg CH_4/kg BOD)	0.60	Default -Table 6.2 (IPCC 2006)
Methane Correction factor MCF- Sea/river discharge	0.10	Adapted from Table 6.3 (IPCC 2006)
Methane Correction factor MCF- septic systems	0.50	WERF/IWA, 2010 for septic tanks
Methane Correction factor MCF- primary treatment	0.06[1]	Expert judgment
Methane Correction factor MCF- secondary treatment	0.03[2]	Expert judgment
Methane Correction factor MCF- industrial waste	0.10	Default -Table 6.8 (IPCC 2006)
EF (kg CH_4/kg BOD) - Sea/river discharge (domestic)	0.06	Calculated using
EF (kg CH_4/kg COD) - Sea/river discharge (industrial)	0.25	(Equation 6.2)
EF (kg CH_4/kg BOD)- septic systems	0.30	

EF (kg CH_4/kg BOD)- primary treatment	0.036	Default -Table 6.2 6.9 (IPCC 2006)
EF (kg CH_4/kg BOD)- secondary treatment	0.018	
Krem (kg BOD/kg sludge) Sludge factor – primary treatment	0.20	
Krem (kg BOD/kg sludge) Sludge factor – secondary treatment	0.65	
Sludge removed – kg BOD /cap/year of organic sludge.	12.43	
CH_4 recovered or flared (%)	0	

[1] There is no particular category for the primary treatment plants in IPCC2006. The primary treatment systems are aerobic, and they decrease the BOD concentration up to 50%, therefore, it is estimated the MCF value as double of the considered value for aerobic secondary treatment plants.
[2] The default IPCC 2006 value for well managed aerobic treatment plant is 0, however, it was increased to 0.03 to account for the risk of mismanagement in some treatment plants.

Nitrous Oxide (N_2O) emissions can occur as direct emissions from treatment plants or from indirect emissions from wastewater after disposal of effluent into waterways, or the sea.

N_2O emissions from centralized wastewater treatment plants may only be of interest for countries that have predominantly advanced centralized wastewater treatment plants with controlled nitrification and denitrification steps. However, since no advanced wastewater treatment plants are operational in Lebanon, only indirect N_2O emissions from wastewater effluent is discharged into aquatic environments is estimated using default emission factors.

Indirect N_2O emissions arising from the discharge of wastewater (treated or untreated) into aquatic receiving environments is also estimated based on the per capita protein consumption in Lebanon and the fraction of nitrogen in the protein.

Table 93 - Wastewater parameters and conversion factors for N_2O emissions

	Sea, river and lake discharge	Source
(Protein) (kg protein/per/yr)	30.66	Expert estimation
F_{NPR} (kg N/kg N)	0.16	Default (IPCC, 2006)
$F_{NON-CON}$ (kg N/kg N)	1.10	Default Table 6.10a (IPCC, 2006)
$F_{IND-COM}$ (kg N/kg N)	1.25	Metcalf and Eddy (2003) and expert judgment
N_{SLUDGE} (kg N/yr)	0	Default (IPCC, 2006)
(EF) (kg N_2O-N/kg N)	0.005	Expert estimation

7.5.3 Description of flexibility if applied

No flexibility provision has been applied.

7.5.4 Uncertainties and time series consistency

According to the information available in the 2006 IPCC, uncertainties associated for BOD and maximum methane producing capacity is ±30%; and COD (kg COD per cubic meter of wastewater) are estimated at ±100%.

Uncertainties related to activity data regarding wastewater generation and industrial production for countries with poorly developed statistical systems such as Lebanon is ±25%.

7.5.5 Category specific QA/QC

The same QA/QC measures implemented for solid waste disposal were also adopted for the wastewater treatment and discharge, including the verification and validation of activity data through expert consultation and comparison with other references, ensuring that emission factors are in line with the IPCC guidelines, and maintaining consistency in calculation methods across all years covered by the inventory.

Additionally, efforts to minimize manual entry errors, such as using automated connections for data processing and ensuring comprehensive documentation and archiving of all methods and data, were also consistently applied.

The overall GHG inventory, including this subcategory, was also subject to an external review by an expert as part of the BTR1 process.

7.5.6 Category-specific recalculations

No recalculations have been undertaken.

7.5.7 Category specific planned improvements

Among the challenges faced on collection data and calculating emissions from this sub-category is the accuracy of information related to wastewater discharge channels and sludge management. Therefore, the most significant improvement planned for the sector is to update the MoEW survey from 2010 of percentage of collection of domestic wastewaters by sewer systems and the precent of wastewater treatment plants that are operational. In addition, there is a need to develop the country-specific BOD and COD to be able to use higher tier methodologies for this category.

Through the CBIT project, Lebanon established a transparency strategy with institutional arrangements and an online platform (MISCAL) to facilitate the sharing and reviewing of activity data and other parameters related to the waste and wastewater sector. The water task force, composed of the main stakeholders of the sector, will be responsible for the timely and reliable provision of information and validation of assumptions and expert judgments.

8. Recalculations and improvements

8.1 Areas of improvement, including in response to the review process

Through the progressive preparation of the 4 BURs, Lebanon is preparing itself to transition to Biennial Transparency Reports (BTR), as per the Modalities, Procedures and Guidelines (MPG) for the transparency framework referred to in Article 13 of the Paris Agreement.

Many provisions in the MPGs have already being applied by Lebanon through its BURs. Some other provisions include flexibility which Lebanon is using and will continue to use while clearly improving the documentation of rationales for the needed flexibility and planning for their achievement in the areas of improvement. In addition, gaps and needs have been identified and compiled through the International Consultation and Analysis (ICA) process in order to improve Lebanon's reporting (Table 94). Most of these listed needs are still valid, even though many of them have been tackled in at least one of Lebanon's 4 submitted BURs. However, given the iterative nature of submissions under the UNFCCC, improvements are always possible, especially in light of the newly adopted MPGs, with which Lebanon is planning to comply.

Table 94 - Gaps and needs identified by the UNFCCC Technical Team of Experts during the ICA of BUR4

	Gaps and needs	Tackled in BTR1
Institutional arrangements	Information on the extent to which the existing arrangements allow for the ongoing collection and management of cross-sectoral data for preparing the GHG inventory and national reports was not clearly reported in Lebanon's BUR. The TTE noted that the transparency of the information reported on institutional arrangements could be enhanced.	Partially - please refer to section I of NIR
	The Ministry of Environment has made efforts to identify and track climate change related activities and associated financing over the years, but the information available for estimating the overall support that Lebanon is receiving for climate action is limited.	Partially - please refer to section I of NIR
GHG emissions and removals	Anthropogenic emissions of PFCs and SF_6 were reported as "NO" or "NE" in the BUR but the reason for this was not clear to the TTE.	Yes – please refer to section 1.7 table 6 of NIR
	The Party reports that private generators are estimated to meet up to 45% of the total electricity demand in the country. However, as explained in the BUR, information on their number is not available and it was not clear to TTE whether emissions from fuel consumption for private generators are included in the total sectoral emissions.	Partially – please refer to section 3.1, 3.2.5 and 3.2.7 of NIR
	Some subcategories of the IPPU sector, including solvent use (category 2.D.3), fire protection (category 2.F.3) and electrical equipment (category 2.G.1), were reported as "NE" for all gases and the reason for this was not clear to the TTE.	Yes – please refer to section 1.7 table 6 of NIR
	Information on the uncertainty analysis for emissions of HFCs, was not reported in Lebanon's BUR and the reason for this was not clear to the TTE.	No, the calculation of HFC was not conducted using the IPCC software

Mitigation Actions	Information on quantitative goals and progress indicators was not reported in Lebanon's BUR.	Partially - please refer section 2.4 of BTR1 report
	Information on methodologies and assumptions and estimated outcomes was not reported for some actions in the energy and transport sectors and for any actions in the agriculture and waste sectors.	Partially - please refer section 2.4 of BTR1 report
	Information on the steps taken or envisaged to achieve the actions and the progress of implementation of those actions and of the underlying steps taken or envisaged to achieve them was not reported for any mitigation actions in the agriculture or waste sector.	No – no new data is available
Support needed received	Lebanon's financial and technical needs were presented in its fourth BUR by thematic area, but capacity-building needs were not explicitly identified.	Partially - please refer section 5.7 of BTR1 report
	Information on whether Lebanon received funds from the GEF for preparing its fourth BUR was not clearly reported.	Yes- please refer to section 5.4 of BTR1 report
	Information on the support received by Lebanon for climate-change related projects was reported in its fourth BUR (tables 108–112), but support received for capacity-building was not explicitly differentiated.	Partially - please refer section 5.7 of BTR1 report
	Information on technology transfer needs was not reported in the BUR.	No – No new data is available

8.2 Areas of improvements related to the flexibility provisions applied

Table 95 - Summary of flexibility provisions used by Lebanon

Area of flexibility	Flexibility provisions for those developing country Parties that need flexibility in the light of their capacities	Flexibility used	Improvements planned
GHG inventory			
Key category analysis Option to identify fewer key categories; less complex methodologies can be used to estimate GHG emissions/ removals for categories that are not key	Flexibility to identify key categories using a threshold no lower than 85%t in place of the 95%t threshold defined in the IPCC guidelines. Key categories are those that, when summed together in descending order of magnitude, add up to 95% of the national sum of the absolute values of emissions and removals.	No	
Uncertainty assessment Option to report only qualitative uncertainty information if quantitative input data are not available	Flexibility to provide, at a minimum, a qualitative discussion of uncertainty for key categories, using the IPCC guidelines, both for the latest inventory year and the trend, instead of quantitatively estimating and qualitatively discussing the uncertainty of the emissions and removal estimates for all categories, including inventory totals, for at least the starting year and the latest reporting year of the inventory time series and also estimating the trend uncertainty for these same categories/inventory totals for the entire time series.	No	

Completeness Option to use a higher threshold for insignificant categories	Flexibility to consider emissions insignificant if the likely level of emissions is below 0.1 per cent of the national total GHG emissions, excluding LULUCF, or 1,000 kt CO_2eq., whichever is lower. For the Parties that do not use this flexibility provision, a category can be considered insignificant only if the likely level of emissions is below 0.05 per cent of the national total GHG emissions, excluding LULUCF, or 500 kt CO2eq., whichever is lower. If flexibility is chosen, the total national aggregate of estimated emis-sions for all gases from categories con-sidered insignificant shall remain below 0.2 per cent of the national total GHG emissions, excluding LULUCF, as op-posed to 0.1 per cent.	No	
QA/QC Encouragement to develop a QA/QC plan and provide information on general QC procedures implemented	In place of the mandatory requirement to elaborate a QA/QC plan, developing country Parties that need flexibility in the light of their capacities are encouraged to elaborate an inventory QA/QC plan in accordance with the IPCC guidelines, including information on the inventory agency responsible for implementing QA/QC. In place of the mandatory requirement to implement and provide this information, developing country Parties that need flexibility in the light of their capacities are encouraged to implement and provide information on general inventory QC procedures in accordance with their QA/QC plan and the IPCC guidelines.	No	
Gases Option to report fewer GHGs	In place of the mandatory requirement to report on seven gases, flexibility to report at least three gases (CO_2, CH_4 and N_2O) as well as on any of the additional four gases (HFCs, PFCs, SF_6 and NF_3) that are included in the Party's NDC under Article 4 of the Paris Agreement, are covered by an activity under Article 6 of the Paris Agreement, or have been previously reported.	Yes	Collect information related to the sources responsible for emissions of PFCs and SF_6
Time series Option to report a shorter time series and an earlier "Latest reporting year"	In place of the mandatory requirement to report a consistent annual time series starting in 1990, flexibility to report data covering, at a minimum, the reference year/ period for a Party's NDC and, in addition, a consistent annual time series from at least 2020 onward.	Yes	Report emissions for the years 1990 -2022

8.3 Gaps and constraints and planned improvements

Based on an assessment of the current inventory data supply, collection processes and sectoral arrangements, the main challenges and gaps that have been identified are as follows:

Access to data

- Lack of formal data exchange mechanisms at most levels in government. There is no national data centre, no data exchange framework between ministries, no cyber security agency to classify data to know what can be shared.
- Lack of long-term data generation and collection procedures. There have been several fragmented and short-term projects where data is collected and shared for their duration only, but once a project is over, the data collection/sharing is stopped and no longer updated. Staff turnover and resources limitations create a lack of institutional memory which in turn produces a GHG inventory compilation and reporting system that is not sustainable.
- Legislation around data is either not enforced (Access to Information Law) or not in place yet (e-transaction law which has element on data protection).

Data management

- Data storage and management issues. There is no central place to store data and no data management systems at ministries.
- There are IT related challenges that make data sharing more difficult – storage of data on the cloud is not allowed, limited internet supply from state owned telecom company, fees for services with ither suppliers.

Resourcing

- Human resource challenges. Ministries are understaffed, and staff are underpaid, leading to lack of regular attendance at work and limited working hours, and high staff turnover.
- Data collection and sharing for GHG inventory is not written into job remits of staff or ministries, this is complicated by a culture of not wanting to share data and data ownership issues.
- Reporting fatigue for those ministries that do report data to donors or other platforms. For example, the MoA mentioned the difficulty of having to report the same/similar data for various reporting requirements (e.g., from donors). It was suggested that it would be more efficient to provide the data once in one platform.
- There is often a “single point of failure” within each department that supports the importance of collating the inventory, knows what data is required, where the data is found/how to collate. If these people leave, their replacement may not have the same understanding or will to continue the work, there may often be not sufficient time for complete handover of the role and instruction on the process, assuming that there is the will to continue from those that takeover.

Implementing appropriate calculation methodologies

- Inability to move to Tier 2 approaches for key categories. This is both due to the lack of country-specific emission factors, but even more so due to activity data which is incomplete or has high uncertainty as it relies heavily on assumptions.

Completeness

- Lack of reporting on perfluorocarbons (PFCs), NF_3 and SF_6.
- Emissions from HFCs related to air conditioning and refrigeration has taken place from 2021 onward (BUR4), emissions from the remaining categories potentially leading to HFC emissions are currently not estimated due to lack of data.

Quality

- There is no energy balance for Lebanon.
- Quite a lot of thought has gone into the approaches to QA/QC. But the quality of the inventory is still fundamentally limited by cases of poor quality activity data for some categories which QA/QC routines cannot alone overcome.

Lebanon has received recommendations on how to improve the GHG inventory improvement several times in the past. An earlier IKI study made a series of recommendations including providing specific suggestions on Memoranda of Understanding (MoUs) for data sharing for various Ministries and key data providers. Our current understanding is that it has been difficult to implement these MoUs. Staff turnover at ministries also means that there is a large variability in the continuity of approach to reliably providing data for the GHG inventory. Data flow may be affected or paused altogether, without the support and commitment of newly appointed personnel, who may consider data supply a burden instead of an important activity.

The main reason for not implementing previous cross-cutting and sectoral recommendations is related to the lack or scarcity of human and financial resources, especially following the economic and financial crisis in 2019. For example, there has been no progress with central storage of data and data management systems. Similarly, studies to improve the quality activity data or to obtain new data not been undertaken.

Guiding principles for improvements:

Improvements rely on several principles, which have been formulated based on the lessons learned from previous recommendations and the current situation in Lebanon:

- **Sustainability of the solution:** The solution can continue to be used over time and be built on as further improvements are applied, also ensuring time-series consistency.
- **Minimising single point of failure:** Experience shows that data provision often relies on one single staff member with the right expertise, contacts or understanding of the importance of quality GHG inventory data. Where such staff members become less available or change positions, data provision might be severely delayed or cease altogether.
- **Maintaining donor trust:** While Lebanon's current situation might require recommending less ambitious approaches than Lebanon might aspire to, recommendations will still ensure an inventory quality allowing evidence-based policy-decision making, thus also ensuring continued donor trust. This is connected to the general principle of "de-risking climate finance".
- **Based on existing country resources:** Lebanon has received recommendations for GHG inventory improvement various times in the past. At a technical level, the existing improvement options are fully understood. Resource scarcity was the main barrier to implementing improvements in the past and the situation has not improved in recent years. Recommendations therefore need build on the resources realistically available.

- **Making use of existing governance structures where possible:** With the aim of allowing recommendations to be implemented with minimum additional effort, these need to make use not only of the existing resources, but also the existing governance structures, using these to the extent feasible, potentially piggy backing on existing processes.

Summary of key planned improvements:

Securing reliable access to activity data should be a key priority for the largest sources of GHG emissions and key categories. Since the use of MoUs does not seem to be feasible due to barriers to sign and implement them, currently most of the data collection relies on written requests between Ministries and data providers, and personal connections. One option to help secure reliable data provision is for the data collection procedure to be secured at a very high level, perhaps for example via national legislation rather than current system to collect AD, based on weaker agreements between individual departments and the GHG inventory team.

Since category 1.A.1 - **Energy industries** are the largest category and it is likely to remain so in the future, and similarly for 1.A.4 - Other Sectors, ensuring timely and reliable provision of activity data is crucial. If establishing MoUs is not possible, institutional arrangements at the national level in order to improve systematic collection of AD should be developed.

For the **transport sector**, the second largest source in the energy sector, using estimates of vehicle distances travelled are derived from the FITS model. An option to ensure reliable access to AD data for this category may be instead to estimate distances travelled according to vehicle class for the major cities by conducting surveys. These estimate distances travelled could then be extrapolated to smaller towns and the rest of the road network.

Emissions estimate for sector 2.F.1 – **Refrigeration/ Air Conditioning**, the largest source of emissions in the IPPU sector, are based on data older than 5 years. Since the usage of RAC equipment is likely to have substantially changed over time, strengthening national capacity to estimate F-gas emissions should be prioritised. It is suggested to hold a thematic meeting with all relevant data provides to review and try to validate current AD assumptions. If major gaps and uncertainties in AD are identified, if possible, they should be filled through expert judgement or by newly identified data. If this is not possible, a specification for a survey/assessment should be developed. New data on appliances sales will be used together with statistical outputs of government departments, previous surveys data, customs data for imported equipment and refrigerants and expert opinions to understand the current use of RAC equipment. The implementation of this action may need external funding.

Since the AD for the whole **waste sector** is considered particularly poor, improving the quality and quantity of data collected on solid waste (4.A) and wastewater management treatment (4.D) may be a further area of improvement.

Annexes

Annex I. Key categories

According to the IPCC definition, a key category is one that is prioritized within the national inventory system because its estimate has a significant influence on a country's total inventory of direct GHGs in terms of the absolute level of emissions, the trend in emissions, or both. Total emissions from the key categories amount to 95% of the total emissions included in the inventory. Key categories for Lebanon are determined under both the trend and level assessments as presented in the below tables.

Key categories for Lebanon in 2022-Level assessment - Including LULUCF

A IPCC Category code	B IPCC Category	C Greenhouse gas	D 2022 Ex,t (Gg CO_2eq.)	E |Ex,t| (Gg CO_2eq.)	F Lx,t	G Cumulative Total of Column F
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO_2)	6,509.72	6,509.72	0.27	0.27
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO_2)	5,544.04	5,544.04	0.23	0.50
3.B.1.a	Forest land Remaining Forest land	CARBON DIOXIDE (CO_2)	(2,007.69)	2,116.62	0.09	0.59
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CARBON DIOXIDE (CO_2)	2,115.15	2,115.15	0.09	0.68
2.F.a	Refrigeration and Air Conditioning	HYDROFLUORO-CARBON (HFC)	1,656.50	1,656.50	0.07	0.75
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO_2)	1,444.16	1,444.16	0.06	0.81
3.B.2.a	Cropland Remaining Cropland	CARBON DIOXIDE (CO_2)	(1,233.31)	1,233.31	0.05	0.86
2.A.1	Cement production	CARBON DIOXIDE (CO_2)	898.88	898.88	0.04	0.90
4.A	Solid Waste Disposal	METHANE (CH_4)	665.53	665.53	0.03	0.93
4.D	Wastewater Treatment and Discharge	METHANE (CH_4)	525.21	525.21	0.02	0.95
3.A.1	Enteric Fermentation	METHANE (CH_4)	387.22	387.22	0.02	0.96
3.C.4	Direct N_2O Emissions from managed soils	NITROUS OXIDE (N_2O)	150.70	150.70	0.01	0.97
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N_2O)	111.64	111.64	0.00	0.98
3.A.2	Manure Management	NITROUS OXIDE (N_2O)	101.00	101.00	0.00	0.98
3.A.2	Manure Management	METHANE (CH_4)	90.48	90.48	0.00	0.98
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N_2O)	77.10	77.10	0.00	0.99
4.C	Incineration and Open Burning of Waste	METHANE (CH4)	51.93	51.93	0.00	0.99
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH4)	41.24	41.24	0.00	0.99
3.B.1.b	Land Converted to Forest land	CARBON DIOXIDE (CO_2)	(28.13)	39.38	0.00	0.99
2.G	Other Product Manufacture and Use	NITROUS OXIDE (N_2O)	27.16	27.16	0.00	0.99

A IPCC Category code	B IPCC Category	C Greenhouse gas	D 2022 Ex,t (Gg CO_2eq.)	E |Ex,t| (Gg CO_2eq.)	F Lx,t	G Cumulative Total of Column F
3.C.6	Indirect N_2O Emissions from manure management	NITROUS OXIDE (N_2O)	24.82	24.82	0.00	0.99
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO_2)	20.28	21.18	0.00	1.00
3.C.5	Indirect N_2O Emissions from managed soils	NITROUS OXIDE (N_2O)	21.00	21.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH_4)	19.92	19.92	0.00	1.00
4.C	Incineration and Open Burning of Waste	CARBON DIOXIDE (CO_2)	12.87	12.87	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N_2O)	10.76	10.76	0.00	1.00
4.C	Incineration and Open Burning of Waste	NITROUS OXIDE (N_2O)	9.02	9.02	0.00	1.00
4.B	Biological Treatment of Solid Waste	METHANE (CH_4)	8.61	8.61	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	NITROUS OXIDE (N_2O)	4.16	4.16	0.00	1.00
4.B	Biological Treatment of Solid Waste	NITROUS OXIDE (N_2O)	4.07	4.07	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N_2O)	3.09	3.09	0.00	1.00
3.C.3	Urea application	CARBON DIOXIDE (CO_2)	2.29	2.29	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	METHANE (CH_4)	2.21	2.21	0.00	1.00
1.A.4	Other Sectors - Biomass - solid	METHANE (CH_4)	1.96	1.96	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH_4)	1.63	1.63	0.00	1.00
2.A.2	Lime production	CARBON DIOXIDE (CO_2)	0.75	0.75	0.00	1.00
2.A.4	Other Process Uses of Carbonates	CARBON DIOXIDE (CO_2)	0.66	0.66	0.00	1.00
3.C.1	Burning	METHANE (CH_4)	0.35	0.35	0.00	1.00
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO_2)	0.32	0.32	0.00	1.00
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N_2O)	0.25	0.25	0.00	1.00
3.C.1	Burning	NITROUS OXIDE (N_2O)	0.10	0.10	0.00	1.00
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO_2)	(0.01)	0.01	0.00	1.00
1.A.1	Energy Industries - Biomass - gas	METHANE (CH_4)	0.00	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass - gas	NITROUS OXIDE (N_2O)	0.00	0.00	0.00	1.00
Total			17,277.68	23,937.05	1.00	

Key categories for Lebanon in 2022-Level assessment - Excluding LULUCF

A IPCC Category code	B IPCC Category	C Greenhouse gas	D 2022 Ex,t (Gg CO_2eq.)	E |Ex,t| (Gg CO_2eq.)	F Lx,t	G Cumulative Total of Column F
1.A.3.b	Road Transportation - Liquid Fuels	CARBON DIOXIDE (CO_2)	6,509.72	6,509.72	0.32	0.32
1.A.4	Other Sectors - Liquid Fuels	CARBON DIOXIDE (CO_2)	5,544.04	5,544.04	0.27	0.59
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CARBON DIOXIDE (CO_2)	2,115.15	2,115.15	0.10	0.69
2.F.a	Refrigeration and Air Conditioning	HYDROFLUORO-CARBON (HFC)	1,656.50	1,656.50	0.08	0.77
1.A.1	Energy Industries - Liquid Fuels	CARBON DIOXIDE (CO_2)	1,444.16	1,444.16	0.07	0.84
2.A.1	Cement production	CARBON DIOXIDE (CO_2)	898.88	898.88	0.04	0.88
4.A	Solid Waste Disposal	METHANE (CH_4)	665.53	665.53	0.03	0.92
4.D	Wastewater Treatment and Discharge	METHANE (CH_4)	525.21	525.21	0.03	0.94
3.A.1	Enteric Fermentation	METHANE (CH_4)	387.22	387.22	0.02	0.96
3.C.4	Direct N_2O Emissions from managed soils	NITROUS OXIDE (N_2O)	150.70	150.70	0.01	0.97
1.A.3.b	Road Transportation - Liquid Fuels	NITROUS OXIDE (N_2O)	111.64	111.64	0.01	0.97
3.A.2	Manure Management	NITROUS OXIDE (N_2O)	101.00	101.00	0.00	0.98
3.A.2	Manure Management	METHANE (CH_4)	90.48	90.48	0.00	0.98
4.D	Wastewater Treatment and Discharge	NITROUS OXIDE (N_2O)	77.10	77.10	0.00	0.99
4.C	Incineration and Open Burning of Waste	METHANE (CH_4)	51.93	51.93	0.00	0.99
1.A.3.b	Road Transportation - Liquid Fuels	METHANE (CH_4)	41.24	41.24	0.00	0.99
2.G	Other Product Manufacture and Use	NITROUS OXIDE (N_2O)	27.16	27.16	0.00	0.99
3.C.6	Indirect N_2O Emissions from manure management	NITROUS OXIDE (N_2O)	24.82	24.82	0.00	0.99
3.B.5.b	Land Converted to Settlements	CARBON DIOXIDE (CO_2)	20.28	21.18	0.00	0.99
3.C.5	Indirect N_2O Emissions from managed soils	NITROUS OXIDE (N_2O)	21.00	21.00	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	METHANE (CH_4)	19.92	19.92	0.00	1.00
4.C	Incineration and Open Burning of Waste	CARBON DIOXIDE (CO_2)	12.87	12.87	0.00	1.00
1.A.4	Other Sectors - Liquid Fuels	NITROUS OXIDE (N_2O)	10.76	10.76	0.00	1.00
4.C	Incineration and Open Burning of Waste	NITROUS OXIDE (N_2O)	9.02	9.02	0.00	1.00

A IPCC Category code	B IPCC Category	C Greenhouse gas	D 2022 Ex,t (Gg CO_2eq.)	E |Ex,t| (Gg CO_2eq.)	F Lx,t	G Cumulative Total of Column F
4.B	Biological Treatment of Solid Waste	METHANE (CH_4)	8.61	8.61	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	NITROUS OXIDE (N_2O)	4.16	4.16	0.00	1.00
4.B	Biological Treatment of Solid Waste	NITROUS OXIDE (N_2O)	4.07	4.07	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	NITROUS OXIDE (N_2O)	3.09	3.09	0.00	1.00
3.C.3	Urea application	CARBON DIOXIDE (CO_2)	2.29	2.29	0.00	1.00
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	METHANE (CH_4)	2.21	2.21	0.00	1.00
1.A.4	Other Sectors - Biomass - solid	METHANE (CH_4)	1.96	1.96	0.00	1.00
1.A.1	Energy Industries - Liquid Fuels	METHANE (CH_4)	1.63	1.63	0.00	1.00
2.A.2	Lime production	CARBON DIOXIDE (CO_2)	0.75	0.75	0.00	1.00
2.A.4	Other Process Uses of Carbonates	CARBON DIOXIDE (CO_2)	0.66	0.66	0.00	1.00
3.C.1	Burning	METHANE (CH_4)	0.35	0.35	0.00	1.00
2.D	Non-Energy Products from Fuels and Solvent Use	CARBON DIOXIDE (CO_2)	0.32	0.32	0.00	1.00
1.A.4	Other Sectors - Biomass - solid	NITROUS OXIDE (N_2O)	0.25	0.25	0.00	1.00
3.C.1	Burning	NITROUS OXIDE (N_2O)	0.10	0.10	0.00	1.00
3.B.3.b	Land Converted to Grassland	CARBON DIOXIDE (CO_2)	(0.01)	0.01	0.00	1.00
1.A.1	Energy Industries - Biomass - gas	METHANE (CH_4)	0.00	0.00	0.00	1.00
1.A.1	Energy Industries - Biomass - gas	NITROUS OXIDE (N_2O)	0.00	0.00	0.00	1.00
Total						
			20,546.82	20,547.73	1.00	

Annex II. Assessment of uncertainty

IPCC Category	Base year emissions (Gg CO_2eq.)	Current year emissions (Gg CO_2eq.)	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Contribution to Variance in current year	Type A sensitivity	Type B sensitivity	Uncertainty in the trend in national emissions introduced by EF	Uncertainty in the trend in national emissions introduced by AD	Uncertainty introduced into the trend in total national emissions
1A1 - Fuel Combustion Activities - Energy Industries (Liquid Fuel) - CO_2	508.00	1,444.16	1%	5%	0.051	0.000	0.033	0.267	0.002	0.004	0.000
1A1 - Fuel Combustion Activities - Energy Industries (Liquid Fuel) - N_2O	1.06	3.10	1%	60%	0.600	0.000	0.000	0.001	0.000	0.000	0.000
1A1 - Fuel Combustion Activities - Energy Industries (Liquid Fuel) - CH_4	0.56	1.64	1%	30%	0.300	0.000	0.000	0.000	0.000	0.000	0.000
1A2 - Fuel Combustion Activities - Manufac-turing Industries and Constru-ction- CO_2	2,534.00	2,115.15	5%	5%	0.071	0.000	1.097	0.391	0.055	0.028	0.004
1A2 - Fuel Combustion Activities - Manufac-turing Industries and Constru-ction - N_2O	4.90	4.16	5%	67%	0.673	0.000	0.002	0.001	0.001	0.000	0.000
1A2 - Fuel Combustion Activities - Manufac-turing Industries and Constru-ction - CH_4	2.60	2.21	5%	289%	2.888	0.000	0.001	0.000	0.003	0.000	0.000
1A3b - Fuel Combustion Activities - Transport - Road transpor-tation - CO_2	1,265.00	6,509.72	5%	5%	0.071	0.001	0.456	1.202	0.023	0.085	0.008
1A3b - Fuel Combustion Activities - Transport - Road transportation - N_2O	16.24	111.46	5%	210%	2.101	0.000	0.011	0.021	0.023	0.001	0.001
1A3b - Fuel Combustion Activities - Transport - Road transportation - CH_4	14.39	41.24	5%	70%	0.702	0.000	0.001	0.008	0.001	0.001	0.000
1A4a b - Fuel Combustion Activities - Other Sectors - CO_2	1,562.00	5,544.04	15%	5%	0.158	0.003	0.103	1.024	0.005	0.217	0.047
1A4a b - Fuel Combustion Activities - Other Sectors - N_2O	2.86	11.23	15%	60%	0.618	0.000	0.000	0.002	0.000	0.000	0.000

1A4a b - Fuel Combustion Activities - Other Sectors - CH_4	6.50	21.90	15%	50%	0.522	0.000	0.000	0.004	0.000	0.001	0.000
2A1 - Mineral industry - Cement Production - CO_2	1,172.45	898.88	1%	10%	0.100	0.000	0.523	0.166	0.052	0.002	0.003
2A2 - Mineral Industry - Lime Production - CO_2	2.90	0.75	10%	2%	0.102	0.000	0.002	0.000	0.000	0.000	0.000
2A4 - Mineral Industry - Soda Ash Use - CO_2	6.90	0.66	20%	1%	0.200	0.000	0.004	0.000	0.000	0.000	0.000
2D2 non-energy yse- parafin wax - CO_2	0.00	0.32	20%	1%	0.200	0.000	0.000	0.000	0.000	0.000	0.000
2F1 Refrigeration and Air Conditioning - HFC	0.00	1,656.51	10%	30%	0.316	0.001	0.306	0.306	0.092	0.043	0.010
2G3 N2O from Product Uses	0.00	27.16	0%	0%	0.000	0.000	0.005	0.005	0.000	0.000	0.000
3A1 - Enteric Fermentation - CH_4	373.00	387.21	20%	20%	0.283	0.000	0.148	0.071	0.030	0.020	0.001
3A2 - Manure Management - CH_4	108.00	90.47	20%	20%	0.283	0.000	0.047	0.017	0.009	0.005	0.000
3A2 - Manure Management - N_2O	100.30	100.97	62%	50%	0.796	0.000	0.040	0.019	0.020	0.016	0.001
3B1 - Forest Land Remaining Forest Land (Removals) - CO_2	-2,075.00	-2,007.69	15%	5%	0.158	0.000	0.855	0.371	0.043	0.079	0.008
3B1- Land Converted to Forest Land (Removals)- CO_2	0.00	-28.13	15%	5%	0.158	0.000	0.005	0.005	0.000	0.001	0.000
3B2 - Cropland Remaining Cropland (Removals) - CO_2	-1,236.00	-1,233.31	10%	10%	0.141	0.000	0.501	0.228	0.050	0.032	0.004
3B4 - Land Converted to Settlements (Emissions) - CO_2	71.00	20.28	10%	10%	0.141	0.000	0.038	0.004	0.004	0.001	0.000

3C1 Biomass Burning Forest land - CH_4	0.00	0.31	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C1 Biomass Burning Forest land - N_2O	0.00	0.10	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C1 Biomass Burning cropland - CH_4	0.00	0.02	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C1 Biomass Burning cropland- N_2O	0.00	0.00	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C1 Biomass Burning grassland- CH_4	0.00	0.02	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C1Biomass Burning grassland- N_2O	0.00	0.00	14%	70%	0.714	0.000	0.000	0.000	0.000	0.000	0.000
3C2 Urea application- CO_2	0.00	2.29	20%	60%	0.632	0.000	0.000	0.000	0.000	0.000	0.000
4D1 - Direct N2O Emissions from Managed Soils - N_2O	102.30	150.71	20%	60%	0.632	0.000	0.032	0.028	0.019	0.008	0.000
4D3 - Indirect N2O Emissions from Managed Soils - indirect N_2O	39.83	21.02	20%	80%	0.825	0.000	0.020	0.004	0.016	0.001	0.000
4D2 - N2O Emissions from Grazing Animals - N_2O	22.97	24.83	20%	70%	0.728	0.000	0.009	0.005	0.006	0.001	0.000
4A - Solid Waste Disposal - CH_4	492.60	665.53	30%	30%	0.424	0.000	0.167	0.123	0.050	0.052	0.005
4B - biological treatment -CH_4	0.00	8.60	50%	100%	1.118	0.000	0.002	0.002	0.002	0.001	0.000
4B - biological treatment -N_2O	0.00	4.07	50%	150%	1.581	0.000	0.001	0.001	0.001	0.001	0.000
4C - Incineration of Waste - CO_2	26.90	12.87	50%	50%	0.707	0.000	0.013	0.002	0.007	0.002	0.000
4C - Incineration of Waste - CH_4	0.00	51.95	50%	50%	0.707	0.000	0.010	0.010	0.005	0.007	0.000
4C - Incineration of Waste - N_2O	0.00	8.85	50%	100%	1.118	0.000	0.002	0.002	0.002	0.001	0.000
6B2 - Wastewater Treatment and Discharge: Domestic - N_2O	33.70	77.12	30%	100%	1.044	0.000	0.006	0.014	0.006	0.006	0.000
6B2 - Wastewater Treatment and Discharge: Domestic - CH_4	256.30	525.20	20%	70%	0.728	0.000	0.054	0.097	0.038	0.027	0.002
	5,416.26	**17,277.58**				**0.006**					**0.094**
					Percentage uncertainty in total inventory	7.6%				**Trend uncertainty**	30.7%

Annex III. QA/QC plan

Quality control

The team uses standardized notations in the documentation sheets to document changes, data sources and necessary improvements.

Recalculation of the time series for the gases CO_2, CH_4 and N_2O for all sectors caused changes to the greenhouse gas calculations which were verified by sum checks and by using the previous data sets to compare the results. The sum checks were performed for the totals and for the sectors to ensure no data was lost. Also, the transfer of activity data from the documentation sheets to IPCC model was made more automatic decreasing a chance for inserting errors. Recalculations files, comparing the current and the previous submission, allow to check that no changes were made unless necessary and documented. General and sectoral QC activities include cross-checking of outputs, tables and calculation files at various stages of the inventory compilation process.

Details of the general QC procedures is included in section 1.5.

Quality assurance

Lebanon's GHG inventory reported under BTR1 has been subject to review by an international expert. Some of the recommended improvements will be applied in the preparation this BTR2. Other improvements -requiring time and resources- will be applied in subsequent GHG inventories. The results of the reviews are prioritized in terms of their contribution to total GHG emissions and the magnitude of the flagged issue.

Results and recommendations from the reviews of previous BURs through the International Consultation and Analysis (ICA) were considered also in the BTR1.

Annex IV. Any additional information, including detailed methodological descriptions

1. Methodology and results of calculating fuel smuggled during 2020-2022

The methodology employed involves aggregating data from grey literature, press reports, clippings, and diverse sources such as articles, newspapers, live news events, TV broadcasts, and social media platforms. Grey literature, referring to research that is not disseminated through traditional academic channels like peer-reviewed journals and books, is instrumental in this context. This choice is motivated by the necessity for real-time and current information that might not be readily available in conventional scholarly publications.

By gathering information from various sources, including dynamic and rapidly updated mediums like live news events and social media, this research seeks to uncover the dimensions of fuel smuggling activities. The utilization of a diverse range of sources aims to provide a comprehensive and up-to-date understanding of the quantities of smuggled fuel during the specified period. Recognizing that conventional academic publishing may not promptly capture unfolding events, the incorporation of grey literature allows for a more agile and responsive approach to tracking fuel smuggling and its environmental implications.

Regarding the relationship between exchange rate fluctuations and the elimination of subsidies, the analysis relies on 2 key assumptions:

- The higher the difference in the official and unofficial exchange rates between LBP and USD, the higher the smuggling: this assumption estimated that an increase in the black-market exchange rate corresponds to an expansion in smugglers' profit margins, hence an increase in smuggled quantities. For instance, in May 2020, there was a noticeable surge in the black-market lira rate, reflecting a 157% increase from May to July (from LBP 3,775 to LBP 9,700). Therefore, it is estimated that a concurrent rise in both the frequency and quantities of smuggled fuel has followed. On the other hand, the decrease in the exchange rate which occurred around July and August 2020 (July to August: 20% decrease from LBP 9,700 to LBP 7,800), is estimated to have led to a decline in smuggling activity.
- Removal of subsidies reduces the smuggling activity: A similar pattern unfolded in 2021, with the rate experiencing an upswing in May (May to July: 40% increase from LBP 12,342 to LBP 17,225) and subsequent stabilization around July/August. However, this time, the primary factor influencing the trend was the partial removal of subsidies, rather than a reduction in the black-market rate. It is estimated that the removal of subsidies on August 12th, 2021, have resulted in a drop in smuggling rates in the subsequent months.

The dual impact of subsidy removal and a change in exchange rate negatively affected smugglers' profit margins, making continued smuggling efforts largely pointless. This trend extended into 2022, with smuggling occurrences diminishing, and only a few isolated cases being reported. This shift became a prevailing pattern, marking a notable decrease in the frequency of smuggling cases, eventually leading to their rarity. The percentage changes in the exchange rate, coupled with both partial and total subsidy removal, exhibit a direct correlation with the frequency of smuggling. As one of these factors begins to decrease, the smuggling rate follows suit. This interplay emphasizes the sensitivity of smuggling activities, emphasizing the crucial role played by both rate fluctuations and subsidy policies in shaping the landscape of fuel smuggling.

Results

Fuel smuggling started in 2020, after the 2019 economic crisis where the multiple exchange rates increased the rate of smuggling from Lebanon to Syria. The price of fuel oil has become cheaper in Lebanon than in Syria due to the ability of the fuel importers to trade the LBP at BDL at a preferential rate (EUI et al., 2022). In 2020, a liter of fuel oil cost less than USD 0.2 in Lebanon (based on the value of the LBP at the black-market exchange rate at the time) and between USD 1.2 and 2 in Syria (equivalent to SYP 3,000 and 5,000 based on the official exchange rate of 2,512 SYP/USD).

Reports estimate the quantities of fuel smuggled between 700 million and 1 billion liters per day per year for the period 2020-2021.

- News investigations estimated that 2 million liters of diesel and gasoline were smuggled daily to Syria, with a distribution of 85% of it being diesel and 15% being gasoline (MTV, 2021).
- The Lebanese Syndicate of Petrol Station Owners estimated the quantities smuggled to be 1 billion liters of fuel in 2021 (EUI et al., 2022).
- Studies such as Re-energize Lebanon (Boukhather, 2023), estimates that the smuggling was between 10-20% of total import which is around 481 and 963 ktonnes of fuel during this period.

For the year 2021, smuggled continued during the first 8 months of the year, and then it declined significantly after the announcement of BDL on August 12th, 2021, the partial lift of subsidies (40%), which resulted in 66% increase in fuel price. The price hike led to the decrease in the gap between the prices of Lebanon and that of Syria. The governmental subsidy bill in 2020 was 3.2 billion dollars whereas, in the year 2021, the bill was 1.3 billion dollars, decreasing the smugglers' profit margins.

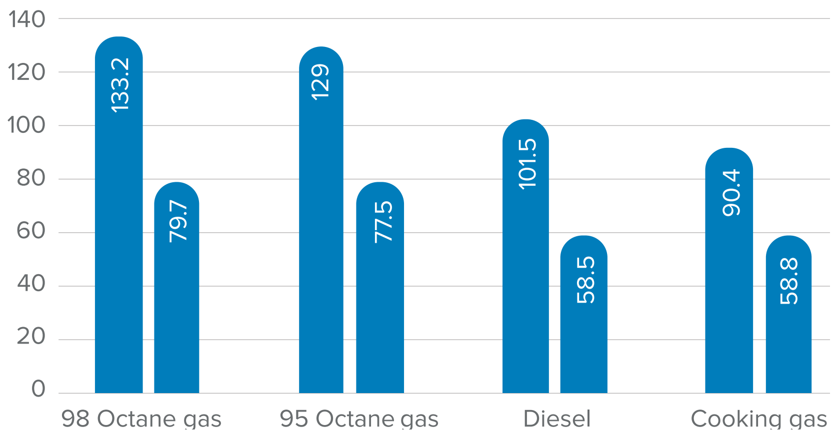


Figure 1: Fuel price hikes after partial ending of government subsidy. (Future, 2021)

Smuggling had further decreased in 2022, when BDL announced the complete lift of subsidies on fuel imports and obliged gas station owners to pay the full price of petroleum products at the country's black-market rate. This has led to a 379% increase in the price of 95 Octane, 375.94% increase in the price of 98 Octane and 682% increase in the price of diesel compared with the partial removal of subsidies. Therefore, buying fuel in Lebanon and selling it back to Syria at this stage was no longer profitable for smugglers.

2. Development of Carbon content of fuel – diesel oil, energy industry

Study Methodology

The 2006 IPCC Guidelines present three tiers for estimating emissions from fossil fuel combustion, represented in the table below:

Table 1: Intergovernmental Panel on Climate Change 2006 Guideline tiers for estimating emissions

Tier	Description
Tier 1	Estimations are made based on the quantity of fuel combusted and average emission factors
Tier 2	Estimations are based on the quantity of fuel combusted and country-specific emission factors. Country-specific emission factors are calculated based on the data on carbon contents in the utilized fuels
Tier 3	Estimations are based on emission models or measurements conducted at individual plant levels

Due to the absence of an energy balance for Lebanon, and the absence of information on specific carbon content and NCV of the imported fuel, the Tier 1 methodology was mainly used for the calculation of energy related emissions. The default emission factors used are 74.1 tonnes/TJ for Gas Diesel Oil and 77.4 tonnes/TJ for heavy fuel oil.

For the transportation sector, CO_2 emissions from road transport have been calculated using IPCC Tier 1 methodology since no information on the specific carbon content of the fuel used in transportation is available. However, Tier 2 technology-specific emissions factors have been used for the calculation of CH_4 and N_2O emissions, which depend largely upon the combustion and emission control technology present in the vehicle. According to the Fourth National Communication, in 2019, the overall fleet emission factor is estimated at 258g CO_2eq./km (including passenger cars, motorcycles, light duty and heavy-duty vehicles) while the passenger cars only emission factor is estimated at 194g CO_2eq./km).

As part of its improvement plan, Lebanon calculated its country-specific emission factors for diesel oil in energy industries for the first time. The sections below represent the methodology used, results, and uncertainty assessment.

The MoEW is the primary source of information related to the energy production and quality of fuel used in the country. Therefore, specific data was requested from MoEW related to EDL operations for the years 2020-2022 including: Energy Production in EDL power plants

- Fuel Consumption in EDL power plants
- Carbon Content of fuel used at power plant level
- NCV of fuel used at power plant level
- Uncertainty associated with fuel testing

Available data on the percent carbon and net calorific value of the different types of fuel used in EDL was limited. Of the 190 fuel test results reviewed, only 22 had the needed parameters. Fortunately, the test results were for diesel oil being used in Zahrani and Deir Ammar Power Plants, which generate collectively almost 90% of Lebanon's supply in the last years. Therefore, the approach was to prioritize the generation of country-specific emission factors for diesel oil and continue to request data for other fuel types, namely:

gasoline (95 and 98 octane) and heavy fuel oil.

Using the data acquired, the emission factor for diesel oil was calculated using the following formula (Ramphull & Surroop 2017, Nana et al., 2023):

Emission Factor (Kg CO_2/TJ) = Carbon Content (Kg/TJ) × Oxidation Factor × 44/12

Where:

- Carbon Content (Kg/TJ)= $\frac{\text{Percent Carbon Content}}{\text{Net Calorific Value } (\frac{TJ}{kg})}$
- Carbon oxidation factor assumed to be equal to 1 according to 2006 IPCC Guidelines for National Greenhouse Gas Inventories
- 44/12 = stoichiometric conversion of C to CO_2

The computed emission factors were cross-checked with the default emission factors listed in the IPCC 2006. In addition, the range of uncertainty associated with the calculations were estimated.

Uncertainties Assessment

Addressing uncertainties begins with understanding what they entail. As per the IPCC 2006 Guidelines, uncertainty is "the lack of knowledge regarding the true value of a variable, represented by a probability density function outlining the range and probability of potential values." (IPCC, 2006). Therefore, uncertainty can be understood as the absence of precise knowledge concerning the accurate emission values at a specific location and timeframe (Frey, 2007).

Uncertainties persist across all tiers—be it Tier 1, Tier 2, or Tier 3 methodologies—when conducting emissions assessments. Despite the detailed focus of Tier 3 methodologies, using context-specific on carbon content and percent carbon, calculation and environmental uncertainties persist, underscoring the complexity of emissions calculations.

Decision 17/CP.8 encourages non-Annex I Parties to the UNFCCC to disclose the level of uncertainty associated with inventory data and underlying assumptions, and to outline any methodologies used for estimating these uncertainties. This uncertainty analysis is essential for both National GHG Inventory and National Inventory Systems, representing a fundamental aspect of best practices in developing national greenhouse gas inventories.

According to Lebanon's 4th Biennial Update Report (BUR), Lebanon has already worked on uncertainty assessment for its national inventory and reported that of the first time in the 4th BUR (MoE & UNDP, 2021).

When it comes to emissions factors, an uncertainty assessment should be conducted to identify potential uncertainties and develop Quality Assurance (QA) and Quality Control (QC) measures in response. The following key considerations were accounted for QC procedures and uncertainty assessment undertaken for this project (Table 2).

According to the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000), QA procedure requires a third-party review of the calculations or assumptions made to assess the quality of the inventory and identify areas where improvement can be made. It is good practice that this procedure be a basic expert review prior to inventory submission by an expert in the relevant technical field (IPCC, 2000). Although there are no standard tools or mechanisms for expert review, the expert peer reviews should be well documented, preferably in a report or checklist format that shows the findings and recommendations for improvement (IPCC, 2000).

Table 2: Key Consideration in Uncertainty Analysis of Emissions Factors (MoE, UNDP, & GEF, 2022; MoE, UNDP, & GEF, 2021)

Key Consideration in Uncertainty Analysis of Emissions Factors	
QA Measures	Conduct a third-party review of documentation associated with the methods and results to ensure they are reasonable.
QC Measures	In data compilation and analysis: • Use automatization (e.g. calculation formulae) to minimize entry error • Check that units are properly labelled in calculation sheets • Check that units are correctly carried through from beginning to end of calculations • Check that conversion factors are correct
	Compare country-specific factors to IPCC defaults and document any significant discrepancies

Study Limitations

The study aimed to calculate emission factors for all types of fuel used in the energy sector. However, several limitations were encountered, resulting in the calculation of emission factors only for diesel oil used in energy industries. These limitations include:

- Lack of data on the quality of fuel used in the local market to power the privately-owned diesel generators.
- The specifications of imported fuel (diesel, gasoline and HFO) don't include the parameters needed to calculate the country-specific emission factors, namely percent carbon and net calorific value.
- Lack of data on the measurement uncertainty ranges of the percent carbon and NCV parameters. Such uncertainty ranges should have been reported in the fuel test results.

Results: Country-specific emission factor for diesel oil

The table below summarizes the test results for diesel oil received from the Ministry of Energy and Water. The tests cover the period between June 2021 and November 2022; 11 samples for NCV and %C each were taken in 2021 and 11 in 2022. The average of all the 22 values is 42.8 MJ/kg for NCV and 86.3% for %C.

Table 3: Summary of Test Results

Date	Location	Product	Lower Heating Value MJ/kg	Carbon %
9-Jun-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.59	86.1
1-Jul-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.63	86.7
15-Sep-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.77	85.8
21-Oct-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.84	86.4
15-Nov-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.9	86.0
22-Nov-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.81	86.5
27-Dec-21	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.78	86.4
17-Jan-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.72	86.0
25-Jan-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.66	86.0
22-Feb-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.74	86.2
16-Mar-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.8	86.5
22-Apr-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.64	86.3
27-May-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.85	86.3
21-June-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	43.12	86.3
26-Jul-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.75	86.5
27-Oct-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.79	86.4
28-Nov-22	Zahrani Power Plant Terminal, Zahrani and Deir Ammar Power Plant	Diesel Oil	42.74	86.4
7-Jul-21	Zahrani Power Plant Terminal,	Diesel Oil	42.83	86.1
11-Aug-21	Zahrani Power Plant Terminal,	Diesel Oil	42.77	86.4
1-Mar-22	Zahrani Power Plant Terminal,	Diesel Oil	42.68	86.4
12-Aug-21	Deir Ammar Power Plant Terminal	Diesel Oil	42.77	86.5
11-Aug-21	Deir Ammar Power Plant Terminal	Diesel Oil	42.77	86.5

Using the data acquired, the emission factor for diesel oil was calculated using the following formula:

Emission Factor (Kg CO_2/TJ) = Carbon Content (Kg/TJ) × Oxidation Factor × 44/12

Where:

$$\text{Carbon Content (Kg/TJ)} = \frac{\textit{Percent Carbon Content}}{\textit{Net Calorific Value } (\frac{TJ}{kg})}$$

When considering each reporting period (2021 and 2022) separately, the average 2021 and 2022 NCV and %C are tabulated in table 4 and the emission factors for the power plants relying on diesel oil are presented in table 5.

Table 4: Average NCV and CC for the Reporting Periods 2021 and 2022

	2021		2022	
	NCV (MJ/kg)	**%C**	**NCV (MJ/kg)**	**%C**
Average	42.769	0.863	42.772	0.863

Table 5: Country-Specific Emission Factors for Power Plants Running on Diesel Oil

	Average fuel consumption (year 2022)	Net Energy Production	NCV	% Carbon Content	Carbon content	Total energy	Country-level CO_2 Emission Factor		Default CO_2 Emission Factor	
Unit	Tonnes	KWh	MJ/kg	% weight	Kg/TJ	TJ	kg CO_2/ Kwh	Tonne CO_2/ TJ	kg CO_2/ Kwh	Tonne CO_2/TJ
Deir Ammar Power Plant	169,170	871,514,000	42.77	86.3	20,177	7,235.74	0.61	73.98	0.62	74.1
Zahrani Power Plant	186,820	1,014,496,000	42.77	86.3	20,177	7,990.67	0.58	73.98	0.58	74.1
Baalbeck Power Plant	1,853	5,415,000	42.77	86.3	20,177	79.26	1.08	73.98	1.08	74.1
Tyre Power Plant	7,104	21,458,000	42.77	86.3	20,177	303.85	1.05	73.98	1.05	74.1

When comparing the emission factor calculated for 2021 and 2022, the standard deviation for both values is 0.0088 with a percent difference of 0.017%, which can be considered relatively small[3] (API, 2015). Therefore, the emission factor is not varying over time as per the results. Given that all EDL powerplants continued to use the same diesel oil in 2023, as in 2022 and 2021 (as per communication with the Ministry of Energy and Water), it can be safely said that the emission factor for diesel oil for the reporting period of 2022 can be used for that of 2023 (API, 2015).

When comparing the country-specific emission factor for diesel oil with the IPCC default emission factor, the percent difference is only 0.16%. This indicates a low level of uncertainty in the fuel testing and emission factors calculation process according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

3 According to API, 2015, uncertainties are considered "relatively small" when the coefficient of variation<0.3

Table 6: Comparison between the Default and Country-Specific Emission Factor for Diesel Oil

	Emission Factor for Diesel Oil	% Difference
Default Value (IPCC, 2006)	74.1 tonne CO_2/TJ	0.16%
Country-Specific (year 2022)	73.98 tonne CO_2/TJ	

Uncertainty Assessment

The most common sources of uncertainties in emission factors include (Frey, H. C., 2007):

- Random sampling error, also known as statistical error, can be quantified using frequentist statistical methods, assuming that data are a random representative sample. For instance, this type of error serves as the basis for estimating confidence intervals, relying on the standard error of the mean.
- Measurement errors due to imperfections in sampling and analytical methods, resulting in errors in each measurement. These errors are commonly categorized as systematic and random. Systematic errors introduce bias, causing the average value of repeated measurements to deviate from the true value of the measured quantity. On the other hand, random errors lead to imprecision in measurements, resulting in repeated measurements being randomly distributed above and below the true value. Measurements may exhibit various combinations of bias and imprecision.

To calculate the emission factor uncertainty for the reporting year 2022, the API Technical report 2572 (API, 2013), IPPC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPPC, 2000), API Addressing uncertainty in oil and gas industry greenhouse gas inventories (API, 2015) and ISO/IEC Guide 98-3 (GUM) (ISO/IEC, 2008) were used as guides.

The measurements of %C and NCV in diesel oil were performed by the laboratory, Bureau Veritas, using the ASTM D5291 and ASTM D4809 tests, respectively, both of which are standard measurement methods (API, 2015). Multiple attempts to contact the laboratory to retrieve the NCV and %C measurement uncertainties were unsuccessful. Although the uncertainty of measurements was not provided in the test results, the API technical report 2572 (API, 2013) and (API, 2015), offer guidance for calculating the sampling uncertainty for the %C and NCV for a reporting period. The uncertainties of the NCV and %C were estimated separately using the Expert Estimation Method, and the uncertainty for the Emission Factor was then estimated using the Propagation of Errors Method. The methodologies are based on the ISO/IEC Guide 98-3 (GUM) and are described below (API, 2015):

Expert Estimation Method

- Experts estimate emission distribution parameters (i.e. mean, standard deviation, and distribution type).
- Simple analytical and graphical techniques are then used to estimate confidence limits from the assumed distributional data.

Propagation of Errors Method:

- Emission parameter means and standard deviations are estimated using expert judgment, measurements or other methods.
- Standard statistical techniques of error propagation typically based upon Taylor's series expansions are then used to estimate the composite uncertainty.

- The following three assumptions can be made:
  - The uncertainties have Gaussian (normal) distribution
  - The uncertainties are relatively small (coefficient of variation<0.3)
  - The uncertainty values are mutually independent.

The data for NCV and %C passed the Shapiro-Wilk test for normality, and the coefficient of variation was calculated to be less than 0.3. Therefore, the samples were assumed to be normally distributed. Accordingly, the %C and NCV reporting period expanded uncertainty at 95% confidence level (IPPC, 2000) was calculated per the below formula for a sampling period of 1 year (ISO/IEC, 2008; API, 2013):

$$Expanded\ Uncertainty_{95} = \mp \frac{k_{95} X \sigma}{\sqrt{Number\ of\ Samples}}$$

Where:

Expanded Uncertainty $_{95\%}$ is the $_{95\%}$ confidence uncertainty;

σ is the standard deviation of the samples; and

$k_{95\%}$ is the 95% confidence coverage factor, which is equivalent to 2.228 for a sample size of 11.

The absolute uncertainty for the average NCV and %C for the reporting period of 2022 are calculated to be $\mp$0.0881 MJ/kg and $\mp$0.0012, respectively (equivalent to a relative uncertainty of $\mp$0.206% and $\mp$ 0.135%, respectively).

The propagation of errors estimate was then used to calculate the uncertainty of the emission factor per the following formula (ISO/IEC, 2008; API, 2015):

$$\delta EF = \sqrt{\left(\frac{\partial EF}{\partial CC}\delta CC\right)^2 + \left(\frac{\partial EF}{\partial NCV}\delta NCV\right)^2}$$

Where:

δEF is the absolute uncertainty of the emission factor;

δCC is the absolute uncertainty of the %C;

δNCV is the absolute uncertainty of the NCV;

$\frac{\partial EF}{\partial CC}$ is the partial derivative with respect to the %C;

$\frac{\partial EF}{\partial NCV}$ is the partial derivative with respect to the NCV;

Therefore:

$$\delta EF = \sqrt{\begin{array}{l}(Oxidation\ Factor\ x\ NCV^{-1}\ x\ Molecular\ Weight\ x\ 1000X\delta_{CC})^2 \\ (Oxidation\ Factor\ X\ Carbon\ Content\ X\ NCV^{-2}\ x\ Molecular\ Weight\ X\ -1\ x\ \delta NCV)^2\end{array}}$$

= $\mp$0.182 tonne CO_2 / TJ

The uncertainty estimates of NCV, %C and emissions factor are summarized the below table

Table 7: Summary of Uncertainty Analysis for the Reporting Year 2022

	NCV	%C	Emission Factor
Absolute Uncertainty	∓0.0881 MJ/kg	∓0.0012	∓0.182 tonne CO_2/TJ
Relative Uncertainty	∓0.206%	∓0.135%	∓0.25%

It is important to note that although information on the emissions factor varies over time, aspects that impact the calculation of the uncertainty are relatively constant (API, 2015). As such, it is not necessary to conduct an uncertainty assessment on an annual basis, and a frequency of every three to five years may be sufficient (API, 2015).

3. Land use definitions and the land representation approaches use and their correspondence of the land use, land use change and forestry categories (land-use and land-use change matrix)

Table 1: Land-use classification, definitions and disaggregation

	Definition according to IPCC	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 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
			Olives combined with field crops	Perennial
			Olives combined with vines	Perennial
			Olives combined with deciduous fruit trees	Perennial
			Olives combined with citrus trees	Perennial

Cropland		Olives combined with intensive field crops	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
		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

Cropland			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
Forestland	Forest: This category includes all land with woody vegetation consistent with thresholds used to define forest land in thenational 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 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.	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.)	Annual
			Low density cypress forests (Cupressus ssp.)	Coniferous
			Low density oak forests (Quercus ssp.)	Broadleaf
			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 pastureland 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 category 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 pastureland 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 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.	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, rivers, and reservoirs.	Continental humid zone	Flooded areas (Artificial reservoirs and hill lakes)
			Marine humid zone	
			Water plane (reservoir)	
			Hill lake	
			Stream or river	
			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	
			Urban sprawl on bare rock Bare soil Beach Sand dune Burned area	No need for disaggregation

Annex V. Common Reporting Tables

Lebanon’s Common Reporting Tables have been submitted separately to the UNFCCC and are available on the following link :
https://unfccc.int/first-biennial-transparency-reports

References

Afif, C., Chélala, C., Borbon, A., Abboud, M., Adjizian-Gérard, J., Farah, W., Jambert, C., Zaarour, R., Badaro Saliba, N., Perros, P., Rizk, T. (2008). SO2 in Beirut: air quality implication and effects of local emissions and long-range transport. Air Quality, Atmosphere & Health 1, 167–178.

ALI (2021). Lebanese industrial sector: Sectoral Study 2018-2021 and beyond. Association of Lebanese Industrialist and European Bank for Reconstruction and Development (EBRD).

API (2015). Addressing uncertainty in oil and natural gas industry greenhouse gas inventories Technical considerations and calculation methods.

Boukhater, C. A. (2023). RE-Energize Lebanon: 5 Action Steps to Rebuilding Lebanon's Collapsed Electricity Sector. https://www.aub.edu.lb/ifi/Documents/publications/research_reports/2022-2023/Re-energize Lebanon Feb 2023.pdf.

EDL (2023). Electricity Production and Fuel Consumption Data for EDL Powerplants and Barges.

El-Hage (2014). Personal communication with captain Said El-Hage. Environment Affairs Manager, Middle East Airlines.

EUI et al. (2022). Lebanon: How the Post War's Political Economy Led to the Current Economic and Social Crisis. Research Project Report, Issue 2022/03 - 12 January 2022.

FAO (2005). Global Forest Resources Assessment 2005. Country Report: Lebanon, Forestry Department, Rome.

Frey (2007). Quantification of Uncertainty in Emission Factors and Inventories - North Carolina State University.

Future (2021). Will Lebanon's government end all fuel subsidies soon? (futureuae.com)

IPCC (2000). Good practice guidance and uncertainty management in national greenhouse gas inventories. Pennman J., Kruger D., Galbally I., Hiraishi T., buruhani N., Emmanuel S. et al. (Eds). Japan: Institute for Global Environmental Strategies.

IPCC (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. Hayama, Kanagawa, Japan: Institute for Global Environmental Strategies (IGES).

IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

ISO/IEC (2008). ISO/IEC Guide 98-3:2008 - Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995). In ISO International Organization for Standardization. http://www.bipm.org/en/publications/guides/gum.html.

LCPS (2023). Lebanon's Economic Crisis by Sector: Challenges and Opportunities in Manufacturing. Lebanese Center of Policy studies - policy brief.

Metcalf & Eddy (2003). Wastewater Engineering: Treatment and Reuse. 4th Edition, McGraw-Hill, New York.

Metcalf & Eddy Inc (1991). Wastewater Engineering: Treatment, Disposal, and Reuse (3rd ed.). In G. Tchobanoglous, & F. L. Burton (Eds.), New York: McGraw-Hill.

MoE/UNDP/EU (2014). Lebanon Environmental Assessment of the Syrian Conflict & Priority Interventions. Beirut, Lebanon.

MoE/UNDP/GEF (2019). Lebanon's Third Biennial Update Report (BUR) to the UNFCCC. Beirut, Lebanon.

MoE/UNDP/GEF (2021). Lebanon Fourth Biennial Update Report on Climate Change 2021.

MoE/UNDP/GEF (2024). Mapping New Directions: A survey of transport patterns and emissions for 2020-2022. Ministry of Environment. Beirut, Lebanon.

MoE/UNDP/GEF(2022). Lebanon's Fourth National Communication to the UNFCCC. https://unfccc.int/documents/624754.

MTV (2021). MTV news chanel. https://www.mtv.com.lb/AMP/Details/1174340 (2021, June 11).

UNDP (2020). Analysis of Lebanon's Nationally Determined Contributions (NDC)-Current State Assessment of Derisking Renewable Energy Instruments. UNDP, Beirut.

Waked and Afif (2012). Emissions of air pollutants from road transport in 987 Lebanon and other countries in the Middle East region. Atmos. Environ. 988 61, 446–452.

World Bank (2011). Republic of Lebanon: Country Environmental Analysis. The World Bank Group, Washington DC.

World Bank (2021). Country Overview Lebanon - https://www.worldbank.org/en/country/lebanon/overview.

World Bank (2024). Lebanon - Country Climate and Development Report (English). Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/099030624151542784/P179617111e46d05c187b91daa689f7b351.

UNDP IS THE LEADING UNITED NATIONS ORGANIZATION FIGHTING TO END THE INJUSTICE OF POVERTY, INEQUALITY, AND CLIMATE CHANGE. WORKING WITH OUR BROAD NETWORK OF EXPERTS AND PARTNERS IN 170 COUNTRIES, WE HELP NATIONS TO BUILD INTEGRATED, LASTING SOLUTIONS FOR PEOPLE AND PLANET.

LEARN MORE AT UNDP.ORG.LB OR FOLLOW AT @UNDP_LEBANON