REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

gef

UNDP
Empowered lives.
Resilient nations.

# LEBANON'S THIRD NATIONAL COMMUNICATION TO THE UNFCCC

MINISTRY OF ENVIRONMENT

2016

# LEBANON'S THIRD NATIONAL COMMUNICATION TO THE UNFCCC

## MINISTRY OF ENVIRONMENT

**November 2016**

**This document should be referenced as:**
MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon.



The United Nations Development Programme (UNDP) is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life. We are on the ground in 166 countries, working with them on their own solutions to global and national development challenges. As they develop local capacity, they draw on the people of UNDP and our wide range of partners.

**For more information**
http://climatechange.moe.gov.lb/
climatechange@moe.gov.lb

**The climate change project management team**
Vahakn Kabakian, Project Manager
Lea Kai Aboujaoudé, Project Officer
Yara Daou, Project Research Assistant
Mary Awad, Project Assistant

**UNFCCC focal point**
Samar Malek, Acting Head of Service of Environmental Technology, Ministry of Environment

**Lebanon's Third National Communication to the UN Framework Convention on Climate Change**

**Reference project**
Enabling Activities for the Preparation of Lebanon's Third National Communication to the UNFCCC

**Executed by**
Ministry of Environment

**Funded by**
Global Environment Facility

**Implemented by**
United Nations Development Programme, Lebanon

**Lead authors**
Lea Kai Aboujaoudé
Yara Daou

**Contributing authors**
Antoine Waked
Charbel Afif
Charbel Mansour
Ernie Niemi
Georges Mitri
Hadi Tabbara
Institute of the Environment – University of Balamand
Karim Osseiran
Marwan Rizkallah

**Main reviewers**
Vahakn Kabakian
Mary Awad

**External inventory reviewer**
Carlos Lopez

**Concept design**
Nathalie Hamadeh

**Layout filling & printing**
Haber Printing s.a.r.l.

# FOREWORD
# Ministry of Environment

The Third National Communication is the most complete and rich snapshot to date of the developments that have taken place in Lebanon on the climate change adaptation, mitigation and reporting levels. The process of preparing this report has been a great opportunity for stakeholders to realize the magnitude of their accomplishments and progress since the publication of Lebanon's Second National Communication in 2011. And through the official submission of this document, we now have the opportunity to celebrate with the rest of the world our national ambitious climate achievements that tend to be sometimes diluted in the difficult socio-political context that is reigning over the region.

Over the past years, considerable efforts have been deployed in Lebanon to create synergies between the various national activities in the environmental and sustainable development fields. Lebanon's Second National Communication quickly became the reference document to mainstream climate change in sectoral plans and policies, and to trigger in-depth research and studies on climate vulnerability and mitigation. Thus, climate change specifically has become one of the largest umbrellas under which a wide range of stakeholders gather to ensure streamlining of mitigation and adaptation within national policies and plans; and to create and enhance channels of communications between line institutions. The work compiled in this national communication is therefore the compilation of the vision, research, responsibilities and capacities of all.

The quality of the different chapters of the present report is also considerably improved. Emissions from many categories of the greenhouse gas inventory were calculated based on more complex and precise methodologies. The mitigation options analysis is more forward looking and the vulnerability assessment was done by costing the impacts of climate change on key economic sectors in the country. In fact, the diversity, innovation and richness of the work performed under the Third National Communication project allowed the development of seven separate sectoral reports, each capturing a comprehensive overview of the sector's emissions, gaps, needs, vulnerabilities, policies and mitigation actions and options. We hope that this knowledge will continue to be used as a reference for future climate action planning. I would like to seize this opportunity to thank the Global Environment Facility that funded the project and the United Nations Development Programme that effectively managed it.

With this, we are aware that with bigger achievements come bigger responsibilities. Therefore, we remain committed to keep on improving the quality of our reporting to the UNFCCC. We are also committed to continuously enrich the national climate action scene by implementing the adaptation and mitigation targets of our Nationally Determined Contribution, by building the capacities of our experts, by strengthening our institutional arrangements and Monitoring, Reporting and Verifying system, and by incentivizing non-state actors to mirror the government's efforts in joining the international climate change momentum.

**Mohamad Al Mashnouk**
**Minister of Environment**

# FOREWORD
# United Nations Development Programme

Ever since the Government of Lebanon ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, the United Nations Development Programme (UNDP) has been supporting the Ministry of Environment and other line ministries in promoting its implementation. With grant funding from the Global Environment Facility, UNDP assisted in the preparation of the official reports submitted by the Government to the Convention, namely the Initial and Second National Communications, the first Biennial Update Report and the Technology Needs Assessment. UNDP also managed several projects that worked on either reducing greenhouse gas emissions or increasing resilience to climate change, in sectors such as the promotion of renewable energy, rainwater harvesting, water conservation and forest restoration.

UNDP is proud to be featured in Lebanon's Third National Communication to the UNFCCC. Looking back at the process of preparing this document, I am delighted to see that national partners are more involved with every round of reporting. The greenhouse gas inventory database, the list of national experts on adaptation and mitigation and the number of stakeholders involved in climate change is growing. The national reports are themselves being referenced and used as a baseline for the development of many sectoral activities and strategies; cooperation between ministries for data exchange is expanding; and the use of guidelines developed under the Convention is spreading. These reports contribute to the continuous improvement of Lebanon's institutional and technical capacities not only to ensure compliance to the UN Convention on Climate Change, but also for Lebanon's own need to integrate climate considerations in development planning.

With this acquired knowledge, Lebanon is preparing itself to address the challenges of climate change under the newly adopted Paris Agreement. Working on the design of Lebanon's Intended Nationally Determined Contribution and planning the implementation of sectoral targets with all key national stakeholders has proven to be a successful cooperation which should be replicated in the forthcoming era of climate governance. UNDP will continue to assist the Government in formulating its climate agenda and mobilize the support needed for its realization.

**Philippe Lazzarini**
**UNDP Resident Representative**

# ACKNOWLEDGEMENTS

The Third National Communication project team would like to express its gratitude to the contributing authors and reviewers of the TNC chapters for their valuable work, patience and perseverance. Appreciation is extended to all those who participated in stakeholder consultation meetings and those who facilitated data collection and analysis.

We also thank the Global Environment Facility for providing the funds to produce this Third National Communication; the Energy & Environment programme at the UNDP country office, specifically Ms. Jihan Seoud and Ms. Joelle Salame for their kind guidance in running the project; and the Ministry of Environment for hosting the project team, specifically Ms. Samar Malek for her trust and support.

A great deal of gratitude goes to Mr. Korkin Kadehjian for assisting the project management team in the finalization of the present work and investing time and effort to develop strategic outlooks for climate change in Lebanon.

**National greenhouse gas inventory and mitigation analysis of the energy sector**

We acknowledge all individuals from the following organizations who provided various forms of support: the Ministry of Energy and Water, the Central Administration for Statistics, the UNDP-CEDRO project, the Lebanese Center for Energy Conservation, IPTEC.

**National greenhouse gas inventory of the industrial processes sector**

We acknowledge the help of data providers: Ms. Abeer Sairawan and Mr. Bassel El Bazzal, Ministry of Agriculture; Ms. Mirna Jammoul, Ministry of Economy and Trade; Brasserie Almaza; Ciment de Sibline; Cimenterie Nationale; Holcim Liban; Société des Chaux et Plâtres du Liban; Union Vinicole du Liban.

Appreciation is extended to Ms. Alaa Abou Daher who assisted the project team in drafting the chapter.

**National greenhouse gas inventory and mitigation analysis of the agriculture sector**

Expert judgement of the following individuals is greatly appreciated: Mr. Fady Asmar, Consultant; Dr. Therese Atallah and Dr. Jean Stephan, Lebanese University; Dr. Issam Bashour, Dr. Fawwak Sleiman, Dr. Darine Salam and Dr. Nuhad Daghir, American University of Beirut; Dr. Talal Darwish, Center for Remote Sensing; Dr. Chadi Hosri, Université Saint-Esprit de Kaslik; Dr. Elias Ibrahim, Mr. Mohammad Abou Zeid, Ms. Fatima Beydoun and Ms. Amal Salibi, Ministry of Agriculture; Dr. Riad Saadé, Comptoir Agricole du Levant; Dr. Chafic Stephan, Dr. Ihab Jomaa and Ms. Nisrine El Hajj, Lebanese Agricultural Research Institute; Mr. Nalin Strivastava, IPCC Task Force on National Greenhouse Gas Inventories; Dr. Francisco Tubiello, Ms. Solange Matta Saadé, Ms. Marie Louise Hayek and Mr. Elie Choueiri, Food and Agriculture Organization; Mr. Raghed Al Hassan, Consultant; Mr. Ghassan Nasrallah, Lebanese Customs; Mr. Ibrahim Tarshishi, Bekaa Grower Association; Mr. Boutros Al Najjar, Dairy Khoury; Mr. Samir Cortbawi, Freiha; Mr. Mostapha Hariri, Hariri farms; Dr. Jean Hawa, Hawa Chicken; Mr. Adnan

Hajj Hasan and Mr. Tony Haddad, Liban Lait; Mr. Nabil Moawad, Moawad foundation; Mr. Maarouf Bakdash, Syndicate of Meat Importers; Dr. Riad Tohme, Tanmia; Ms. Sylvana Hanna, Wilco; Mr. Fadi Khouri, Turbol; Dr. Hassan Machlab, International Center for Agricultural Research in the Dry Areas; Mr. Yousef El Khoury, Instituto Mediterraneo Di Certificazione.

Gratitude goes to the research assistants Ms. Michelle Moawad and Mr. Mohammad Murtada.

**National greenhouse gas inventory and mitigation analysis of the waste sector**

The work on the waste section could not be accomplished without the cooperation of: Mr. Bassam Sabbagh, Ministry of Environment; Mr. Ismail Makki, Council for Development and Reconstruction; Mr. Nicolas Gharib, UNDP/Ministry of Environment; Mr. Naji Chamieh, SES; Mr. Mohamad Baraki, OMSAR; Mr. Raji Maasri and Ms. Maria El Kotob, MORES; Dr. Farouk Merhebi and Dr. Mutasem El Fadel, American University of Beirut; Ms. Rana Ghoussainy and Ms. Arwa El Zein, LACECO; Mr. Jean Khoury, BATCO.

**National greenhouse gas inventory and mitigation analysis of the LULUCF sector**

We recognize the contribution of the following entities: the Ministry of Agriculture, the Greenplan, the National Centre for Scientific Research, the Association for Forests, Development and Conservation, and the Lebanese Reforestation Initiative.

The use of the satellite SPOT imagery was made possible through the Planet Action (SPOT initiative).

**National climate change vulnerability and adaptation assessment**

Our deep appreciation goes to Mrs. Lama Bashour who nationally backstopped Dr. Ernie Niemi, the main author of the economic cost section and provided precious input in terms of review, data collection and validation of assumptions.

We would like to thank the following individuals who provided written feedback on the economic cost section: Mr. Georges Akl, Dr. Georges Mitri, Dr. Hassan Harajli, Dr. Ihab Jomaa, Dr. Jean Stephan, Mr. Karim Osseiran, Ms. Lara Samaha, Mr. Nizar Hani, Ms. Petra Obeid, Mr. Samir Salameh.

We also thank the ESCWA through the RICCAR project for providing information on future climate projections, and the World Health Organization office in Lebanon for their cooperation in providing information.

# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

# ACRONYMS

| | |
|---|---|
| ACSAD | Arab Center for the Studies of Arid Zones and Dry Lands |
| AFDC | Association for Forests, Development and Conservation |
| AUB | American University of Beirut |
| BAU | Business-As-Usual |
| BDL | Banque du Liban |
| BUR | Biennial Update Report |
| CAS | Central Administration for Statistics |
| CBD | Convention on Biological Diversity |
| CCCU | Climate Change Coordination Unit |
| CCGT | Combined Cycle Gas Turbine |
| CCPP | Combined Cycle Power Plant |
| CDR | Council for Development and Reconstruction |
| CNRS | Centre National de Recherche Scientifique |
| CoM | Council of Ministers |
| CORDEX | Coordinated Regional Climate Downscaling Experiment |
| CSP | Concentrated Solar Power |
| DALYs | Disability-Adjusted Life-Years |
| DO | Diesel Oil |
| DOC | Degradable Organic Carbon |
| EDL | Electricité du Liban |
| EIA | Environmental Impact Assessment |
| EMR | Eastern Mediterranean Region |
| ENS | Energy Not Supplied |
| ESCWA | Economic and Social Commission for Western Asia |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| FEV | Fuel-Efficient Vehicle |
| ForFITS | For Future Inland Transport Systems |
| FSRU | Floating Storage and Regasification Unit |
| GBA | Greater Beirut Area |
| GDP | Gross Domestic Product |
| GEF | Global Environment Facility |
| GHG | Greenhouse Gas |
| GIS | Geographic Information System |
| GIZ | Gesellschaft für Internationale Zusammenarbeit |
| GoL | Government of Lebanon |
| GPS | Global Positioning System |
| GWP | Global Warming Potential |

| | |
|---|---|
| HCW | Health Care Waste |
| HDV | Heavy Duty Vehicle |
| HEV | Hybrid Electric Vehicle |
| HFO | Heavy Fuel Oil |
| ICARDA | International Center for Agricultural Research in the Dry Areas |
| ICE | Internal Combustion Engine |
| ICZM | Integrated Coastal Zone Management |
| INBO | International Network of Basins Organisations |
| INDC | Intended Nationally Determined Contribution |
| IPCC | Intergovernmental Panel on Climate Change |
| IUCN | International Union for Conservation of Nature |
| KP | Kyoto Protocol |
| LARI | Lebanese Agriculture Research Institute |
| LCA | Lebanon Climate Act |
| LDV | Light Duty Vehicle |
| LECB | Low Emission Capacity Building |
| LIBNOR | Lebanese Standards Institution |
| LPG | Liquefied Petroleum Gas |
| LRI | Lebanese Reforestation Initiative |
| LULUCF | Land Use, Land Use Change and Forestry |
| MEA | Middle East Airlines |
| MENA | Middle East North Africa |
| MMI | Mobility Monitoring Indicators |
| MMS | Manure Management System |
| MoA | Ministry of Agriculture |
| MoE | Ministry of Environment |
| MoEW | Ministry of Energy and Water |
| MoF | Ministry of Finance |
| MoI | Ministry of Industry |
| MoIM | Ministry of Interior and Municipalities |
| MoPWT | Ministry of Public Works and Transport |
| MRV | Measuring, Reporting and Verifying |
| MSW | Municipal Solid Waste |
| NAMAs | Nationally Appropriate Mitigation Actions |
| NBSAP | National Biodiversity Strategy and Action Plan |
| NCE | National Council for the Environment |
| NDC | Nationally Determined Contribution |
| NEEAP | National Energy Efficiency Action Plan |

| | |
|---|---|
| NG | Natural Gas |
| NGO | Non-Governmental Organization |
| NPO | Net Power Output |
| NRP | National Reforestation Plan |
| PC | Passenger Cars |
| PES | Payment for Environmental Services |
| PG | Private Generation |
| pkm | Passenger Kilometer |
| PV | Photovoltaics |
| RCM | Regional Climate Model |
| RCP | Representative Concentration Pathway |
| RICCAR | Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources in the Arab Region |
| SC | Simple Cycle |
| SFOC | Specific Fuel Oil Consumption |
| SMEs | Small and Medium Enterprises |
| SNC | Second National Communication |
| SUV | Sport Utility Vehicle |
| SWDS | Solid Waste Disposal Sites |
| TEU | Total Equivalent Unit |
| TMO | Traffic Management Organization |
| TNA | Technology Needs Assessment |
| TNC | Third National Communication |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USAID | United States Agency for International Development |
| USFS | United States Forest Service |
| VAT | Value Added Tax |
| vkm | Vehicle-kilometer |
| WAUs | Water User's Associations |
| WtE | Waste to Energy |
| WWEs | Water and Wastewater Establishments |
| WWTPs | Wastewater Treatment Plants |

# Executive summary

Lebanon became a party to the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, after having ratified the Convention as per Law 359. As a non-Annex I Party to the Convention, Lebanon has committed itself to regularly prepare, publish and report its national communication to the Conference of Parties to the UNFCCC. The country has submitted in 1999 and 2011 its First and Second National Communication respectively. While building on the work of the 2 previous reports, this Third National Communication (TNC) presents an improved methodology of national Greenhouse Gas (GHG) emissions for 2012 with a trend series for 1994-2012, and analysis of reduction potentials, climate change vulnerability, impacts and adaptation capacity.

The content of the Third National Communication is the result of many consultations with academics and representatives from government institutions, private sector and non-governmental organizations, in order to capture their expert judgement in the sectors covered in the TNC, and to ensure improvement of data estimations and calculations compared to previous national communications.

## National circumstances

Lebanon is located on the eastern basin of the Mediterranean Sea, with a surface area of 10,452 $km^2$, a coastline extending on 225 km and a landscape characterized by mostly mountainous areas. Lebanon has a Mediterranean-type climate characterized by hot and dry summers and cool and rainy winters, with an average annual temperature of 15˚C.

Lebanon's population has been estimated to be 5,187,027 in 2012, including foreign workers and Palestinian refugees, and is characterized by a high density of around 496 persons/$km^2$. Lebanon has a free market economy, with the costs of most goods and services determined mainly by supply and demand. Current Gross Domestic Product (GDP) increased from USD 38 billion in 2010 to an estimated USD 47.5 billion in 2014. The largest sector in Lebanon is commercial trade accounting for 15% of the GDP, followed by real estate at 14%. The sector with the lowest contributing share to the GDP is the agriculture, forestry & fishing sector at 4%. Lebanon imports more than it exports and is largely dependent on imports for food and fuel. Due to the dependence on imports and services (including banking and tourism), economic productivity is highly influenced by regional and international shocks.

Since the 1990s, Lebanon has been witnessing a significant growth in environmental governance and related policies and institutions. The Environmental Protection Law (law no. 444/2002) is the overarching legal instrument for environmental protection and management in Lebanon. With respect to climate change, apart from law 359/1994 and law 738/2006 relating to the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP) respectively, no major legislation directly addresses climate change in Lebanon. A number of national regulations have

addressed issues that could be linked to climate change. At the moment of drafting of this report, Lebanon has initiated the process of ratifying the Paris Agreement.

On the executive level of governance, climate change issues fall under the mandate of the Ministry of Environment. The latter chairs the National Council for the Environment (NCE) which provides policy and planning suggestion for the Council of Ministers. The National Climate Change Coordination Unit serves as a technical advisory unit to the NCE.

## National greenhouse gas emissions

The total GHG emissions in 2012, excluding removals by sinks, amounted to 26.3 million tonnes $CO_2$eq., which represents 89% emissions increase from 1994 and 39% emissions increase from 2000, and averaging to 4.67% annual increase of greenhouse gases in Lebanon.

The main contributor to greenhouse gas emissions is the energy production sector with 53% of GHG emissions, followed by the transport sector (23%), waste sector (10.7%) and industrial processes (9.7%). $CO_2$ removals from the land-use, land use change and forestry category amounted to -3,036 Gg $CO_2$eq., bringing Lebanon's net emissions down to 23,188 Gg $CO_2$eq.

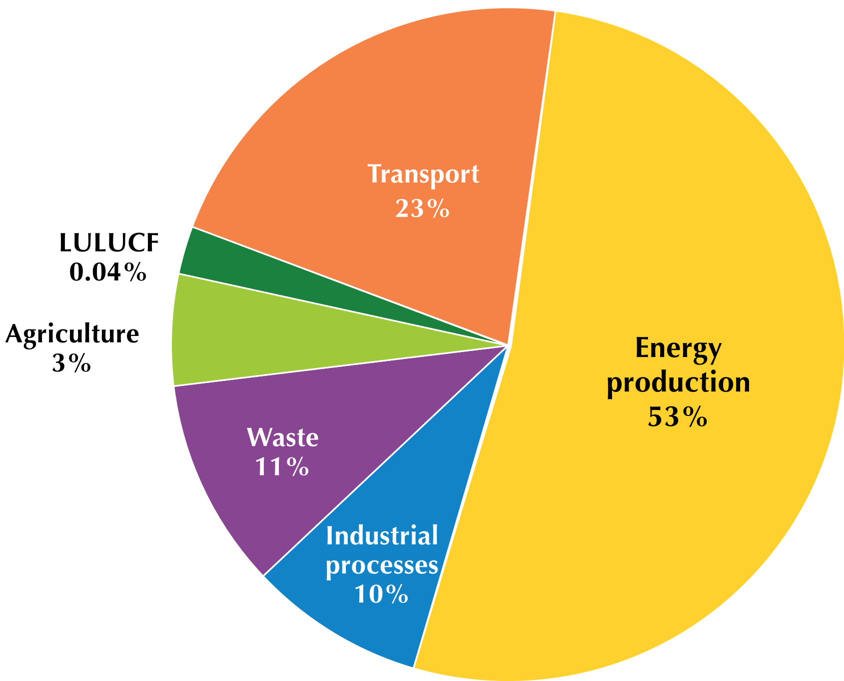



**Figure i:** Lebanon's greenhouse gas emissions by source for the year 2012

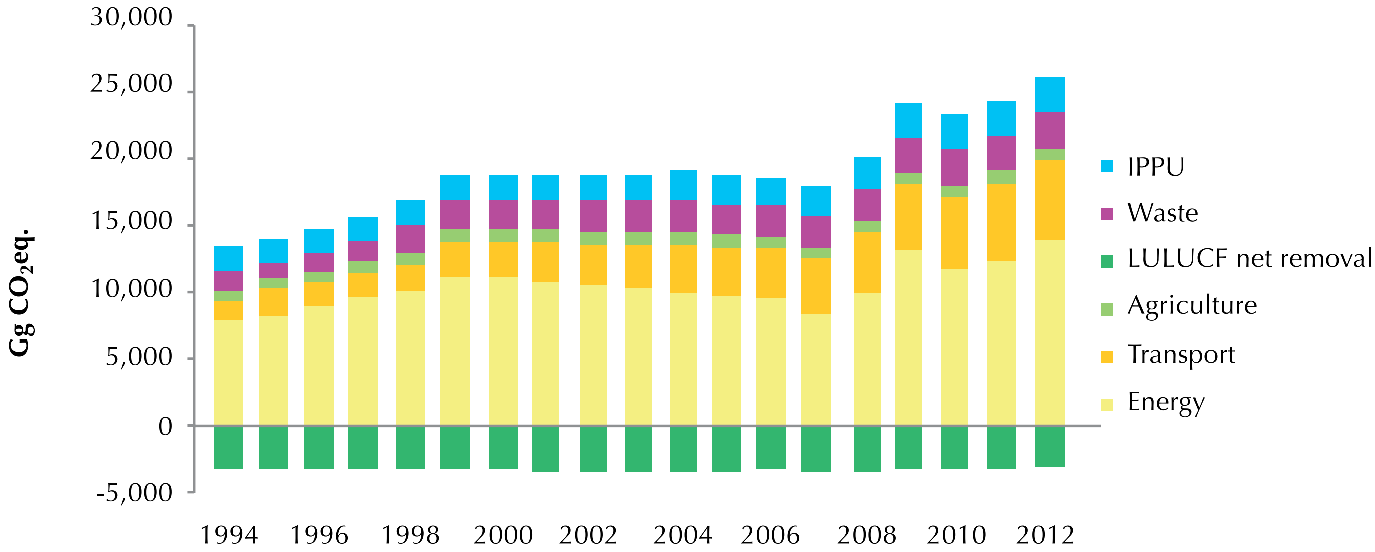



**Figure ii:** Trend in GHG emissions 1994-2012

Carbon dioxide is the main emitted gas with 85% of emissions in 2012, mainly generated from energy production and transport. The waste sector constitutes the main source of $CH_4$ emissions (90%) and agriculture the main source of $N_2O$ (66%).

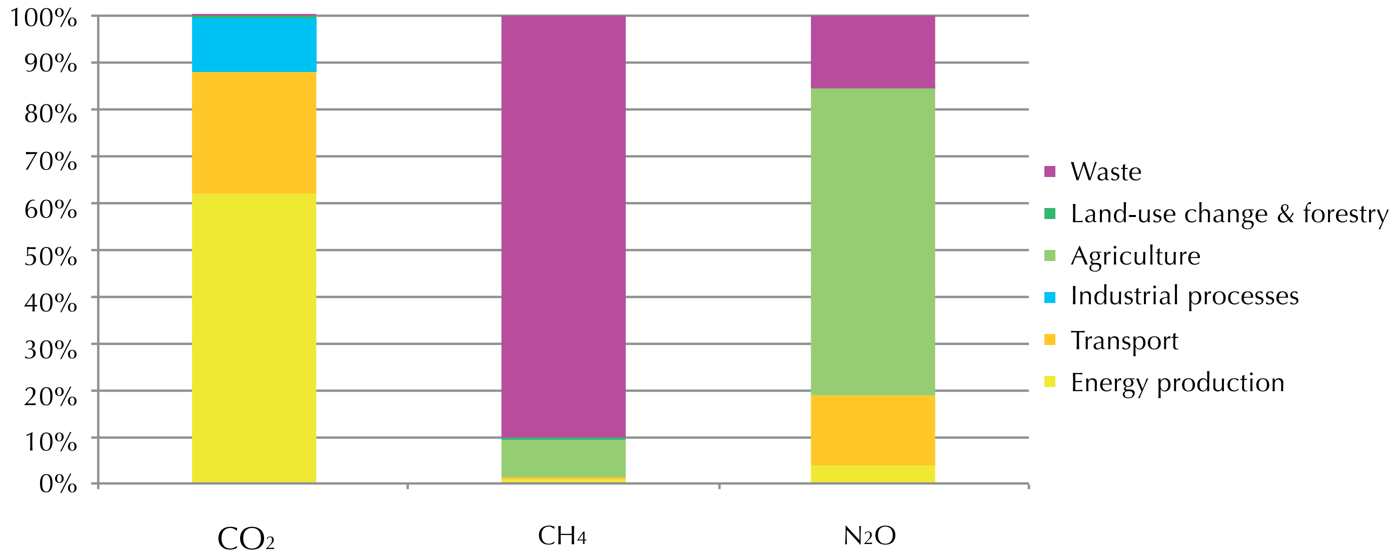



**Figure iii:** Greenhouse gas emissions by gas in 2012

**Table i:** Lebanon's national GHG inventory of anthropogenic emissions by sources and removals by sinks

| Greenhouse gas source and sink categories | $CO_2$ emissions | $CO_2$ removals | $CH_4$ | $CH_4$ | $N_2O$ | $N_2O$ | Total |
|---|---|---|---|---|---|---|---|
| | Gg | Gg | Gg | Gg $CO_2$eq. | Gg | Gg $CO_2$eq. | Gg $CO_2$eq. |
| **Total national emissions & removals** | **22,402.38** | **-3,145.06** | **141.10** | **2,963.18** | **3.12** | **967.33** | **26,332.90** |
| **1 Energy** | **19,736.19** | | **2.11** | **44.31** | **0.58** | **179.80** | **19,960.30** |
| Fuel combustion | 19,736.19 | | 2.11 | 44.31 | 0.58 | 179.80 | 19,960.30 |
| Energy industries | 7,296.67 | | 0.30 | 6.30 | 0.06 | 18.60 | 7,321.57 |
| Manufacturing industries and construction | 3,331.34 | | 0.08 | 1.68 | 0.03 | 9.30 | 3,342.32 |
| Transport | 5,811.95 | | 1.22 | 25.62 | 0.46 | 142.60 | 5,980.17 |
| Other sectors | 3,296.22 | | 0.51 | 10.71 | 0.03 | 9.30 | 3,316.23 |
| Fugitive emissions from fuels | NO | | NO | NO | | NO | - |
| **2 Industrial processes** | **2,557.05** | | **0.00** | **0.00** | **0.00** | **0.00** | **2,557.05** |
| Mineral products | 2,557.05 | | | | | | **2,557.05** |
| Chemical industry | NE | | NE | NE | NE | NE | - |
| Metal production | NE | | NE | NE | NE | NE | - |
| Other production | NA | | NA | NA | NA | NA | - |
| Production of halocarbons & sulphur | | | | | | | |
| Consumption of halocarbons and sulphur | | | | | | | |
| **3 Solvent & other product use** | **NE** | | | **NE** | **NE** | **NE** | - |
| **4 Agriculture** | | | **11.32** | **237.72** | **2.06** | **638.60** | **876.32** |
| Enteric fermentation | | | 9.55 | 200.55 | | | 200.55 |
| Manure management | | | 1.77 | 37.17 | 0.49 | 151.90 | 189.07 |
| Rice cultivation | | | NO | NO | | | 0.00 |
| Agricultural soils | | | | | 1.57 | 486.70 | 486.70 |
| Prescribed burning of savannas | | | NO | NO | NO | | - |
| Field burning of agricultural residues | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **5 Land-use, land use change and forestry** | **108.11** | **-3,145.06** | **0.05** | **1.05** | **0.00** | **0.19** | **109.34** |
| Changes in forest and other woody biomass stocks | 0.00 | | | | | | 0.00 |
| Forest and grassland conversion | NO | NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Abandonment of managed lands | | NO | | | | | |
| $CO_2$ emissions & removals from soil | 0.0 | 0.00 | | | | | 0.00 |
| **6 Waste** | **1.05** | | **127.62** | **2,680.10** | **0.48** | **148.75** | **2,829.89** |
| Solid waste disposal on land | 0.00 | | 108.24 | 2,273.04 | | 0.00 | **2,273.04** |
| Wastewater handling | | | 19.38 | 407.06 | 0.48 | 148.75 | **555.81** |
| Waste incineration | 1.05 | | 0.00 | 0.00 | 0.00 | 0.00 | **1.05** |

NA: Not Applicable – NE: Not Estimated – NO: Not Occurring
Numbers reflect rounding

The energy sector, which includes energy production and transport, is the largest source of greenhouse gas emissions which reflects Lebanon's heavy reliance on imported petroleum products to meet its power and transport requirements. More than 87% of imported fuel oil and 40% of imported gas diesel oil are used in thermal power plants, thus making public electricity generation, referred here as energy industries, the main source of emissions with around 37% of the energy sector's emissions and 28% of total national emissions. Transport is also a significant source of GHG emissions, with 23% of total emissions, mainly emitted from private passenger cars.

Emissions from industrial processes in Lebanon were estimated at 2,557 Gg $CO_2$ in 2012, representing 9.7% of national emissions. Cement industries are the main contributors to GHG emissions from this sector (over 99%), since Lebanon does not have other mineral, chemical and metal industries that emit greenhouse gases.

Agricultural activities contributed to 3.3% of national emissions, which originate mainly from agricultural soils (55%) and from domestic livestock through enteric fermentation (23%) and manure management (22%). Agriculture is the main source of $N_2O$ emissions in Lebanon, caused mainly from the application of synthetic nitrogen fertilizers, crop residues and animal manure to the soil, from the atmospheric deposition of $NH_3$ and NOx, from the leaching and runoff of nitrogen and from animal grazing.

As for emissions from waste and wastewater, they contribute to 10.7% of total GHG emissions. Methane or $CH_4$ is the main greenhouse gas emitted and is mainly caused by the decomposition of the organic component of waste in waste disposal sites. Although some of this methane is recovered and flared in Lebanon's 3 controlled landfills (Naameh, Tripoli and Zahleh), a significant amount is still being emitted from the 504 municipal waste dumpsites spread around the country. Emissions from waste incineration is insignificant, caused by the small amount of healthcare waste that is being incinerated in hospitals. The discharge of wastewater without prior treatment in the Mediterranean sea, river beds and septic tanks is responsible for emitting 555 Gg of $CO_2$eq. or around 20% of the sector's emissions.

Land use, Land Use Change and Forestry (LULUCF) is considered as a greenhouse gas sink in Lebanon, with net removals equal estimated at to -3,036 Gg $CO_2$eq. in 2012. Indeed Lebanon's wide forest cover still represents a significant carbon dioxide sink, although a downward trend in sink capacities has been observed in recent years due to deforestation, forest fires and most importantly, urbanization.

Indirect greenhouse gases such as carbon monoxide (CO), nitrogen oxides (NOx) non-methane organic volatile compounds (NMVOCs) and sulphur dioxide which have indirect impacts on climate and alter the atmospheric lifetimes of other greenhouse gases have also been estimated. In Lebanon, the transport sector is the major source of indirect greenhouses, being responsible for 60% of NOx emissions, 99% of CO emissions and 57% of NMVOCs. Fuel combustion for energy production is the main emitter of $SO_2$ with 94% of emissions, mainly caused by the sulphur content in burnt fuel.

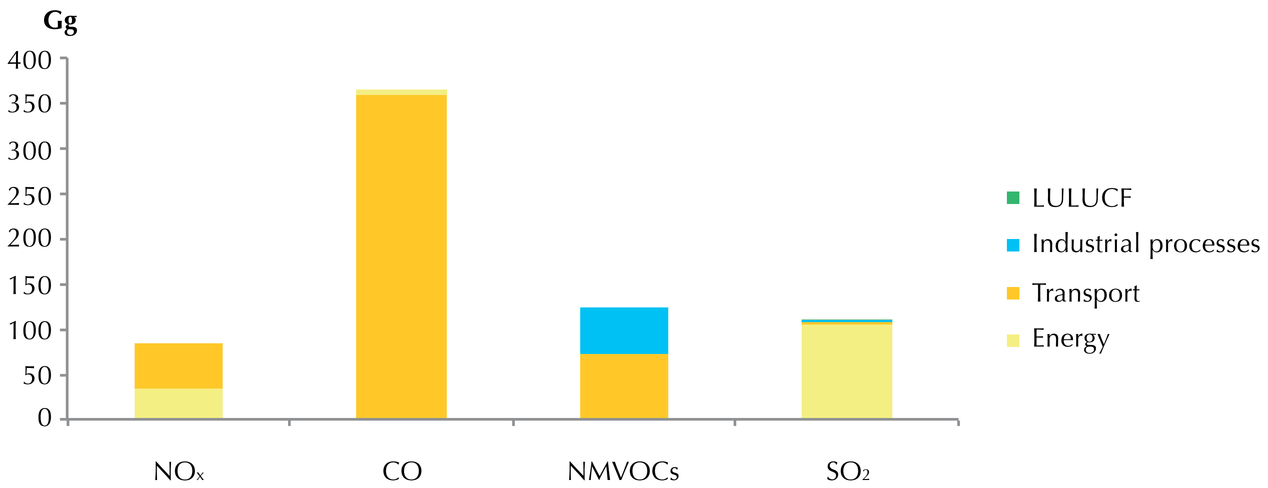



**Figure iv:** Indirect GHG emissions and $SO_2$ emissions in 2012

## Mitigation analysis and emission reduction potential

Lebanon, as a non-Annex I Party to the Convention has no obligation to reduce its greenhouse gas emissions. However, following COP21 and as part of the new Paris Agreement, the Government of Lebanon has declared in its Intended Nationally Determined Contribution (INDC) its intention to reduce greenhouse gas emissions by 15% by 2030 as an unconditional target and by 30% as a conditional one. Emissions reduction will emanate from the implementation of various strategies and policies related to the main sources of greenhouse gas emissions in Lebanon.

The analysis of the reduction potential from the implementation of some of these sectoral policies presents the energy sector as the sector with the strongest abatement potential. The cumulative mitigation potential at national level for the range of sectors considered, namely, electricity generation, road transportation, agriculture, LULUCF, solid waste and wastewater handling, show that the potential of emissions reductions can range from 18% to 38% in 2030 compared to the Business-As-Usual (BAU) scenario.

It is worth noting that not all the proposed activities presented in the TNC have been incorporated in the INDC. While this chapter presents a range of sectoral activities that have a potential to reduce emissions, the INDC only took into account activities that have been already approved by the Lebanese Government as part of ministerial strategies and plans.

**Table ii:** Emission reduction potential by 2030

| Sectors | BAU emissions in 2030 | Emission reduction in 2030 (Gg $CO_2$eq.) | |
|---|---|---|---|
| | | Optimistic scenario | Pessimistic scenario |
| Energy | 21,145 | -7,789 | -3,894 |
| Transport | 5,187.55 | - 2,349.04 | -541.90 |
| IPPU | - | - | - |
| Agriculture | 692.71 | -87.92 | -30.79 |
| LULUCF* | 367.77 | -147.05 | -49.65 |
| Waste | 4,199.01 | -1,480.32 | -1,141.09 |
| Total | 31,592 | -11,853 | -5,658 |
| Emission reduction | | 38% | 18% |

*excluding removals

***Energy sector***

The Government of Lebanon has set a number of priorities for the development of the energy sector in general, and for the modernization and expansion of the power sector in particular. A policy paper on the energy sector was issued in 2010 (PP2010) to establish a global framework for the electric energy sector in Lebanon. Planned activities relate to the addition of generating capacity through conventional and renewable energy sources (up to 5,000 MW additional capacity, from which 2,500 MW from Independent Power Producers (IPP)), upgrade of the transmission and distribution infrastructure including one for natural gas, establishment of a smart grid, development of demand side management and energy efficiency as well as tariff restructuring. The implementation of the policy paper, taking into account some delays on the initially planned schedule (table iii), can inflict a cumulative decrease of 82,600 Gg $CO_2$eq. from 2017 to 2030, with an average annual decrease of 5,900 Gg $CO_2$eq. per year as compared to the business-as-usual scenario. Implementing the policy paper will reduce emissions by 36% by 2030 compared to the BAU scenario.

**Table iii:** Updated schedule of Energy Policy Paper 2010

| Initiative | Planned production date | Rescheduled production date | Remarks |
|---|---|---|---|
| Power wheeling | 2010 | 2010 | Done |
| Barges | 2010 | 2013 | Done |
| Zouk 194 MW ICE Plant | End 2014 | End 2015 | In Progress |
| Jiyeh 78.2 MW ICE Plant | Mid 2014 | Mid 2015 | In Progress |
| Deir Aamar II CCPP 539 MW | End 2016 | End 2017 | In Suspension |
| Rehabilitation of Zouk and Jiyeh thermal power plants | End 2015 | End 2018 | Under Procurement |
| Upgrade of Zahrani and Deir Aamar CCPP | 2013 | 2014 | Done |
| CC add on of Tyre and Baalbeck power plants | 2012 | 2018 | Under Study |
| IPP 1,500 MW | 2015 | 2018 | Under Study |
| IPP 1,000 MW | 2018 | 2021 | Under Study |
| Hydro 40 MW | 2015 | 2018 | Under Study |
| Wind 60 MW | 2013 | 2017 | Under Procurement |
| Waste to energy | 2014 | 2017 | In Progress |

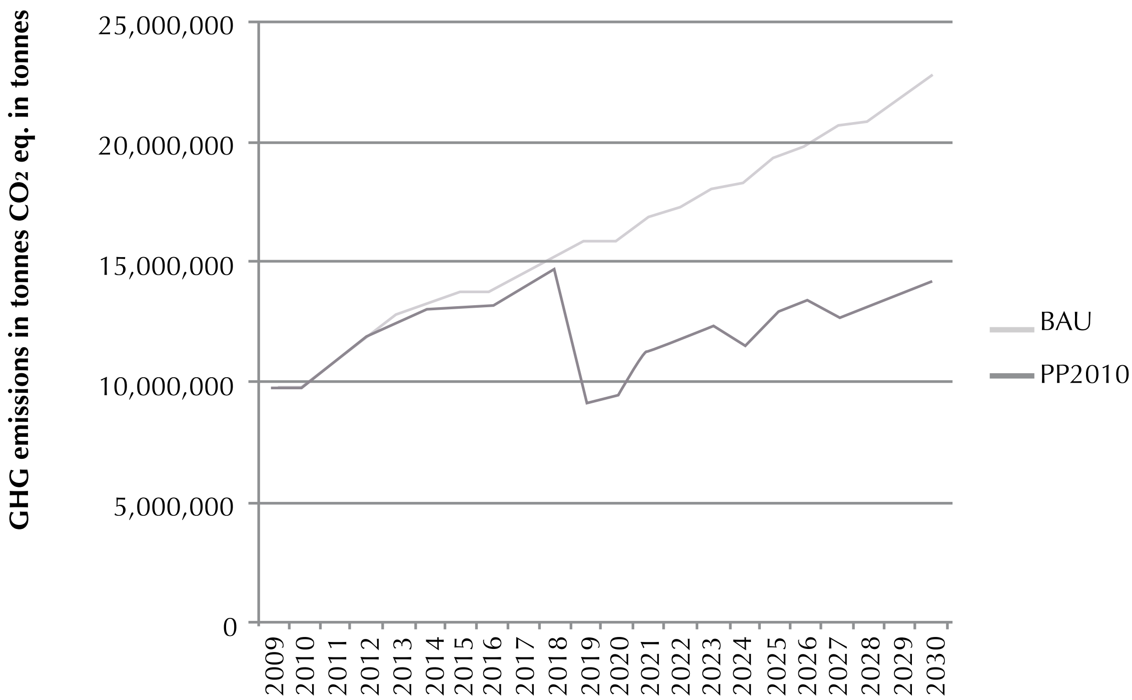



**Figure v:** Emission reduction potential from implementing scenario PP2010

***Transport sector***

The transport sector accounts for more than 40% of national oil consumption and emits 23% of GHG emissions, while being the main source of urban air pollution. Efficient and modern transport systems are critical not only for emission reduction but also for development and economic growth. The mitigation analysis of this sector shows that the replacement of old and inefficient vehicles gradually with fuel-efficient vehicles can reduce emissions by up to 19% by 2040. Indeed, increasing the share of small passenger vehicles to 35% and decreasing the share of large vehicles to 10% renews the vehicle fleet with a more energy-efficient one. Introducing hybrid electric vehicles in the market to reach a share of 10% by 2040 can inflict an additional 8% of emission reduction. On the other hand, restructuring and modernizing the bus transport system in the Greater Beirut Area can lead to a reduction of 40% in emissions by 2040. The implementation of all mitigation combinations concurrently can reduce up to 67% of GHG emissions while improving traffic congestion and resolving other major environmental, economic and social problems associated with increased transport activity in Lebanon (table iv).

**Table iv:** Emission reduction potentials of transport mitigation scenarios

| | **2020 (Gg $CO_2$eq.)** | **2040 (Gg $CO_2$eq.)** | **% reduction in 2040 compared to BAU** |
|---|---|---|---|
| **Business-as-usual scenario (BAU)** | 4,747 | 5,514 | |
| **Mitigation option 1:** Increase share of Fuel Efficient Vehicles (FEV) | 4,502 | 4,486 | 19% |
| **Mitigation option 2:** Increase share of FEVs and hybrid vehicles | 4,431 | 4,007 | 27% |
| **Mitigation option 3:** Increase share of mass transport | 3,912 | 3,308 | 40% |

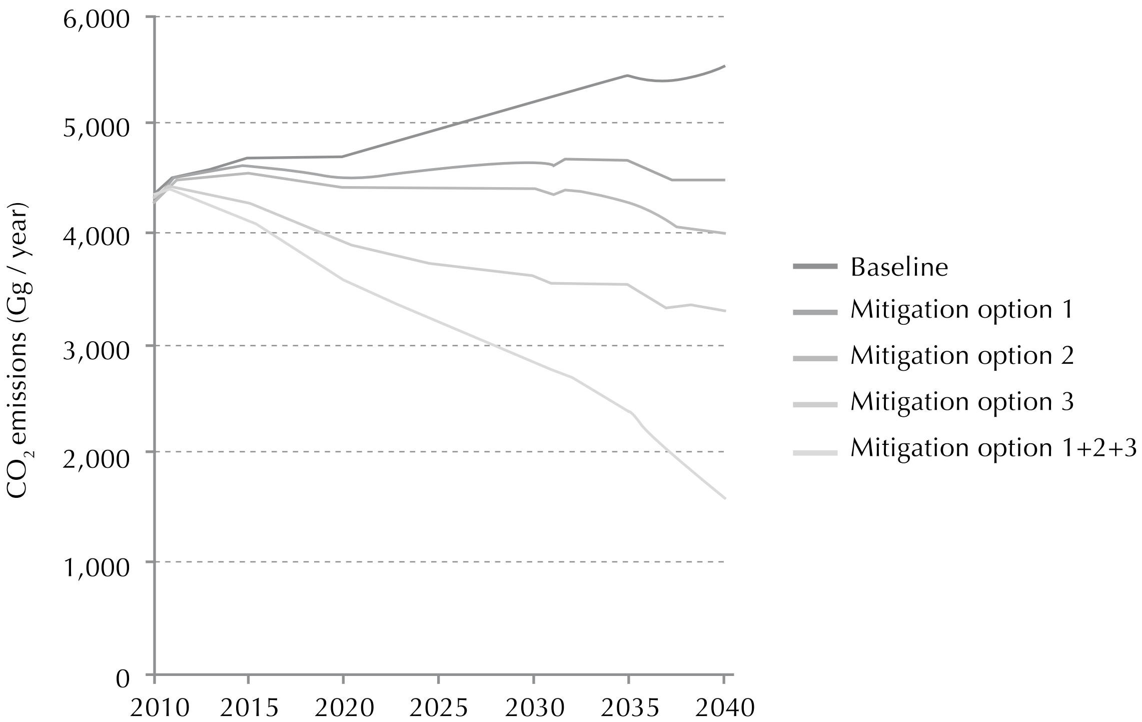



**Figure vi:** Change in $CO_2$ emissions

***Agricultural sector***

Agriculture is not a major source of GHG emissions, contributing only to 3.3% of national emissions. However, planning adequate activities for the agriculture sector offers the opportunity to efficiently manage resources (water, fertilizers, seeds, fuel), increase rural income, sustain the livelihoods of 170,000 farm holdings in addition to reducing emissions and increasing resilience to better adapt to the impacts of climate change. The use of simple agricultural practices such as conservation agriculture and fertigation to a limited crop type and harvest area have shown the ability to reduce GHG emissions by 10% in 2020 and 27% in 2040, compared to the Business-as-Usual scenario (table v). This mitigation potential is the minimum that can be achieved since the analysis is limited to a specific area (10% to 20% of land planted with cereals, olive and fruit trees for conservation agriculture) and to a specific crop (potato plantation for fertigation). These practices can be easily replicated to other crops, thus increasing the adaptation, economic and social co-benefits the implementation of these measures can provide.

**Table v:** GHG emission reduction from conservation agriculture and fertigation

| Year | BAU GHG emissions (Gg $CO_2$eq.) | Conservation agriculture GHG emissions (Gg $CO_2$eq.) | % reduction | Fertigation GHG emissions (Gg $CO_2$eq.) | % reduction |
|---|---|---|---|---|---|
| 2020 | 788 | 729 | 7% | 767 | 3% |
| 2040 | 595 | 478 | 20% | 554 | 7% |

In addition to reducing GHG emissions and contributing to efficient resource management and sustainable rural development , the adoption of conservation agriculture and fertigation contribute to an increase of net revenue. Demonstration projects showed an increase of USD 400 to USD 980 per hectare of barley, barley-vetch and maize plantations using conservation agriculture in the Bekaa and a net profit of USD 3,096 per hectare per year in potato plantation using fertigation.

***Land Use, Land Use Change and Forestry***

Land Use, Land Use Change and Forestry (LULUCF) proved to be a major sink for greenhouse gases with an average of -3,321 Gg/year of $CO_2$eq. sequestrated over the inventory period of 1994 to 2012. However a net decrease of 12% in $CO_2$ removals was recorded between 1994 and 2012, mainly due to the conversion of vegetated lands into settlements and forest fires. Therefore, increasing the removal potential of Lebanese forests relies mainly on 1) protecting existing carbon reservoirs from losses associated with deforestation, forest and land degradation and urbanization, 2) enhancing carbon sequestration through reforestation, afforestation, and forest management and 3) reducing emissions from fire management. Implementing these measures through 2 scenarios: a pessimistic and an optimistic scenarios, can reduce emissions by 12.57% to 38.5% by 2030 (table vi).

**Table vi:** Emission reduction potential from implementing scenario 1 and 2 in LULUCF

| Mitigation scenario 1 | Mitigation scenario 2 |
|---|---|
| Reducing and compensating losses due to urbanization through the implementation of appropriate economic instruments: the cumulative reduction potential from 2013 to 2030 is equal to 39 Gg $CO_2$eq. (Approx. 0.57%).<br><br>Preventing large and intense wildfires: the cumulative reduction potential from 2013 to 2030 (including $CH_4$ and $N_2O$) is equal to 813 Gg $CO_2$eq. (Approx. 12%).<br><br>Total cumulative reduction potential of mitigation scenario 1 is equal to 852 Gg $CO_2$eq. (Approx. 12.57%).<br><br>It should be noted that the prevention of large and intense wildfires contributes to 95.42% of the emission reduction of the mitigation scenario. | Increasing the current extent by 7% through the implementation of appropriate economic instruments. The cumulative reduction potential from 2013 to 2030 is equal to 1,792 Gg $CO_2$eq. (Approx.26.5%).<br><br>Preventing large and intense wildfires: the cumulative reduction potential from 2013 to 2030 is equal to 813 Gg $CO_2$eq. (Approx.12%).<br><br>Total cumulative reduction potential of mitigation scenario 2 is equal to 2,605 Gg $CO_2$eq. (Approx. 38.5%).<br><br>It should be noted that the prevention of large and intense wildfires contributes to 31.2% of the emissions reduction of the mitigation scenario. |

***Waste and wastewater sector***

The mismanagement of waste and wastewater in Lebanon is responsible for emitting 10.7% of national greenhouse gas emissions, and 90.5% of national methane emissions. Finding efficient and sustainable management solutions for waste and wastewater has become a priority at the country level, especially following the waste crisis of 2015. Introducing and progressively increasing the rate of use of waste-to-energy technologies in waste management in addition to increasing the rate of wastewater collection and treatment and consequently, decreasing discharges in septic tanks and in surface waters can reduce the sectors' emissions by 32 to 38% by 2040.

The mitigation analysis explored 2 scenarios: Scenario 1 assumes the adoption of waste-to-energy technology by 2020 only in Beirut and Mount Lebanon and the treatment of wastewater at a rate of 35% by 2020 and 51% by 2040. Scenario 2 considers the expansion of waste-to-energy to include Saida and Tripoli and increase the rate of wastewater treatment to 51% and 74% in 2020 and 2040 respectively. Most of the emission reductions are the result of treating solid waste rather than treating wastewater, and more specifically using waste to energy to replace landfilling and open dumping.

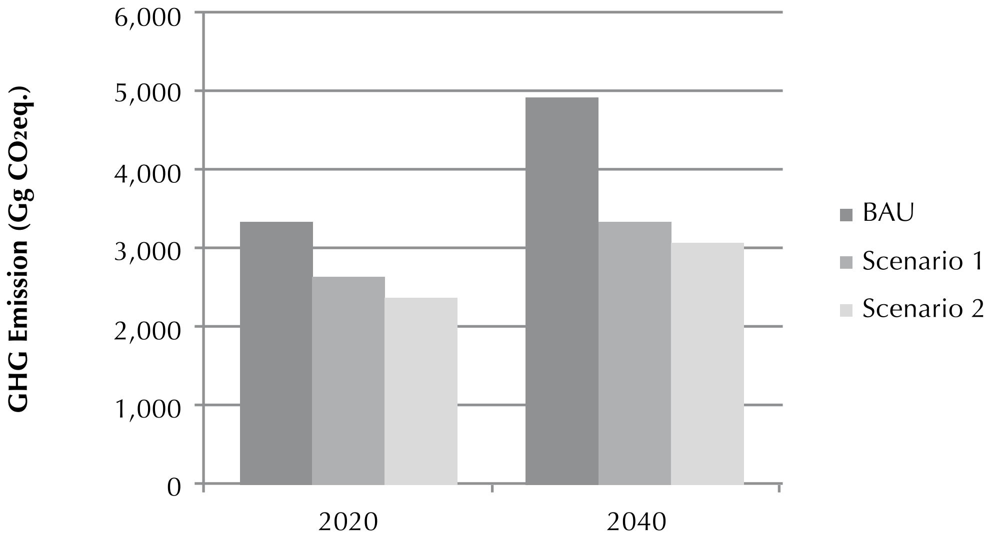



**Figure vii:** GHG emissions comparison of scenario 1 and scenario 2 in the waste sector

## Climate risks, vulnerability and adaptation assessment

***Future climatic changes in Lebanon***

Analysis of historical climatic records of Lebanon from the early 20th century with future emissions trajectories indicates that the expected warming in Lebanon has no precedent. Climate projections show an increase of 1.7°C by mid-century and up to 3.2°C by 2100 and a decrease in precipitation of 4 to 11% with drier conditions by the end of the century (up to 5.8 mm decrease in average monthly precipitation). Projections also show increasing trends of warming, reaching up to 43 additional days with maximum daily temperature higher than 35°C and an increase in number of consecutive dry days when precipitation is less than 1.0 mm by the end of the century, causing the seasonal prolongation and geographical expansion of drought periods. This combination of significantly less wet and substantially warmer conditions will result in hotter and drier climate.

***Impacts of climate change in Lebanon***

Climatic changes are expected to have diverse implications on Lebanon's environment, economy, and social structure. Extreme weather events can have adverse impacts on public heath, human settlements, transport infrastructure, agriculture production, power supply and the economy at large. The fragile biodiversity, ecosystems, and natural habitats will be threatened by increased forest fires, pest outbreaks and sea level rise. A summary of the climate change impacts is presented in table vii.

**Table vii:** Summary of sectoral climate change impacts in Lebanon

| | |
|---|---|
| **Less snow** | - Loss of ski season as a reduction of 40% of the snow cover of Lebanon with an increase of 2°C in temperature is projected, reaching 70% decrease in snow cover with an increase of 4°C.<br>- Less precipitation will fall as snow, with snow that currently falls at 1,500 m shifting to 1,700 m by 2050, and to 1,900 m by 2090.<br>- Decrease in snow residence time from 110 days to 45 days. |
| **Less water availability** | - Snow will melt earlier in the spring. These changes will affect the recharge of most springs, reduce the supply of water available for irrigation during the summer, and increase winter floods by up to 30%. The declines in precipitation will also exacerbate existing challenges to water availability for agriculture, commercial and residential uses.<br>- This will have adverse impacts on rivers and groundwater recharge, and will affect water availability during the summer season and in drought periods. |
| **Increase drought period** | Droughts will occur 15 days to 1 month earlier, and countrywide drought periods will extend 9 days longer by 2040 and 18 days longer by 2090. The already dry regions, such as the Bekaa, Hermel, and the South, will experience the sharpest effects. In addition, cost impacts will be added to irrigation needs, as more pumping hours will be required, therefore consuming more energy. |
| **Less agriculture productivity** | - Soil moisture will decline in response to higher temperatures, reduced precipitation, and higher evapotranspiration.<br>- Changes in temperature and rainfall will decrease productivity of lands currently used to produce most crops and fruit trees, especially wheat, cherries, tomatoes, apples, and olives, and may affect the quality of grapes, despite some transient benefits from the expansion of the coastal plantations such as banana and tomatoes.<br>- Most crops also will face increased infestation of fungi and bacterial diseases. |
| **Higher energy demand** | Higher temperatures in summer will increase demand for cooling, with related consumption of electricity increasing 1.8% for a 1°C increase in temperature, and 5.8% for a 3°C increase in temperature. |
| **Weakened tourism** | Winter outdoor tourism will diminish as warmer temperatures and reduced precipitation shorten the skiing season. Other impacts on tourism will occur in response to changes in ecosystems, loss of natural attractions, such as sandy public beaches, and structural damage to the nation's archaeological heritage. |
| **Sea level rise** | Sea levels will rise up to 30-60 cm in 30 years, if the recent rate of rise, approximately 20 mm/year, continues. The higher sea levels will lead to seawater intrusion into aquifers, increase the risk of coastal flooding and inundation, increase coastal erosion, cover sand beaches, and alter coastal ecosystems in natural reserves and elsewhere. |
| **Forests at risk** | Forests will be adversely affected by climate change, especially that forest stands suffer from fragmentation, pest outbreaks, forest fires and unsuitable practices that already challenge their capacity to survive and develop. |
| **Increased mortality and morbidity** | Lebanon will experience increases in the incidence of infectious diseases, morbidity, and mortality resulting from higher temperatures, more frequent extreme weather events, increased malnutrition from droughts and floods that affect agriculture, and reduced availability of clean water. Increases in temperatures will cause 2,483 to 5,254 additional deaths per year between 2010 and 2030.<br>The effects of climate change on public health include the outbreak of infectious diseases from changing temperatures, increased morbidity and mortality from heat and other extreme weather events, malnutrition from droughts and floods and other water-borne, rodent-borne diseases and vector-borne diseases. |
| **Damaged infrastructure** | Buildings and public infrastructure will suffer damage from changing patterns in precipitation, sea level rise, and increased frequency and intensity of storms. This damage will materialize from inundation of coastal settlements and buildings, floods, mudslides, and rockslides. |

***Economic costs of climate change to Lebanon***

If current trends in greenhouse gas emissions continue, anticipated changes in climate likely would impose economic costs on Lebanon both directly and indirectly. Direct costs would materialize as higher temperatures, changes in precipitation, and extreme weather events such as storms, reduce agricultural productivity, adversely affect human health, cause flooding, and impose similar damage on different segments of Lebanon's economy and society. This would impose costs on Lebanon of about USD 320 million in 2020 and USD 23,200 million in 2080.

Indirect costs would materialize as the direct costs slow the country's economic growth. The slower growth would reduce Lebanon's Gross Domestic Product (GDP) by about USD 1,600 million, or 3% by 2020, 14% in 2040, 32% in 2080. This forgone GDP would constitute a real cost, or reduction in economic wellbeing for Lebanon's households, businesses, and government.

The total estimated cost from direct-damage and forgone GDP will be borne by the government at a cost of USD 610 million in 2020 to USD 44,300 million in 2080 and by households at an average annual cost of USD 1,500 in 2020 to USD 107,200 in 2080. Rural households generally would experience larger percentage reductions than urban households. If meaningful actions were taken to significantly reduce global greenhouse gas emissions, total costs from adverse impacts of climate change on Lebanon would be reduced in 2020 by about 28%, and by as much as 91% in 2080 (table viii).

**Table viii:** Present value of economic costs that annual global GHG emissions would impose on Lebanon under the highest-emissions and lowest scenario (2015 USD)

| | 2020 | 2040 | 2080 |
|---|---|---|---|
| **A. Potential costs if global emissions follow the IPCC's highest-emissions scenario (current trends)** | | | |
| Total cost (millions) | USD 21,200 | USD 80,700 | USD 1,009,700 |
| Average per household | USD 16,400 | USD 57,300 | USD 721,900 |
| Government's share (millions) | USD 6,800 | USD 25,800 | USD 322,000 |
| **B. Potential costs if global emissions follow the IPCC's lowest-emissions scenario** | | | |
| Total cost (millions) | USD 15,200 | USD 30,800 | USD 91,300 |
| Average per household | USD 11,700 | USD 21,900 | USD 65,200 |
| Government's share (millions) | USD 4,800 | USD 9,800 | USD 29,100 |
| **C. Potential savings from reducing global emissions to the lowest-emissions scenario** | | | |
| Potential savings (millions) | USD 6,000 | USD 49,900 | USD 918,400 |
| Potential savings (percentage) | 28 | 62 | 91 |

Numbers reflect rounding.

Climate change will impose costs on every person, family, farm, business, community and region of Lebanon. However, the study revealed that potential impacts on human health pose the greatest risks. Costs associated with potential increases in the risk of death—from heat stress, malnutrition, diarrhea, malaria, floods, and cardiovascular disease—total USD 47.2 billion in 2020. Costs associated with potential increases in illness and disability—from the same climate-related factors—total USD 177,900 million in

the same year. Other major costs might materialize through the impacts of climate change on Lebanon's agricultural production and the prices Lebanese consumers pay for food. Reductions in Lebanon's overall agricultural production—resulting from higher temperatures, changes in precipitation, increases on soil aridity, etc.—would reduce Lebanon's overall GDP by about USD 300 million in 2020. If current trends continue, potential increases in global food prices might impose costs of USD 470 million on Lebanese consumers by raising the prices they pay for food and, because of the higher prices, inducing them to consume less food. A summary of all the costs estimated is presented in table ix and figure viii.

**Table ix:** Costs that climate change might impose on different segments of Lebanon's economy and society (million 2015 USD)

| Potential cost | 2020 | 2040 | 2080 |
|---|---|---|---|
| **A. Costs from impacts of climate change on agriculture and food supplies** | | | |
| 1. Reductions in Lebanon's agricultural production | USD 300 | USD 860 | USD 2,300 |
| 2. Reductions in production of wheat and maize | USD 10 | USD 17 | USD 28 |
| 3. Reductions in fish harvest | USD 13 | USD 32 | USD 32 |
| 4. Increases in global food prices | USD 470 | USD 1,700 | USD 5,000 |
| **B. Costs from impacts of climate change on water** | | | |
| 1. Reductions in agricultural and domestic / industrial water supply | USD 21 | USD 320 | USD 1,200 |
| 2. Reductions in water supply for generation of hydroelectricity | USD 3 | USD 31 | USD 110 |
| **C. Costs from climate-related natural disasters** | | | |
| 1. Increases in droughts, floods/landslides, and storms | USD 7 | USD 36 | USD 1,600 |
| **D. Costs from impacts of climate change on tourism** | | | |
| 1. Reductions in attractiveness of Lebanon's coastal resources | USD 22 | USD 160 | USD 1,800 |
| **E. Costs from impacts of climate change on electricity consumption** | | | |
| 1. Increases in demand for cooling | USD 110 | USD 900 | USD 34,800 |
| **F. Costs from impacts of climate change on human health** | | | |
| 1. Increases in risk of death | USD 47,200 | USD 54,700 | USD 61,400 |
| 2. Increases in risk of illness and disability | USD 177,900 | USD 194,300 | USD 191,500 |
| **G. Costs from impacts of climate change on ecosystems** | | | |
| 1. Reductions in biodiversity | USD 62 | USD 150 | USD 330 |
| 2. Increases in land degradation | USD 29 | USD 78 | USD 170 |
| 3. Increases in sea level | USD 59 | USD 140 | USD 320 |
| **H. Costs from impacts of climate change on society** | | | |
| 1. Increases in violence from higher temperatures | USD 38 | USD 840 | USD 8,600 |
| 2. Reductions in workers' productivity from heat stress | USD 43 | USD 160 | USD 1,400 |
| 3. Reductions in workers' productivity from childhood undernourishment | USD 22 | USD 51 | USD 280 |
| 4. Increases in internal migration | USD 57 | USD 130 | USD 320 |

Numbers reflect rounding.

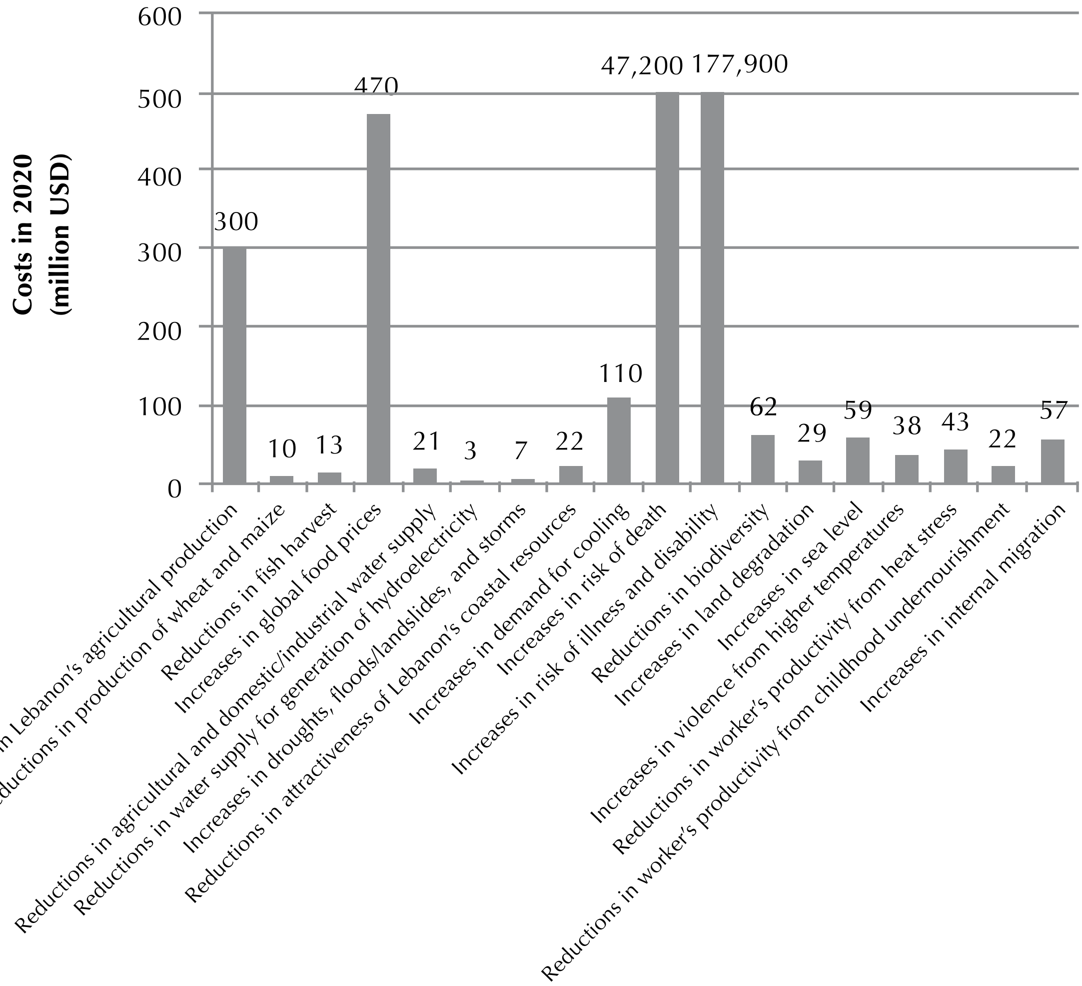



**Figure viii:** Summary of the economic cost of climate change to Lebanon

### ***Proposed adaptation actions***

It is important to recognize that, although Lebanon might be able to reduce its vulnerability to climate-related risks, it cannot avoid them entirely. Global GHG emissions will, inevitably, have adverse effects on Lebanon's households, businesses, communities, and government. Hence, efforts to reduce the costs that these emissions impose on Lebanon should include elements that increase the ability of households, businesses, communities, and the government to respond to and recover from changes in climate. In other words, adaptive actions should focus not just on reducing vulnerability to climate-related risks but also on strengthening resilience to adverse events when they occur. Although a number of initiatives have already been undertaken in various sectors to directly or indirectly enhance adaptation to climate change, additional measures have to be put in place to reduce the vulnerability of Lebanon's capital resources and increasing their resilience to climate change.

In the water sector, potential adaptation measures include reducing the likelihood that coastal freshwater aquifers will experience from saltwater intrusion as sea level rises, increasing the water-use efficiency of domestic, industrial, and agricultural sectors, developing watershed-managed plans appropriate for expected changes in climate, investigating the feasibility of alternative sources of water supply, and improving the available information about Lebanon's water resources and water systems. A national adaptation framework for the water sector is needed to restructure water governance, implement measures for water resources and infrastructure, improve surface and groundwater quality, improve equitable access to sustainable water supply and enhance knowledge and capacity for climate change adaptation. The Paris Pact on Water and Adaptation that Lebanon joined during COP21 in Paris in December 2015 is one initiative that can take water governance in the right direction.

For agriculture, potential options to increase climate resilience include increasing the water-use efficiency of irrigation systems, developing species and hybrids more tolerant of high temperatures and drought, changing the timing of planting, irrigation, and harvesting, adopting sustainable agricultural practices and integrated pest management techniques, developing rangeland-management practices that recognize the effects of climate change, and providing farmers with better, timely information about pending extreme weather events. In recognition of the importance of tackling climate change in this sector, the Ministry of Agriculture introduced for the first time "Responding to climate change impacts" as one of the central courses of action of its 2015-2019 strategy. The Ministry plans to assist the agricultural sector in many areas of intervention to better adapt to the impacts of climate change and to reduce its emissions, mainstream MoA activities related to climate change and introduce adaptation measures through various implemented programmes.

The national afforestation and reforestation programme and the national biodiversity strategy and action plan have also set the stage for improving resilience of forest resources and biodiversity. The strategies aim at increasing forests from 13% of Lebanon's total area to 20% over a period of 20 years and to develop and implement adaptation plans for ecosystems vulnerable to climate change.

As for public health, adaptation measures quickly became a priority after having been identified as one of the most affected sectors by climate change. Recommended adaptation measures include improving knowledge about and awareness of the interactions between climate change and public health, strengthen systems for monitoring and responding to the effects of climate change on public health, encouraging development related strategies, and strengthen institutions responsible for preparing for and responding to the effects of climate change on public health. A regional strategy and plan of action on health and the environment for the period 2014–2019 has been recently developed by WHO which tackles climate change as one of the main target areas.

For the electricity sector, increasing resilience includes improving energy-use efficiency of buildings and transportation systems and developing energy-supply systems that are less vulnerable to the disruptions of extreme weather events, higher average temperatures, and other aspects of climate change. The National Energy Efficiency Action Plans (NEEAP) recently developed by the Lebanese Center for

Energy Conservation and the Ministry of Energy and Water have set a road map for the country towards reaching its objectives in energy efficiency.

The vulnerability of coastal communities and ecosystems could be reduced by developing and implementing plans for pulling human activities back from coastal areas that will be exposed to expected rises in sea level, creating coastal marine reserves, developing and implementing a strategy for protecting capital and people unlikely to move and providing coastal residents with better, timely information about pending extreme weather events.

As for the tourism sector, potential options to increase climate resilience include developing better insurance and other short-run tools for managing risks to tourism, such as disruptions from coastal storms or lack of snowfall at mountain resorts, developing appropriate long-run plans for managing risks, such as moving coastal tourism facilities away from potential storm surges and winter facilities to higher altitudes, reducing the stress on climate-sensitive natural resources important to tourism from e.g., erosion and urban sprawl, and providing the tourism industry with better, timely information about pending extreme weather events.

## Gaps, constraints and related financial, technical and capacity building needs

### *Reporting and related institutional and MRV arrangements*

The main challenges faced in the preparation of the Greenhouse Gas (GHG) inventories, national communications and biennial reports are still the same since the preparation of the country's first inventory in 1994 and are mainly related to unavailability, inaccessibility and inconsistency of activity data and emission factors, lack of reporting and coordination between institutions and the difficulty in tracking the emission reduction achieved by the implementation of mitigation actions.

Progress has been observed only in the area of capacity building. Other types of support to tackle technical and institutional constraints are very limited. Progress is slow and institutional arrangements take time given the unstable political situation of the country. As a result, Lebanon still does not have a clearly defined system for data collection and processing, quality assurance and control, and a reporting and monitoring framework. Proper regulations that would fully define competences and responsibilities in this area are needed. In addition, the sustainability in the involvement of dedicated and competent individuals in all relevant institutions is crucial to ensure good quality reporting.

### *Implementation of policies and projects*

Implementing climate related projects and policies requires strong coordination between institutions to support sectors with the planning and implementation of mitigation and adaptation actions, the assessment and communication of support needs (nationally and internationally) and the Measuring, Reporting and Verifying (MRV) related to their implementation. This will also include further mainstreaming of mitigation and adaptation, promoting climate action, improving the cooperation among ministries as

well as mobilizing support for planning and implementation. The establishment of a permanent MRV unit at the Ministry of Environment can ensure such as role. The support of the international community in order to successfully continue the efforts put in place is highly needed.

***Financial gaps and constraints***

Additional financial resources are needed to continue to develop and consolidate existing technical and institutional capacities in order to implement planned climate actions and monitor their progress and impacts on national emissions. Direct financial support is not sufficient and flexible enough to ensure a complete and adequate reporting and the implementation of nationally prioritized mitigation and adaptation actions. There is an urgent need to increase the funds available for countries and increase flexibility to encourage the initiation of new activities that aim at improving reporting and implementation of climate action.

# الملخص التنفيذي

أصبح لبنان طرفاً في اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ في العام ١٩٩٤، وذلك بعد التصديق عليها بموجب القانون ٣٥٩. وبموجب كونه طرفاً غير مدرج في المرفق الأول للاتفاقية، يترتب على لبنان الالتزام باعداد وتقديم ونشر بانتظام بلاغه الوطني إلى مؤتمر الأطراف في الاتفاقية الإطارية. وقد قدّم لبنان في العامين ١٩٩٩ و٢٠١١ أول وثاني بلاغ له على التوالي. ومع أنّ البلاغ الوطني الثالث يبني على عمل البلاغين السابقين، فهو يقدّم أيضاً منهجية محسّنة لاحتساب الانبعاثات الوطنية للغازات الدفيئة للعام ٢٠١٢ مع سلسلة سباقة للأعوام ١٩٩٤ إلى ٢٠١٢ وتحليل لإمكانيات الحد من الانبعاثات، وقابلية التأثر بتغير المناخ، والانعكاسات السلبية، والقدرة على التكيف.
مضمون البلاغ الوطني الثالث هو ثمرة مشاورات عدة مع أكاديميين وممثلين عن المؤسسات الحكومية والقطاع الخاص والمنظمات غير الحكومية، بغرض تبيان حكمهم كخبراء في القطاعات المشمولة في البلاغ الوطني الثالث وكذلك ضمان تحسين تقديرات البيانات والحسابات بالمقارنة مع البلاغين الوطنيين السابقين.

## الظروف الوطنية

يقع لبنان على الحوض الشرقي للبحر الأبيض المتوسط، وتبلغ مساحته ١٠،٤٥٢ كلم مربع، كما يتمتع بساحل يمتد على طول ٢٢٥ كيلومتراً ومناظر طبيعية تتميز بكونها مناطق جبلية في الغالب. يتمتع لبنان بمناخ البحر الأبيض المتوسط الذي يتميز بصيف حار وجاف وشتاء بارد وممطر، ومتوسط درجة الحرارة السنوي فيه هو ١٥ درجة مئوية.

قُدّر عدد سكان لبنان في العام ٢٠١٢ بـ ٥،١٨٧،٠٢٧ نسمة، بما في ذلك العمال الأجانب واللاجئين الفلسطينيين، وتتّسم البلاد بكثافة سكانية عالية تعادل حوالى٤٩٦ نسمة في الكيلومتر المربع الواحد. يتبع لبنان نظام اقتصاد السوق الحر، ويتم تحديد تكاليف معظم السلع والخدمات بشكل رئيسي بحسب العرض والطلب. ارتفع الناتج المحلي الإجمالي من ٣٨ مليار دولار أميركي في العام ٢٠١٠ إلى ما يقدّر بـ٤٧,٥ مليار دولار في العام ٢٠١٤. التبادل التجاري هو القطاع الأكبر في لبنان، إذ يشكّل ١٥ بالمئة من الناتج المحلي الإجمالي، يليه قطاع العقارات بنسبة ١٤ بالمئة. أما قطاع الزراعة والغابات وصيد الأسماك، فهو الأقل مساهمة في الناتج المحلي الإجمالي بنسبة ٤ بالمئة. تزيد واردات لبنان عن صادراته، وتعتمد البلاد إلى حدّ كبير على واردات الغذاء والوقود. ونظراً للاعتماد على الواردات والخدمات (بما في ذلك المصارف والسياحة)، تتأثر الإنتاجية الاقتصادية بشدة بالصدمات الإقليمية والدولية.

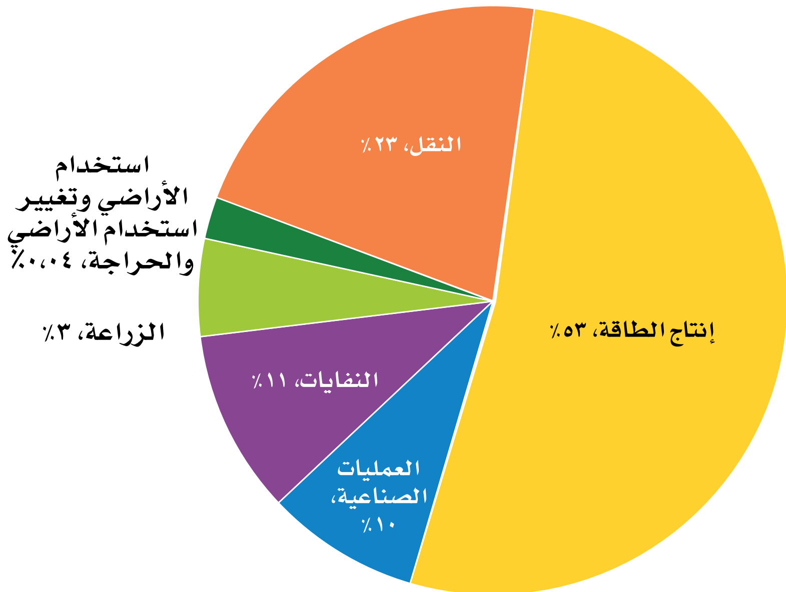
يشهد لبنان منذ تسعينات القرن الماضي نمواً كبيراً في الحوكمة البيئية والسياسات والمؤسسات ذات الصلة. ويشكّل قانون حماية البيئة (القانون رقم ٢٠٠٢/٤٤٤) وثيقة قانونية شاملة لحماية البيئة والإدارة البيئية في لبنان. أما في ما يتعلق بتغير المناخ، وبصرف النظر عن القانون ١٩٩٤/٣٥٩ والقانون ٢٠٠٦/٧٣٨ ذوي الصلة بالتصديق على اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ وبروتوكول كيوتو على التوالي، ما من أي تشريع رئيسي يتناول تغير المناخ في لبنان بشكل مباشر، ولكن تتناول عدد من اللوائح الوطنية قضايا يمكن أن تكون مرتبطة بتغير المناخ. وحتى لحظة إعداد هذا التقرير، كان لبنان قد بدأ بعملية التصديق على اتفاقية باريس.

على مستوى الحكم التنفيذي، تندرج قضايا تغير المناخ تحت ولاية وزارة البيئة، التي تترأس المجلس الوطني للبيئة، الذي يضع بدوره السياسات ويقترح المخططات على مجلس الوزراء. وتعمل وحدة التنسيق الوطني لتغير المناخ كوحدة استشارية فنية للمجلس الوطني للبيئة.

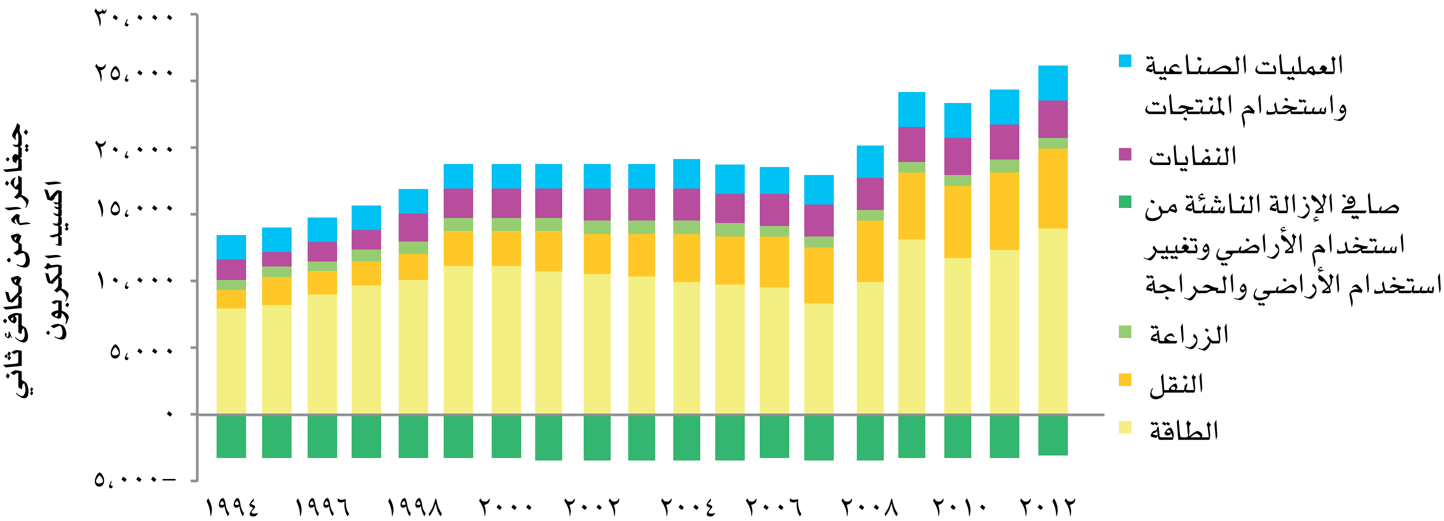
## الانبعاثات الوطنية للغازات الدفيئة

في العام ٢٠١٢ بلغ إجمالي انبعاثات الغازات الدفيئة ٢٦,٣ مليون طن من مكافئ ثاني أكسيد الكربون، وذلك لو استثنينا عمليات إزالة انبعاثات الغازات الدفيئة بواسطة احواض امتصاص الكربون. ويمثل هذا الرقم زيادة للانبعاثات بنسبة ٨٩ بالمئة عن العام ١٩٩٤ و٣٩ بالمئة عن العام ٢٠٠٠، مع متوسط زيادة سنوية بنسبة ٤,٦٧ بالمئة من الغازات الدفيئة في لبنان.

قطاع إنتاج الطاقة هو المساهم الرئيسي في انبعاثات الغازات الدفيئة، إذ يستأثر بنسبة ٥٣ بالمئة من هذه الانبعاثات، يليه قطاع النقل (٢٣ بالمئة)، وقطاع النفايات (١٠,٧٪)، والعمليات الصناعية (٩,٧ بالمئة). وقد بلغت إزالة ثاني أكسيد الكربون الناشئة من استخدام الأراضي وتغيير استخدام الأراضي والحراجة -٣،٠٣٦ جيغاغراماً من مكافئ ثاني أكسيد الكربون، بما حقق لصافي الانبعاثات في لبنان انخفاضاً حتى ٢٣،١٨٨ جيغاغراماً من مكافئ ثاني أكسيد الكربون.

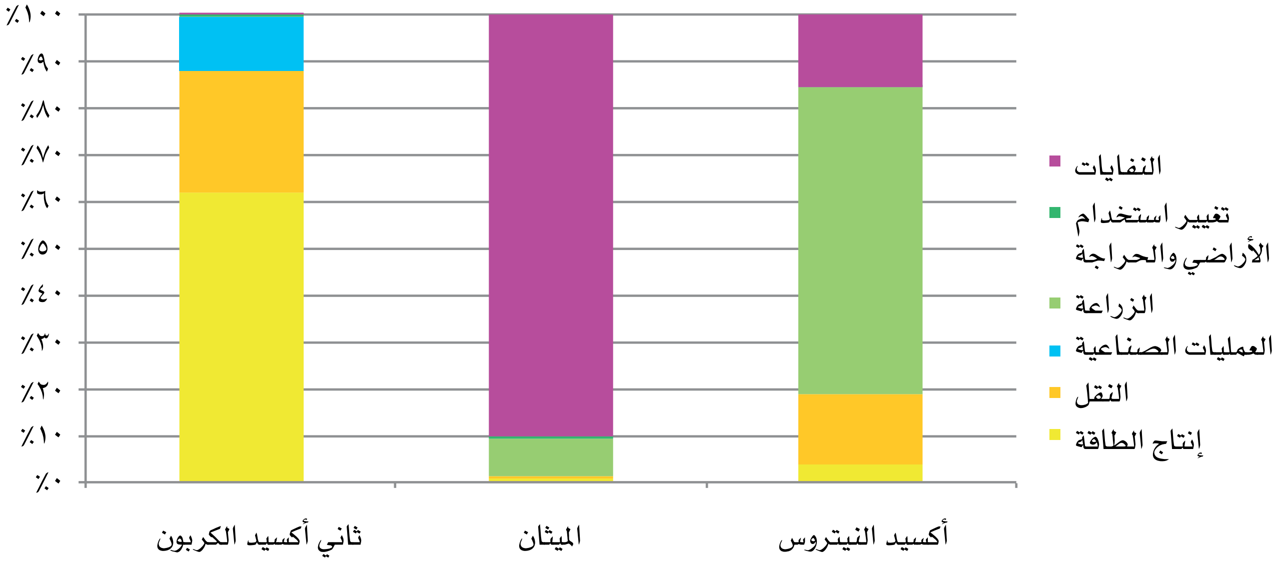



**الرسم أ:** انبعاثات الغازات الدفيئة في لبنان بحسب المصدر للعام ٢٠١٢




**الرسم ب:** اتجاهات انبعاثات الغازات الدفيئة للفترة الممتدة من ١٩٩٤ إلى ٢٠١٢

ثاني أكسيد الكربون هو الغاز المنبعث الرئيسي، إذ شكّل ٨٥ بالمئة من الانبعاثات في العام ٢٠١٢، وكان مصدره الأساسي من إنتاج الطاقة والنقل. يشكل قطاع النفايات المصدر الرئيسي لانبعاثات الميثان (٩٠٪) بينما قطاع الزراعة هو المصدر الرئيسي لأكسيد النيتروس (٦٦ ٪).




**الرسم ج:** انبعاثات الغازات الدفيئة للعام ٢٠١٢ بحسب الغاز

**الجدول أ:** جردة انبعاثات الغازات الدفيئة في لبنان للانبعاثات البشرية بحسب المصادر وإزالتها بواسطة احواض امتصاص الكربون

| فئات مصدر الغازات الدفيئة واحواض امتصاص الكربون | انبعاثات ثاني أكسيد الكربون | عمليات إزالة ثاني أكسيد الكربون | الميثان | الميثان | أكسيد النيتروس | أكسيد النيتروس | المجموع |
|---|---|---|---|---|---|---|---|
| | جيغاغرام | جيغاغرام | جيغاغرام | جيغاغرام من مكافئ ثاني أكسيد الكربون | جيغاغرام | جيغاغرام من مكافئ ثاني أكسيد الكربون | جيغاغرام من مكافئ ثاني أكسيد الكربون |
| **مجموع الانبعاثات الوطنية وعمليات الإزالة** | **٢٢،٤٠٢,٣٨** | **٣،١٤٥,٠٦-** | **١٤١,١٠** | **٢،٩٦٣,١٨** | **٣,١٢** | **٩٦٧,٣٣** | **٢٦،٣٣٢,٩٠** |
| **١ طاقة** | **١٩،٧٣٦,١٩** | | **٢,١١** | **٤٤,٣١** | **٠,٥٨** | **١٧٩,٨٠** | **١٩،٩٦٠,٣٠** |
| احتراق الوقود | ١٩،٧٣٦,١٩ | | ٢,١١ | ٤٤,٣١ | ٠,٥٨ | ١٧٩,٨٠ | ١٩،٩٦٠,٣٠ |
| صناعات الطاقة | ٧،٢٩٦,٦٧ | | ٠,٣٠ | ٦,٣٠ | ٠,٠٦ | ١٨,٦ | ٧،٣٢١,٥٧ |
| عمليات التصنيع والبناء | ٣،٣٣١,٣٤ | | ٠,٠٨ | ١,٦٨ | ٠,٠٣ | ٩,٣ | ٣،٣٤٢,٣٢ |
| النقل | ٥،٨١١,٩٥ | | ١,٢٢ | ٢٥,٦٢ | ٠,٤٦ | ١٤٢,٦ | ٥،٩٨٠,١٧ |
| القطاعات الأخرى | ٣،٢٩٦,٢٢ | | ٠,٥١ | ١٠,٧١ | ٠,٠٣ | ٩,٣ | ٣،٣١٦,٢٣ |
| الانبعاثات الهاربة الناجمة عن الوقود | لا يحصل | | لا يحصل | لا يحصل | | لا يحصل | – |
| **٢ العمليات الصناعية** | **٢،٥٥٧,٠٥** | | **٠,٠٠** | **٠,٠٠** | **٠,٠٠** | **٠,٠٠** | **٢،٥٥٧,٠٥** |
| المنتجات المعدنية | ٢،٥٥٧,٠٥ | | | | | | **٢،٥٥٧,٠٥** |
| الصناعة الكيميائية | لم يتم التقدير | | لم يتم التقدير | لم يتم التقدير | لم يتم التقدير | لم يتم التقدير | – |
| إنتاج المعادن | لم يتم التقدير | | لم يتم التقدير | لم يتم التقدير | لم يتم التقدير | لم يتم التقدير | – |
| صناعة أخرى | لا ينطبق | | لا ينطبق | لا ينطبق | لا ينطبق | لا ينطبق | – |
| إنتاج الهالوكربونات والكبريت | | | | | | | |
| استهلاك الهالوكربونات والكبريت | | | | | | | |
| **٣ استخدام المذيبات والمنتجات الأخرى** | لم يتم التقدير | | | لم يتم التقدير | لم يتم التقدير | لم يتم التقدير | – |
| **٤ الزراعة** | | | **١١,٣٢** | **٢٣٧,٧٢** | **٢,٠٦** | **٦٣٨,٦٠** | **٨٧٦,٣٢** |
| التخمر المعوي | | | ٩,٥٥ | ٢٠٠,٥٥ | | | ٢٠٠,٥٥ |
| إدارة السماد | | | ١,٧٧ | ٣٧,١٧ | ٠,٤٩ | ١٥١,٩٠ | ١٨٩,٠٧ |
| زراعة الأرز | | | لا يحصل | لا يحصل | | | ٠,٠٠ |
| الأتربة الزراعية | | | | | ١,٥٧ | ٤٨٦,٧٠ | ٤٨٦,٧٠ |
| حرق السافانا المحدد | | | لا يحصل | لا يحصل | لا يحصل | لا يحصل | – |
| حرق المخلفات الزراعية في الحقول | | | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ |
| **٥ استخدام الأراضي وتغيير استخدام الأراضي والحراجة** | **١٠٨,١١** | **٣،١٤٥,٠٦-** | **٠,٠٥** | **١,٠٥** | **٠,٠٠** | **٠,١٩** | **١٠٩,٣٤** |
| تغييرات في الغابات وغيرها من مخازن الكتلة الحيوية الخشبية | ٠,٠٠ | | | | | | ٠,٠٠ |
| تحويل الغابات والأراضي العشبية | لا يحصل | لا ينطبق | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ |
| التخلي عن الأراضي المدارة | | لا يحصل | | | | | |
| انبعاثات ثاني أكسيد الكربون وإزالتها من الأتربة | ٠,٠٠ | ٠,٠٠ | | | | | ٠,٠٠ |
| **٦ النفايات** | **١,٠٥** | | **١٢٧,٦٢** | **٢،٦٨٠,١٠** | **٠,٤٨** | **١٤٨,٧٥** | **٢،٨٢٩,٨٩** |
| التخلص من النفايات الصلبة على الأرض | ٠,٠٠ | | ١٠٨,٢٤ | ٢،٢٧٣,٠٤ | | ٠,٠٠ | ٢،٢٧٣,٠٤ |
| معالجة مياه الصرف الصحي | | | ١٩,٣٨ | ٤٠٧,٠٦ | ٠,٤٨ | ١٤٨,٧٥ | ٥٥٥,٨١ |
| حرق النفايات | ١,٠٥ | | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ٠,٠٠ | ١,٠٥ |

لقد تمّ تقريب الأرقام

قطاع الطاقة الذي يشتمل على إنتاج الطاقة والنقل هو أكبر مصدر لانبعاثات الغازات الدفيئة، مما يعكس اعتماد لبنان الكبير على المنتجات النفطية المستوردة لتلبية متطلبات الطاقة والنقل. يُستخدم أكثر من ٨٧ بالمئة من زيت الوقود المستورد و٤٠ بالمئة من زيت غاز الديزل المستورد في محطات توليد الطاقة الحرارية، أي أنّ هاتين النسبتين تولدان الكهرباء العامة، ويشار إلى هذه الأخيرة هنا بعبارة «صناعات الطاقة،» التي تشكّل المصدر الرئيسي للانبعاثات مع حوالى ٣٧ بالمئة من انبعاثات قطاع الطاقة و٢٨ بالمئة من إجمالي الانبعاثات الوطنية. يشكّل النقل أيضاً مصدراً مهماً لانبعاثات الغازات الدفيئة إذ يستأثر بنسبة ٢٣ من إجمالي الانبعاثات، والتي تنبعث بشكل خاص من سيارات الركاب الخاصة.

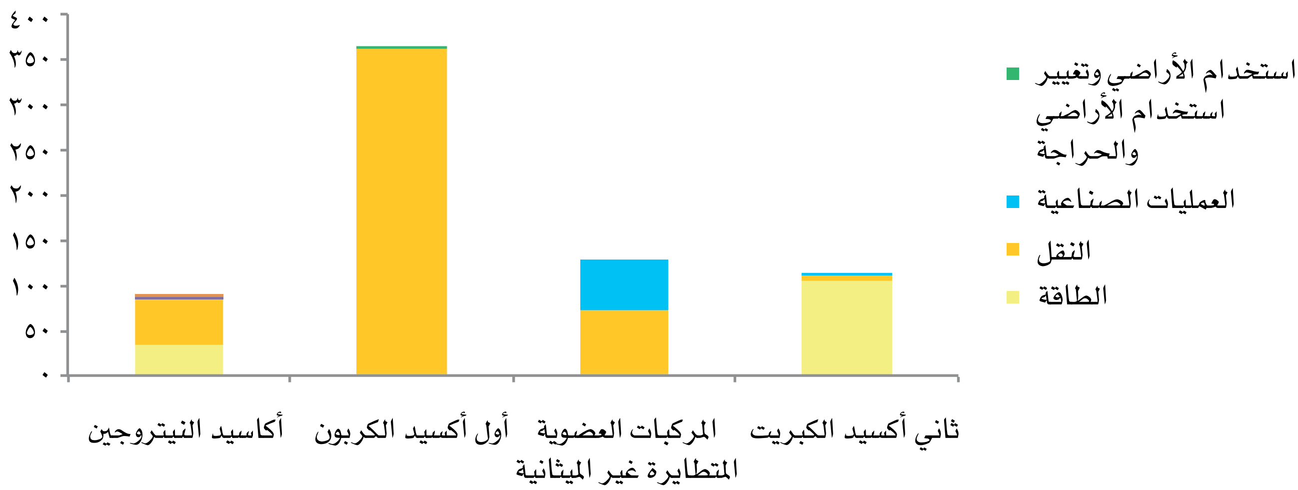
قُدّرت الانبعاثات الناتجة عن العمليات الصناعية في لبنان بـ ٢،٥٥٧ جيغاغراماً من ثاني أكسيد الكربون في العام ٢٠١٢، أي ما يمثل ٩,٧ بالمئة من الانبعاثات الوطنية. صناعة الاسمنت هي المساهم الرئيسي في انبعاثات الغازات الدفيئة من هذا القطاع (أكثر من ٩٩ بالمئة)، لأنّ لبنان لا ينتج الصناعات المعدنية والكيماوية الأخرى التي تنبعث منها الغازات الدفيئة.

وساهمت الأنشطة الزراعية بـ ٣,٣ بالمئة من الانبعاثات الوطنية، وقد نشأت هذه النسبة بالأساس من التربة الزراعية (٥٥ بالمئة)،والماشية المحلية عن طريق التخمر المعوي (٢٣ بالمئة)، وإدارة السماد (٢٢ بالمئة). وتشكّل الزراعة المصدر الرئيسي لانبعاثات أكسيد النيتروس في لبنان، والناجمة أساساً عن استعمال الأسمدة النيتروجينية الاصطناعية، ومخلفات المحاصيل، وروث الحيوانات في التربة، ومن ترسب الأمونياك وأكاسيد النيتروجين في الغلاف الجوي، وكذلك من الرشح والجريان السطحي للنيتروجين ورعي الحيوانات.

أما فيما يتعلق بالانبعاثات من النفايات ومياه الصرف الصحي، فهي تسهم بـ ١٠,٧ بالمئة من إجمالي انبعاثات الغازات الدفيئة. غاز الميثان هو الغاز الرئيسي المنبعث، وينجم أساساً عن تحلل المكون العضوي من النفايات في مواقع التخلص من النفايات. وعلى الرغم من أنه يتم استرداد قسم من هذا الميثان وإحراقه في مطامر النفايات الثلاثة الخاضعة للرقابة في لبنان (الناعمة وطرابلس وزحلة)، لا تنفك نسبة كبيرة منه تنبعث من ٥٠٤ مكباً بلدياً للنفايات منتشراً في مختلف أنحاء البلاد. تشكّل الانبعاثات الناتجة عن حرق النفايات نسبة لا تُذكر، ويعود سبب ذلك إلى حرق كمية صغيرة من نفايات الرعاية الصحية في المستشفيات. أما تصريف مياه الصرف الصحي بدون معالجة مسبقة في البحر الأبيض المتوسط، والأنهار، وخزانات الصرف الصحي، فهو مسؤول عن انبعاث ٥٥٥ جيغاغراماً من مكافئ ثاني أكسيد الكربون أو حوالي ٢٠ بالمئة من انبعاثات القطاع.

يعتبر استخدام الأراضي وتغيير استخدام الأراضي والحراجة من احواض امتصاص الغازات الدفيئة في لبنان، إذ يُقدّر صافي الإزالة بـ -٣،٠٣٦ جيغاغراماً من مكافئ ثاني أكسيد الكربون في العام ٢٠١٢. وبالفعل، ما زال الغطاء الحرجي الواسع في لبنان يمثل مصرفاً رئيسياً لثاني أكسيد الكربون، على الرغم من الاتجاه النزولي في قدرات احواض الامتصاص في السنوات الأخيرة بسبب إزالة الغابات وحرائق الغابات، والأهم من ذلك بسبب التحضر.

وقد تمّ أيضاً تقدير نسبة الغازات الدفيئة غير المباشرة مثل أول أكسيد الكربون، وأكاسيد النيتروجين، والمركبات العضوية المتطايرة غير الميثانية، وثاني أكسيد الكبريت، والتي لها تأثيرات غير مباشرة على المناخ وتغيّر الحياة الجوية للغازات الدفيئة الأخرى. يشكل قطاع النقل في لبنان المصدر الرئيسي للغازات الدفيئة غير المباشرة، كونه مسؤولاً عن ٦٠ بالمئة من انبعاثات أكاسيد النيتروجين، و٩٩ بالمئة من انبعاثات اول أكسيد الكربون، و٥٧ بالمئة من المركبات العضوية المتطايرة غير الميثانية. واحتراق الوقود لإنتاج الطاقة هو الباعث الرئيسي لثاني أكسيد الكبريت مع ٩٤ بالمئة من الانبعاثات، والناجمة أساساً عن محتوى الكبريت في الوقود المحترق.




**الرسم د:** انبعاثات الغازات الدفيئة غير المباشرة وانبعاثات ثاني أكسيد الكبريت في العام ٢٠١٢

## تحليل التخفيف وإمكانات خفض الانبعاثات

بصفته طرفاً غير مدرج في المرفق الأول للاتفاقية، ليس لبنان ملزماً بالحد من انبعاثات الغازات الدفيئة. ومع ذلك، بعد مؤتمر باريس ٢١ للمناخ وكطرف في اتفاقية باريس الجديدة، أعلنت الحكومة اللبنانية في المساهمة المعتزمة المحددة وطنياً الخاصة بها عن نيتها الحد من انبعاثات الغازات الدفيئة بنسبة ١٥ بالمئة بحلول العام ٢٠٣٠ كهدف غير مشروط وبنسبة ٣٠ بالمئة كهدف مشروط. وسيتم خفض الانبعاثات عن طريق تنفيذ استراتيجيات وسياسات مختلفة ذات صلة بالمصادر الرئيسية لانبعاثات الغازات الدفيئة في لبنان.

يعرض تحليل إمكانيات الحد عن طريق تنفيذ بعض من هذه السياسات القطاعية قطاع الطاقة كالقطاع ذي إمكانات التخفيف الأقوى. وتبيّن إمكانيات التخفيف المتراكمة على المستوى الوطني لمجموعة القطاعات التي تمّ أخذها بعين الاعتبار - وهي توليد الكهرباء، والنقل البري، والزراعة، واستخدام الأرض، والنفايات الصلبة، ومعالجة مياه الصرف الصحي، أنّ إمكانات خفض الانبعاثات قد تتراوح بين ١٨ و٣٨ بالمئة في العام ٢٠٣٠ مقارنةً بسيناريو الوضع الراهن.

تجدر الإشارة إلى أنه لم يتم إدراج كل الأنشطة المقترحة المقدمة في البلاغ الوطني الثالث في المساهمة المعتزمة المحددة وطنياً. وفي حين أنّ هذا الفصل يعرض مجموعة من الأنشطة القطاعية التي لديها القدرة على خفض الانبعاثات، لم تأخذ المساهمة المعتزمة المحددة وطنياًبعين الاعتبار إلا الأنشطة التي سبق أن وافقت عليها الحكومة اللبنانية كجزء من الاستراتيجيات والخطط الوزارية.

**الجدول ب:** إمكانيات تخفيف الانبعاثات بحلول العام ٢٠٣٠

| القطاعات | انبعاثات العام ٢٠٣٠ حسب سيناريو الوضع الراهن | تخفيف الانبعاثات في العام ٢٠٣٠ (جيغاغرام من مكافئ ثاني أكسيد الكربون) | |
|---|---|---|---|
| | | سيناريو متفائل | سيناريو متشائم |
| الطاقة | ٢١،١٤٥ | – ٧،٧٨٩ | – ٣،٨٩٤ |
| النقل | ٥،١٨٧,٥٥ | – ٢،٣٤٩,٠٤ | – ٥٤١,٩٠ |
| العمليات الصناعية واستخدام المنتجات | – | – | – |
| الزراعة | ٦٩٢,٧١ | – ٨٧,٩٢ | – ٣٠,٧٩ |
| استخدام الأراضي وتغيير استخدام الأراضي والحراجة* | ٣٦٧,٧٧ | – ١٤٧,٠٥ | – ٤٩,٦٥ |
| النفايات | ٤،١٩٩,٠١ | – ١،٤٨٠,٣٢ | – ١،١٤١,٠٩ |
| المجموع | ٣١،٥٩٢ | – ١١،٨٥٣ | – ٥،٦٥٨ |
| تخفيف الانبعاثات | | ٣٨ بالمئة | ١٨ بالمئة |

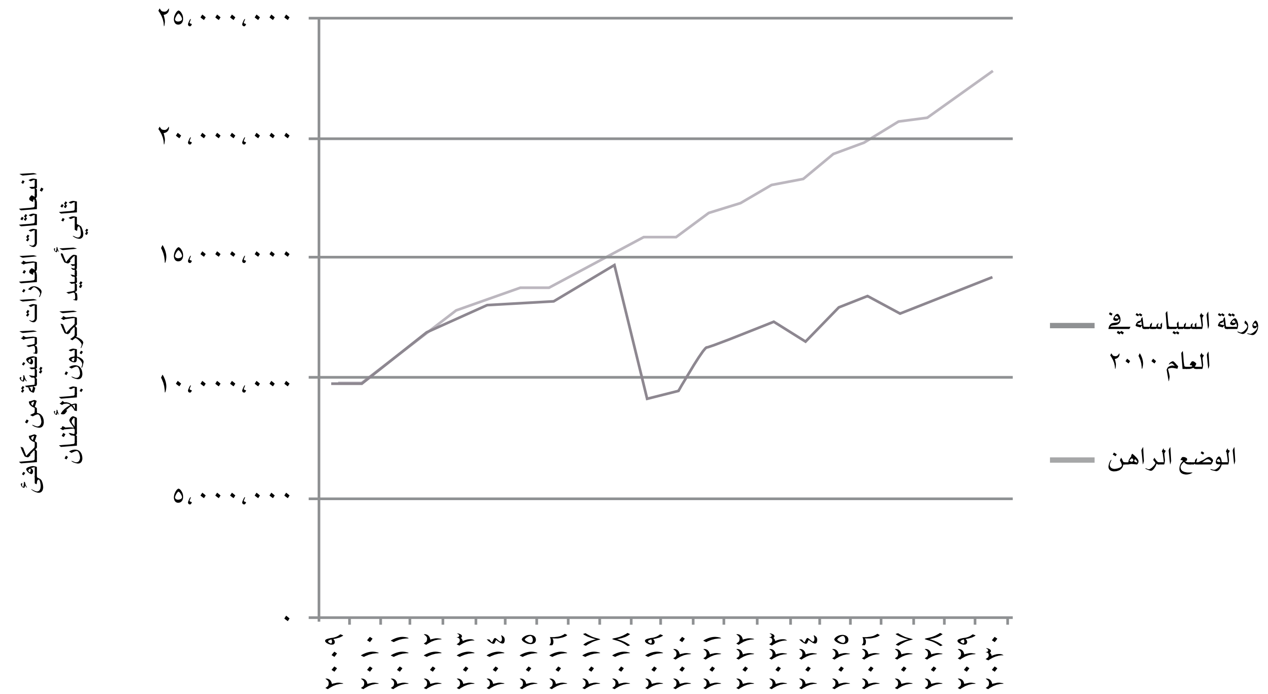
*مع استثناء الإزالة

## قطاع الطاقة

حددت الحكومة اللبنانية عدداً من الأولويات لتطوير قطاع الطاقة بشكل عام، ولتحديث قطاع الطاقة وتوسيعه بشكل خاص. وقد صدرت ورقة سياسة بشأن قطاع الطاقة في العام ٢٠١٠ لتأسيس إطار عام لقطاع الطاقة الكهربائية في لبنان. وتتعلق الأنشطة المخططة بإضافة قدرة التوليد من خلال مصادر الطاقة التقليدية والمتجددة (ما يصل إلى ٥ آلاف ميغاواط كقدرة إضافية، منها ٢،٥٠٠ ميغاواط من منتجي الطاقة المستقلين)، ورفع مستوى البنية التحتية للنقل والتوزيع، بما في ذلك بنية الغاز الطبيعي، وإنشاء شبكة ذكية، وتطوير إدارة الطلب وكفاءة الطاقة، فضلاً عن إعادة هيكلة التعريفة. مع الأخذ بعين الاعتبار بعض التأخير على الجدول الزمني المخطط في البداية (الجدول ج)، يمكن أن يثمر تنفيذ ورقة السياسة عن انخفاضاً تراكمياً بنسبة ٨٢،٦٠٠ جيغاغرام من مكافئ ثاني أكسيد الكربون من العام ٢٠١٧ إلى ٢٠٣٠، مع انخفاض سنوي متوسط قدره ٥،٩٠٠جيغاغرام من مكافئ ثاني أكسيد الكربون سنوياً بالمقارنة مع سيناريو الوضع الراهن. وسيقوم تنفيذ ورقة السياسة بخفض الانبعاثات بنسبة ٣٦ بالمئة بحلول العام ٢٠٣٠ بالمقارنة مع سيناريو الوضع الراهن.

**الجدول ج:** الجدول الزمني المحدث لورقة سياسة الطاقة للعام ٢٠١٠

| المبادرة | تاريخ الإنتاج المخطط | تاريخ الإنتاج بعد إعادة الجدولة | ملاحظات |
|---|---|---|---|
| خزن الطاقة | ٢٠١٠ | ٢٠١٠ | تمّت المبادرة |
| السفن | ٢٠١٠ | ٢٠١٣ | تمّت المبادرة |
| محطة الذوق بقدرة ١٩٤ ميغاواط وأنظمة الأجهزة والتحكم والكهربائية | نهاية العام ٢٠١٤ | نهاية العام ٢٠١٥ | قيد العمل |
| محطة الجية بقدرة ٧٨,٢ ميغاواط وأنظمة الأجهزة والتحكم والكهربائية | منتصف العام ٢٠١٤ | منتصف العام ٢٠١٥ | قيد العمل |
| محطة دير عمار بقدرة ٥٣٩ ميغاواط ونظام الدورة المركبة | نهاية العام ٢٠١٦ | نهاية العام ٢٠١٧ | المبادرة معلّقة |
| إعادة تأهيل محطتي الطاقة الحراريتين في الذوق والجية | نهاية العام ٢٠١٥ | نهاية العام ٢٠١٨ | قيد التوريد |
| تطوير محطتي الزهراني ودير عمار العاملتين بنظام الدورة المركبة | ٢٠١٣ | ٢٠١٤ | تمت المبادرة |
| إضافة نظام الدورة المركبة في محطّتي صور وبعلبك | ٢٠١٢ | ٢٠١٨ | قيد الدراسة |
| ١،٥٠٠ ميغاواط من منتجي الطاقة المستقلين | ٢٠١٥ | ٢٠١٨ | قيد الدراسة |
| ١،٠٠٠ ميغاواط من منتجي الطاقة المستقلين | ٢٠١٨ | ٢٠٢١ | قيد الدراسة |
| ٤٠ ميغاواط من المياه | ٢٠١٥ | ٢٠١٨ | قيد الدراسة |
| ٦٠ ميغاواط من الرياح | ٢٠١٣ | ٢٠١٧ | قيد التوريد |
| تحويل النفايات إلى طاقة | ٢٠١٤ | ٢٠١٧ | قيد العمل |



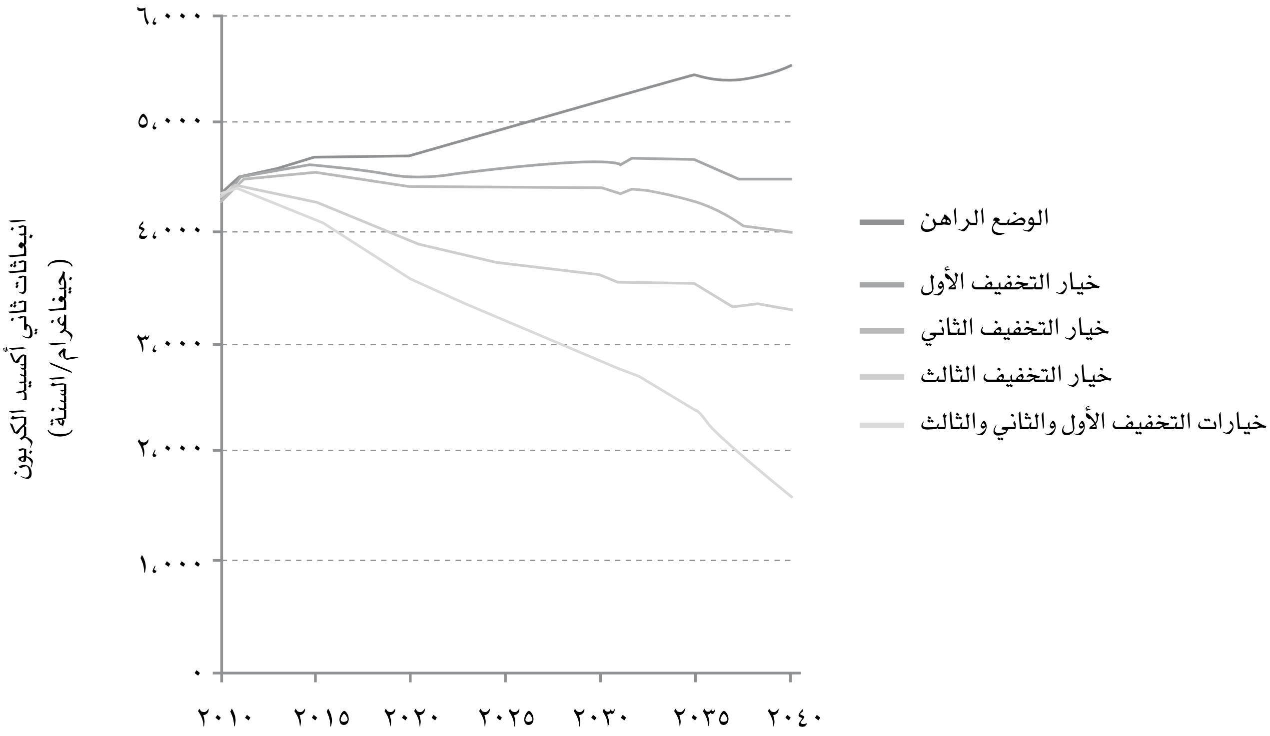

**الرسم ٥:** إمكانية تخفيف الانبعاثات من تطبيق سيناريو ورقة السياسة في العام ٢٠١٠

## قطاع النقل

يقوم قطاع النقل باستهلاك أكثر من ٤٠ بالمئة من النفط الوطني ويتسبب بـ ٢٣ بالمئة من انبعاثات الغازات الدفيئة، كما أنه المصدر الرئيسي لتلوث الهواء في المناطق الحضرية. أنظمة النقل الفعالة والحديثة بالغة الأهمية، ليس للحد من الانبعاثات فحسب، ولكن أيضاً من أجل التنمية والنمو الاقتصادي. ويبيّن تحليل التخفيف من هذا القطاع أنّ استبدال المركبات السيارة القديمة وغير الفعالة تدريجياً بمركبات كفوءة لناحية استهلاك الوقود يمكن أن يقلّل من الانبعاثات بنسبة تصل إلى ١٩ بالمئة بحلول العام ٢٠٤٠. وبالفعل، يتجدّد أسطول المركبات ويستبدل بواحد أكثر كفاءة في استخدام الطاقة من خلال زيادة حصة سيارات الركاب الصغيرة إلى ٣٥ بالمئة وخفض حصة المركبات الكبيرة إلى ١٠ بالمئة. ويمكن أن يساهم إدخال السيارات الكهربائية الهجينة إلى السوق لتصل نسبتها إلى ١٠ بالمئة بحلول العام ٢٠٤٠ بالحدّ من ٨ بالمئة إضافية من الانبعاثات. ومن ناحية أخرى، يمكن أن تؤدي إعادة هيكلة نظام النقل بالحافلات وتحديثه في منطقة بيروت الكبرى إلى تخفيض ٤٠ بالمئة من الانبعاثات بحلول العام ٢٠٤٠. ويمكن أن يخفّف تنفيذ كلّ تركيبات التخفيف في الوقت عينه مما يصل إلى ٦٧ بالمئة من انبعاثات الغازات الدفيئة، وتحسين الازدحام المروري، وحلّ المشاكل البيئية والاقتصادية والاجتماعية الكبرى الأخرى المرتبطة بزيادة نشاط النقل في لبنان (الجدول د).

**الجدول د:** إمكانات الحدّ من الانبعاثات بسيناريوهات تخفيف النقل

| | ٢٠٢٠ (جيغاغرام من مكافئ ثاني أكسيد الكربون) | ٢٠٤٠ (جيغاغرام من مكافئ ثاني أكسيد الكربون) | نسبة الحدّ المئوية في ٢٠٤٠ بالمقارنة مع الوضع الراهن |
|---|---|---|---|
| **سيناريو الوضع الراهن** | ٤،٧٤٧ | ٥،٥١٤ | |
| **خيار التخفيف الأول:** زيادة نسبة المركبات الكفوءة في استهلاك الوقود | ٤،٥٠٢ | ٤،٤٨٦ | ١٩ بالمئة |
| **خيار التخفيف الثاني:** زيادة نسبة المركبات الكفوءة في استهلاك الوقود والمركبات الهجينة | ٤،٤٣١ | ٤،٠٠٧ | ٢٧ بالمئة |
| **خيار التخفيف الثالث:** زيادة نسبة النقل العام | ٣،٩١٢ | ٣،٣٠٨ | ٤٠ بالمئة |




**الرسم و:** تغييرات انبعاثات ثاني أكسيد الكربون

### قطاع الزراعة

ليست الزراعة مصدراً رئيسياً لانبعاثات الغازات الدفيئة، ولا تصدر إلا ٣,٣ بالمئة من الانبعاثات الوطنية. ومع ذلك، يوفّر التخطيط لأنشطة مناسبة للقطاع الزراعي فرصة إدارة الموارد (المياه، والأسمدة، والبذور، والوقود) بكفاءة، وزيادة الدخل في المناطق الريفية، والحفاظ على سبل العيش لـ ١٧٠ ألف مزارع، وكذلك الحد من الانبعاثات وزيادة المرونة في التكيف على نحو أفضل مع آثار تغير المناخ. وقد أظهر استخدام الممارسات الزراعية البسيطة مثل الزراعة الصونية والتسميد لنوع محدود من المحاصيل ومنطقة الحصاد القدرة على الحد من انبعاثات الغازات الدفيئة بنسبة ١٠ بالمئة في العام ٢٠٢٠ و٢٧ بالمئة في العام ٢٠٤٠، مقارنة مع سيناريو الوضع الراهن (الجدول د). إمكانات التخفيف هذه هي الحد الأدنى الذي يمكن أن يتحقق، إذ يقتصر التحليل على منطقة معينة (١٠ إلى ٢٠ بالمئة من الأراضي المزروعة بالحبوب، والزيتون، وأشجار الفاكهة للزراعة الصونية) وعلى محصول معين (زرع البطاطا للتسميد). ويمكن تكرار هذه الممارسات بسهولة مع المحاصيل الأخرى، مما يزيد من التكيف والفوائد الاقتصادية والاجتماعية المشتركة التي قد تنتج عن تنفيذ هذه التدابير.

**الجدول هـ:** الحدّ من انبعاثات غازات الدفيئة من خلال الزراعة الصونية والتسميد

| العام | الوضع الراهن انبعاثات الغازات الدفيئة (جيغاغرام من مكافئ ثاني أكسيد الكربون) | الزراعة الصونية انبعاثات الغازات الدفيئة (جيغاغرام من مكافئ ثاني أكسيد الكربون) | نسبة التخفيف المئوية | التسميد انبعاثات الغازات الدفيئة (جيغاغرام من مكافئ ثاني أكسيد الكربون) | نسبة التخفيف المئوية |
|---|---|---|---|---|---|
| ٢٠٢٠ | ٧٨٨ | ٧٢٩ | ٧ بالمئة | ٧٦٧ | ٣ بالمئة |
| ٢٠٤٠ | ٥٩٥ | ٤٧٨ | ٢٠ بالمئة | ٥٥٤ | ٧ بالمئة |

بالإضافة إلى الحد من انبعاثات الغازات الدفيئة والمساهمة في إدارة الموارد بكفاءة والتنمية الريفية المستدامة، يساهم اعتماد الزراعة الصونية والتسميد في زيادة صافي الإيرادات. وأظهرت مشروعات تجريبية زيادة تتراوح بين ٤٠٠ و٩٨٠ دولاراً أميركياً للهكتار الواحد من مزارع الشعير، والكرسنة، والذرة باستخدام الزراعة الصونية في البقاع، مع صافي ربح قدره ٣،٠٩٦ دولاراً أميركياً لكل هكتار سنوياً في مزارع البطاطا باستخدام التسميد.

### استخدام الأراضي وتغيير استخدام الأراضي والحراجة

ثبت أنّ استخدام الأراضي وتغيير استخدام الأراضي والحراجة حوض رئيسي لامتصاص الغازات الدفيئة، بمعدل -٣،٣٢١ جيغاغراماً في السنة من مكافئ ثاني أكسيد الكربون موزعة على فترة الجردة من العام ١٩٩٤ إلى العام ٢٠١٢. ومع ذلك، تم تسجيل انخفاض صافٍ قدره ١٢ بالمئة في عمليات إزالة ثاني أكسيد الكربون بين عامي ١٩٩٤ و٢٠١٢، ويرجع ذلك أساساً إلى تحويل الأراضي المزروعة إلى مستوطنات وإلى حرائق الغابات. لذلك، تعتمد زيادة إمكانية إزالة الغابات اللبنانية أساساً على: ١) حماية خزانات الكربون الموجودة من الخسائر المرتبطة بإزالة الغابات والأحراج وتدهور الأراضي والتحضر؛ ٢) تعزيز امتصاص الكربون من خلال إعادة التحريج والتشجير وإدارة الغابات؛ ٣) خفض الانبعاثات الناتجة عن إدارة الحرائق. ويمكن أن يخفّف تنفيذ هذه التدابير من خلال سيناريوهين - واحد متشائم وآخر متفائل- الانبعاثات بنسبة ١٢,٥٧ بالمئة لتصل إلى ٣٨,٥ بالمئة بحلول العام ٢٠٣٠ (الجدول و).

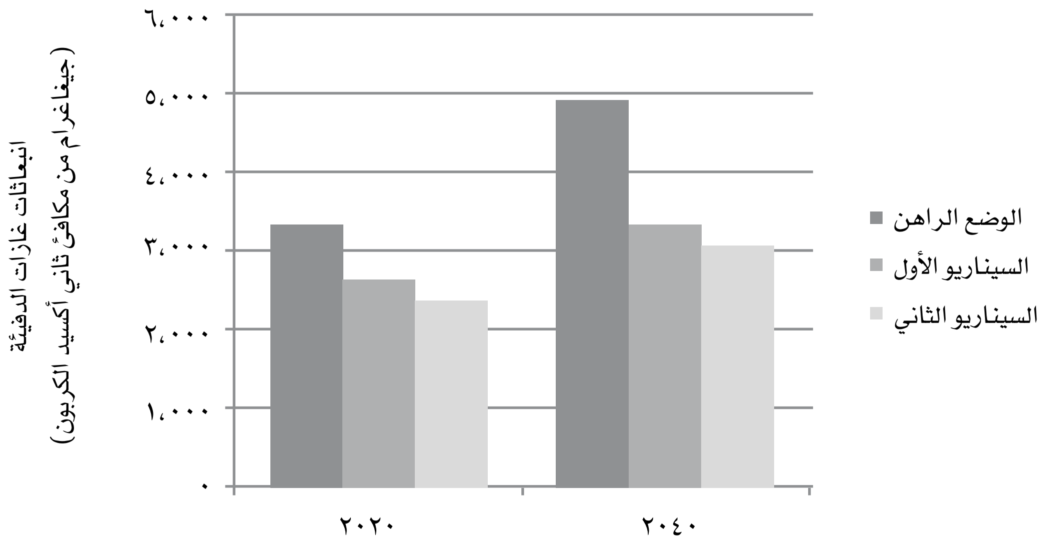
**الجدول و:** إمكانات الحد من الانبعاثات من خلال تطبيق السيناريو الأول والثاني في استخدام الأراضي وتغيير استخدام الأراضي والحراجة

| سيناريو التخفيف الأول | سيناريو التخفيف الثاني |
|---|---|
| خفض الخسائر الناجمة عن التحضر وتعويضها من خلال تنفيذ الأدوات الاقتصادية المناسبة: إمكانات تخفيض تراكمية من ٢٠١٣ إلى ٢٠٣٠ بما يساوي ٣٩ جيغاغراماً من مكافئ ثاني أكسيد الكربون (حوالى ٠,٥٧ بالمئة). | زيادة المدى الحالي بنسبة ٧ بالمئة من خلال تنفيذ الأدوات الاقتصادية المناسبة. إمكانات تخفيض تراكمية من ٢٠١٣ إلى ٢٠٣٠ بما يساوي ١،٧٩٢ جيغاغراماً من مكافئ ثاني أكسيد الكربون (حوالى ٢٦،٥ بالمئة). |
| الوقاية من حرائق الغابات الكبيرة والمكثفة: إمكانات تخفيض تراكمية من ٢٠١٣ إلى ٢٠٣٠ (بما في ذلك الميثان وأكسيد النيتروس) بما يساوي ٨١٣ جيغاغراماً من مكافئ ثاني أكسيد الكربون (حوالى ١٢ بالمئة). | الوقاية من حرائق الغابات الكبيرة والمكثفة: إمكانات تخفيض تراكمية من ٢٠١٣ إلى ٢٠٣٠ بما يساوي ٨١٣ جيغاغراماً من مكافئ ثاني أكسيد الكربون (حوالى ١٢ بالمئة). |
| يساوي مجموع إمكانات التخفيض التراكمية لسيناريو التخفيف الأول ٨٥٢ جيغاغراماً من مكافئ ثاني أكسيد الكربون (حوالى ١٢,٥٧ بالمئة). | يساوي مجموع إمكانات التخفيض التراكمية لسيناريو التخفيف الثاني ٢،٦٠٥ جيغاغرامات من مكافئ ثاني أكسيد الكربون (حوالى ٣٨,٥ بالمئة). |
| وتجدر الإشارة إلى أنّ الوقاية من حرائق الغابات الكبيرة والمكثفة يساهم في ٩٥,٤٢ بالمئة من خفض الانبعاثات ضمن سيناريو التخفيف. | وتجدر الإشارة إلى أنّ الوقاية من حرائق الغابات الكبيرة والمكثفة يساهم في ٣١,٢ بالمئة من خفض الانبعاثات ضمن سيناريو التخفيف. |

### قطاع النفايات ومياه الصرف الصحي

سوء إدارة النفايات ومياه الصرف الصحي في لبنان مسؤول عن انبعاث ١٠,٧ بالمئة من انبعاثات الغازات الدفيئة و٩٠,٥ بالمئة من انبعاثات الميثان في البلاد. لقد أصبح إيجاد حلول فعالة ومستدامة لإدارة النفايات ومياه الصرف الصحي أولوية على المستوى الوطني، وبخاصة بعد أزمة النفايات في العام ٢٠١٥. ويمكن تخفيف انبعاثات هذا القطاع بنسبة تتراوح بين ٣٢ و٣٨ بالمئة بحلول العام ٢٠٤٠ من خلال تقديم استخدام تقنيات تحويل النفايات إلى طاقة في مجال إدارة النفايات وزيادة معدل هذا الاستخدام تدريجياً، بالإضافة إلى زيادة معدل جمع المياه العادمة ومعالجتها، وبالتالي تقليل التصريف في خزانات الصرف الصحي والمياه السطحية.

استكشف تحليل التخفيف سيناريوهين: السيناريو الأول يفترض اعتماد تكنولوجيا تحويل النفايات إلى طاقة بحلول العام ٢٠٢٠ في بيروت وجبل لبنان فحسب ومعالجة مياه الصرف الصحي بمعدل ٣٥ بالمئة بحلول العام ٢٠٢٠ و٥١ بالمئة بحلول العام ٢٠٤٠. أما السيناريو الثاني، فيأخذ في عين الاعتبار التوسع في تحويل النفايات إلى طاقة لتشمل المبادرة صيدا وطرابلس، ويزيد من معدل معالجة مياه الصرف الصحي إلى ٥١ بالمئة و٧٤ بالمئة في العام ٢٠٢٠ و٢٠٤٠ على التوالي. معظم تخفيضات الانبعاثات هي نتيجة لمعالجة النفايات الصلبة بدلاً من معالجة مياه الصرف الصحي، وبشكل أكثر تحديداً، نتيجة لاستخدام تقنية تحويل النفايات إلى طاقة لاستبدال الطمر الصحي للنفايات والمكبات المفتوحة.




**الرسم ز:** مقارنة انبعاثات الغازات الدفيئة بحسب السيناريو الأول والثاني في قطاع النفايات

## تقييم مخاطر المناخ وقابلية التأثر والتكيّف

### التغييرات المناخية المستقبلية في لبنان

يشير تحليل السجلات المناخية التاريخية في لبنان منذ وقت مبكر من القرن العشرين مع مسارات الانبعاثات في المستقبل إلى أنّه لا سابق لارتفاع درجات الحرارة المتوقع في لبنان. وتشير التوقعات المناخية إلى زيادة قدرها ١,٧ درجة مئوية بحلول منتصف القرن الحالي، وزيادة تصل إلى ٣,٢ درجة مئوية بحلول العام ٢١٠٠، وانخفاضاً في هطول الأمطار من ٤ إلى ١١ بالمئة مع ظروف أكثر جفافاً في نهاية القرن (انخفاض يصل إلى ٥,٨ ملم في متوسط هطول الأمطار الشهري). وتظهر التوقعات أيضاً زيادة في اتجاهات ارتفاع الحرارة بما يصل إلى ٤٣ يوماً إضافياً مع درجة حرارة يومية قصوى أعلى من ٣٥ درجة مئوية، وزيادة في عدد الأيام الجافة المتتالية عندما يكون هطول الأمطار أقل من ١,٠ ملم بحلول نهاية القرن، مما يتسبب بإطالة موسمية وتوسع جغرافي لفترات الجفاف. وسيتسبب هذا المزيج من الظروف الرطبة أقل بكثير والأكثر دفئاً إلى حد كبير بمناخ أكثر حرارة وجفافاً.

### تأثيرات تغير المناخ في لبنان

من المتوقع أن يكون للتغيرات المناخية آثار متنوعة على البيئة، والاقتصاد، والبنية الاجتماعية في لبنان. قد يكون للظواهر الجوية المتطرفة آثار سلبية على الصحة العامة، والمستوطنات البشرية، والبنية التحتية الخاصة بالنقل، والإنتاج الزراعي، وإمدادات الطاقة، والاقتصاد ككل. وسيكون التنوع البيولوجي الهش، والنظم الإيكولوجية، والموائل الطبيعية مهددة بسبب زيادة حرائق الغابات، وانتشار الآفات، وارتفاع مستوى سطح البحر. وفي ما يلي موجز لآثار تغير المناخ في الجدول ز.

**الجدول ز:** موجز عن آثار تغيّر المناخ على القطاعات في لبنان

| | |
|---|---|
| كمية أقل من الثلوج | - من المتوقع فقدان موسم التزلج مع انخفاض ٤٠ بالمئة من الغطاء الثلجي في لبنان مع ارتفاع قدره درجتين مئويتين في درجة الحرارة، وصولاً حتى انخفاض بنسبة ٧٠ بالمئة في الغطاء الثلجي مع زيادة ٤ درجات مئوية.<br>- هطول كمية أقل من الأمطار كما الثلوج، والثلوج التي تتساقط حالياً على ارتفاع ١،٥٠٠ متر ستنتقل إلى ١،٧٠٠ متر بحلول العام ٢٠٥٠و١،٩٠٠ متر بحلول العام ٢٠٩٠.<br>- سينخفض عدد أيام وجود الغطاء الثلجي من ١١٠ إلى ٤٥ يوم. |
| توافر كمية أقل من المياه | - ستذوب الثلوج في وقت أبكر من فصل الربيع. وستؤثر هذه التغيرات على شحن معظم الينابيع، وتحدّ من إمدادات المياه المتاحة للري في خلال فصل الصيف، وتزيد الفيضانات في الشتاء بنسبة تصل إلى ٣٠ بالمئة. يؤدي انخفاض هطول الأمطار أيضاً إلى تفاقم التحديات الحالية لتوفر المياه للزراعة والاستخدامات التجارية والسكنية.<br>- وسيكون لذلك آثار سلبية على الأنهار والمياه الجوفية، وسيؤثر على توافر المياه في خلال موسم الصيف وفترات الجفاف. |
| زيادة فترة الجفاف | ستبدأ فترة الجفاف قبل ١٥ يوماً إلى شهر، وستمتد فترات الجفاف في البلاد لفترة أطول بتسعة أيام بحلول العام ٢٠٤٠ و١٨ يوماً بحلول العام ٢٠٩٠. ستشهد المناطق الجافة أصلاً، مثل البقاع والهرمل والجنوب، الآثار الأقوى. وبالإضافة إلى ذلك، سيتم إضافة تأثيرات التكلفة على احتياجات الري، إذ سيكون ثمة حاجة إلى المزيد من ساعات الضخ، مما سيستهلك بالتالي المزيد من الطاقة. |
| إنتاجية زراعية أقل | - ستنخفض رطوبة التربة نتيجة لارتفاع درجات الحرارة، وانخفاض هطول الأمطار، وارتفاع التبخر.<br>- ستخفّض التغيرات في درجة الحرارة وهطول الأمطار من إنتاجية الأراضي المستخدمة حالياً لإنتاج معظم المحاصيل والأشجار المثمرة، وبخاصة القمح والكرز والطماطم والتفاح والزيتون، ويمكن أن تؤثر على نوعية العنب، على الرغم من بعض المكاسب العابرة من توسع المزارع الساحلية مثل الموز والطماطم.<br>- ستواجه معظم المحاصيل أيضاً إصابة متزايدة بالفطريات والأمراض البكتيرية. |
| زيادة الطلب على الطاقة | سيزيد ارتفاع درجات الحرارة في الصيف من الطلب على التبريد، مع ارتفاع الاستهلاك ذي الصلة بالكهرباء بنسبة ١،٨ بالمئة لكل درجة مئوية كزيادة في درجة الحرارة، و٥،٨ بالمئة لكل ٣ درجات زيادة في درجة الحرارة. |
| ضعف السياحة | ستضعف السياحة الشتوية في الهواء الطلق مع تقصير موسم التزلج بفعل ارتفاع درجات الحرارة وانخفاض معدلات هطول الأمطار. وستحدث التأثيرات الأخرى على السياحة نتيجة التغيرات في النظم الإيكولوجية، وفقدان المعالم الطبيعية، مثل الشواطئ العامة الرملية، والضرر الهيكلي على التراث الأثري في البلاد. |
| ارتفاع مستوى البحر | سترتفع مستويات مياه البحار بما يصل بين ٣٠ و٦٠ سنتم في خلال ٣٠ عاماً، إذا ما استمر معدل الارتفاع مؤخراً والذي يبلغ حوالى ٢٠ ملم سنوياً. وسيؤدي ارتفاع مستويات البحر إلى تسرب مياه البحر إلى المياه الجوفية، وزيادة خطر الفيضانات الساحلية والغمر، وزيادة تآكل السواحل، وتغطية الشواطئ الرملية، وتغيير النظم الإيكولوجية الساحلية في المحميات الطبيعية وغيرها. |
| الخطر على الغابات | ستتأثر الغابات بشكل سلبي بتغير المناخ، لا سيما أنّ الغابات الحالية تعاني من التشرذم، وتفشي الآفات، وحرائق الغابات، والممارسات غير المناسبة التي تتحدى بالفعل قدرتها على البقاء والتطور. |
| زيادة معدل الوفيات والمرض | سيواجه لبنان زيادات في معدلات الإصابة بالأمراض المعدية، والاعتلال، والوفيات الناجمة عن ارتفاع درجات الحرارة، وزيادة تواتر الظواهر الجوية المتطرفة، وزيادة سوء التغذية من الجفاف والفيضانات التي تؤثر على الزراعة، وقلة توفر المياه النظيفة. وستتسبب الزيادات في درجات الحرارة بما بين ٢،٤٨٣ إلى ٥،٢٥٤ حالة وفاة إضافية سنوياً بين العامين ٢٠١٠ و٢٠٣٠.<br>وتشمل آثار تغير المناخ على الصحة العامة تفشي الأمراض المعدية بسبب تغير درجات الحرارة، وزيادة معدلات الاعتلال والوفيات الناجمة عن الحرّ وغيره من الظواهر الجوية المتطرفة، وسوء التغذية بسبب الجفاف والفيضانات، وغيرها من الأمراض التي تنتقل عن طريق القوارض والتي تنتقل عن طريق المياه والأمراض التي تنقلها الحشرات. |
| بنية تحتية متضررة | ستعاني المباني والبنية التحتية العامة من الضرر بسبب تغيّر أنماط هطول الأمطار، وارتفاع مستوى سطح البحر، وزيادة تواتر العواصف وشدتها. وسيتحقق هذا الضرر من غمر المستوطنات الساحلية والمباني والفيضانات والانهيارات الطينية والانهيارات الصخرية. |

## التكلفة الاقتصادية لتغير المناخ في لبنان

إذا استمرت الاتجاهات الحالية في انبعاث الغازات الدفيئة على حالها، ستفرض التغيرات المتوقعة في المناخ على الأرجح تكاليف اقتصادية على لبنان، سواء بصورة مباشرة أو غير مباشرة. اسباب التكاليف المباشرة ارتفاع درجات الحرارة، والتغيرات في هطول الأمطار، والأحداث المناخية المتطرفة مثل العواصف، التي تحد من الإنتاجية الزراعية، وتؤثر سلباً على صحة الإنسان، وتتسبب بالفيضانات، وتتسبب بأضرار مماثلة في قطاعات مختلفة من الاقتصاد والمجتمع في لبنان. وهذا من شأنه أن يفرض تكاليف على لبنان بحوالى ٣٢٠ مليون دولار أميركي في العام ٢٠٢٠ و٢٣،٢٠٠ مليون دولار في العام ٢٠٨٠.

أما التكاليف غير المباشرة، فستترجم بكون التكاليف المباشرة ستبطّئ النمو الاقتصادي في البلاد. وسيقلل النمو الأبطأ الناتج المحلي الإجمالي اللبناني بنحو ١،٦٠٠ مليون دولار، أو ٣ بالمئة بحلول العام ٢٠٢٠، و١٤ بالمئة في العام ٢٠٤٠، و٣٢ بالمئة في العام ٢٠٨٠. ومن شأن هذا الناتج المحلي الإجمالي الضائع أن يشكل التكلفة الحقيقية، أو يخفّض من الرفاهية الاقتصادية للأسر والشركات والحكومة في لبنان.

وستتحمل الحكومة التكلفة الإجمالية المقدرة من الأضرار المباشرة والناتج المحلي الإجمالي الضائع، بتكلفة ٦١٠ مليون دولار أميركي في العام ٢٠٢٠ حتى ٤٤،٣٠٠ مليون دولار في العام ٢٠٨٠،كما ستتحمل الأسر ذلك بتكلفة سنوية قدرها ١،٥٠٠ دولار في العام ٢٠٢٠ إلى ١٠٧،٢٠٠ دولار في العام ٢٠٨٠. وستعاني الأسر الريفية عموماً من النسبة الأكبر من الانخفاض مقارنةً بالأسر في المناطق الحضرية.

إذا تم اتخاذ إجراءات هادفة للحد من انبعاثات الغازات الدفيئة إلى حدّ كبير، سيتم تخفيض مجموع التكاليف من الآثار السلبية لتغير المناخ على لبنان في العام ٢٠٢٠ بنحو ٢٨ بالمئة، وبنسبة تصل إلى ٩١ بالمئة في العام ٢٠٨٠ (الجدول ح).

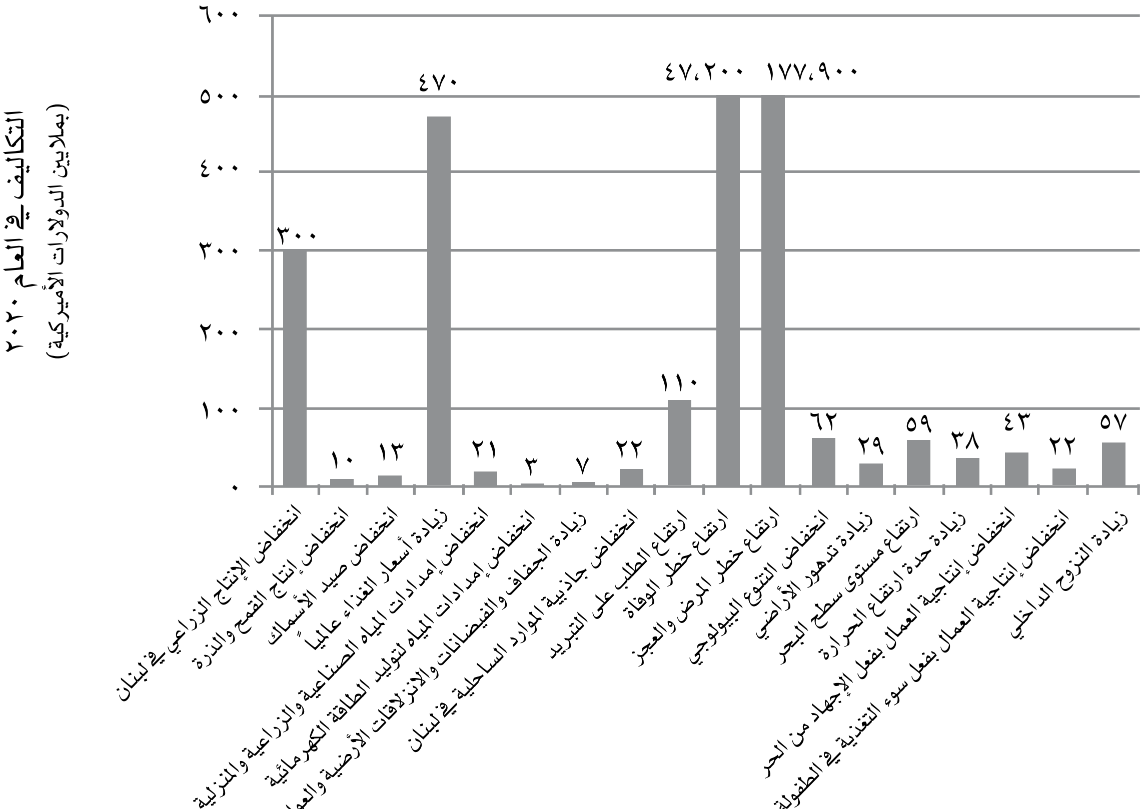
**الجدول ح:** القيمة الحالية للتكاليف الاقتصادية التي ستفرضها الانبعاثات العالمية السنوية للغازات الدفيئة على لبنان في ظل سيناريو الانبعاثات الأعلى والأدنى (بالدولار الأميركي للعام ٢٠١٥)

| | ٢٠٢٠ | ٢٠٤٠ | ٢٠٨٠ |
|---|---|---|---|
| أ. التكاليف المحتملة إذا اتبعت الانبعاثات العالمية سيناريو الانبعاثات الأعلى الذي وضعه الفريق الحكومي الدولي المعني بتغير المناخ (الاتجاهات الحالية) | | | |
| إجمالي التكلفة (بالملايين) | ٢١،٢٠٠ دولار أميركي | ٨٠،٧٠٠ دولار أميركي | ١،٠٠٩،٧٠٠ دولار أميركي |
| المتوسط لكل أسرة | ١٦،٤٠٠ دولار أميركي | ٥٧،٣٠٠ دولار أميركي | ٧٢١،٩٠٠ دولار أميركي |
| حصة الحكومة (بالملايين) | ٦،٨٠٠ دولار أميركي | ٢٥،٨٠٠ دولار أميركي | ٣٢٢،٠٠٠ دولار أميركي |
| ب. التكاليف المحتملة إذا اتبعت الانبعاثات العالمية سيناريو الانبعاثات الأدنى الذي وضعه الفريق الحكومي الدولي المعني بتغير المناخ | | | |
| إجمالي التكلفة (بالملايين) | ١٥،٢٠٠ دولار أميركي | ٣٠،٨٠٠ دولار أميركي | ٩١،٣٠٠ دولار أميركي |
| المتوسط لكل أسرة | ١١،٧٠٠ دولار أميركي | ٢١،٩٠٠ دولار أميركي | ٦٥،٢٠٠ دولار أميركي |
| حصة الحكومة (بالملايين) | ٤،٨٠٠ دولار أميركي | ٩،٨٠٠ دولار أميركي | ٢٩،١٠٠ دولار أميركي |
| ج. التوفير المحتمل من تخفيض الانبعاثات العالمية حتى سيناريو الانبعاثات الأدنى | | | |
| التوفير المحتمل (بالملايين) | ٦،٠٠٠ دولار أميركي | ٤٩،٩٠٠ دولار أميركي | ٩١٨،٤٠٠ دولار أميركي |
| التوفير المحتمل (النسبة المئوية) | ٢٨ | ٦٢ | ٩١ |

لقد تمّ تقريب الأرقام.

سيفرض تغير المناخ تكاليف على كل شخص، وأسرة، ومزارع، وعمل تجاري، ومجتمع، ومنطقة من لبنان. ومع ذلك، كشفت الدراسة أنّ الآثار المحتملة على صحة الإنسان تشكل أكبر المخاطر، فالتكاليف المرتبطة بالزيادات المحتملة في خطر الوفيات - من الإجهاد الحراري، وسوء التغذية، والإسهال، والملاريا، والفيضانات، وأمراض القلب والأوعية الدموية - ستشكل ما مجموعه ٤٧٫٢ مليار دولار في العام ٢٠٢٠. أما التكاليف المرتبطة بالزيادات المحتملة في المرض والعجز - من العوامل عينها ذات الصلة بالمناخ - ما مجموعه١٧٧،٩٠٠ مليون دولار أميركي في العام عينه.

وقد تنعكس التكاليف الرئيسية الأخرى من خلال آثار تغير المناخ على الإنتاج الزراعي في لبنان والأسعار التي يدفعها المستهلكون اللبنانيون مقابل الغذاء. وستتسبب الانخفاضات عامة في لبنان لناحية الإنتاج الزراعي- بسبب ارتفاع درجات الحرارة، والتغيرات في هطول الأمطار، وزيادة جفاف التربة -بانخفاض الناتج المحلي الإجمالي العام في لبنان بنحو ٣٠٠ مليون دولار في العام ٢٠٢٠. وإذا استمرت الاتجاهات الحالية، قد تفرض الزيادات المحتملة في أسعار الغذاء العالمية تكاليف قدرها ٤٧٠ مليون دولار أميركي على المستهلكين اللبنانيين من خلال رفع الأسعار التي يدفعونها للغذاء بسبب ارتفاع الأسعار، مما يحثهم على استهلاك كمية أقل من الطعام. وفي ما يلي موجز للتكاليف المقدرة كلها في الجدول ط والرسم ط.




**الرسم ط:** موجز التكلفة الاقتصادية لتغير المناخ على لبنان

**الجدول ط:** التكاليف التي قد يفرضها تغير المناخ على شرائح مختلفة من الاقتصاد والمجتمع اللبناني (بملايين الدولارات الأميركية للعام ٢٠١٥)

| التكلفة المحتملة | ٢٠٢٠ | ٢٠٤٠ | ٢٠٨٠ |
|---|---|---|---|
| أ. تكاليف تأثير تغير المناخ على الزراعة والإمدادات الغذائية | | | |
| ١. انخفاض الإنتاج الزراعي في لبنان | ٣٠٠ | ٨٦٠ | ٢،٣٠٠ |
| ٢. انخفاض إنتاج القمح والذرة | ١٠ | ١٧ | ٢٨ |
| ٣. انخفاض صيد الأسماك | ١٣ | ٣٢ | ٣٢ |
| ٤. زيادة أسعار الغذاء عالمياً | ٤٧٠ | ١،٧٠٠ | ٥،٠٠٠ |
| ب. تكاليف تأثير تغير المناخ على المياه | | | |
| ١. انخفاض إمدادات المياه الصناعية والزراعية والمنزلية | ٢١ | ٣٢٠ | ١،٢٠٠ |
| ٢. انخفاض إمدادات المياه لتوليد الطاقة الكهرمائية | ٣ | ٣١ | ١١٠ |
| ج. تكاليف تأثير تغير المناخ لناحية الكوارث الطبيعية | | | |
| ١. زيادة الجفاف والفيضانات والانزلاقات الأرضية والعواصف | ٧ | ٣٦ | ١،٦٠٠ |
| د. تكاليف تأثير تغير المناخ على السياحة | | | |
| ١. انخفاض جاذبية الموارد الساحلية في لبنان | ٢٢ | ١٦٠ | ١،٨٠٠ |
| ه. تكاليف تأثير تغير المناخ على استهلاك الكهرباء | | | |
| ١. ارتفاع الطلب على التبريد | ١١٠ | ٩٠٠ | ٣٤،٨٠٠ |
| و. تكاليف تأثير تغير المناخ على الصحة البشرية | | | |
| ١. ارتفاع خطر الوفاة | ٤٧،٢٠٠ | ٥٤،٧٠٠ | ٦١،٤٠٠ |
| ٢. ارتفاع خطر المرض والعجز | ١٧٧،٩٠٠ | ١٩٤،٣٠٠ | ١٩١،٥٠٠ |
| ز. تكاليف تأثير تغير المناخ على النظم البيئية | | | |
| ١. انخفاض التنوع البيولوجي | ٦٢ | ١٥٠ | ٣٣٠ |
| ٢. زيادة تدهور الأراضي | ٢٩ | ٧٨ | ١٧٠ |
| ٣. ارتفاع مستوى سطح البحر | ٥٩ | ١٤٠ | ٣٢٠ |
| ح. تكاليف تأثير تغير المناخ على المجتمع | | | |
| ١. زيادة حدة ارتفاع الحرارة | ٣٨ | ٨٤٠ | ٨،٦٠٠ |
| ٢. انخفاض إنتاجية العمال بفعل الإجهاد من الحر | ٤٣ | ١٦٠ | ١،٤٠٠ |
| ٣. انخفاض إنتاجية العمال بفعل سوء التغذية في الطفولة | ٢٢ | ٥١ | ٢٨٠ |
| ٤. زيادة النزوح الداخلي | ٥٧ | ١٣٠ | ٣٢٠ |

لقد تمّ تقريب الأرقام.

## خطوات التكيّف المقترحة

من المهم أن ندرك أنه على الرغم من أنّ لبنان قد يتمكن من الحد من التعرض للمخاطر المرتبطة بالمناخ، فهو لا يستطيع تجنبها بالكامل. ولا شك في أنه سيكون للانبعاثات العالمية للغازات الدفيئة آثار سلبية على الأسر والشركات والمجتمعات المحلية والحكومة في لبنان. وبالتالي، ستشتمل جهود الحدّ من التكاليف التي تفرضها هذه الانبعاثات على لبنان العناصر التي تزيد من قدرة الأسر والشركات والمجتمعات المحلية والحكومة للاستجابة إلى تغيرات المناخ والتعافي منها. وبعبارة أخرى، لا ينبغي أن تركّز إجراءات التكيف على الحد من التعرض للمخاطر المرتبطة بالمناخ فحسب، ولكن أيضاً على تعزيز قدرة التكيف مع الأحداث السلبية عند حدوثها. وعلى الرغم من اتخاذ عدد من المبادرات في مختلف القطاعات لتعزيز التكيف بشكل مباشر أو غير مباشر مع تغير المناخ، يجب تطبيق إجراءات إضافية للحد من ضعف الموارد المالية في لبنان وزيادة قدرته على التكيف مع تغير المناخ.

تتضمن تدابير التكيف المحتملة في قطاع المياه الحدّ من احتمال تسرب المياه المالحة إلى مخازن المياه الجوفية العذبة الساحلية مع ارتفاع مستوى سطح البحر، وزيادة كفاءة استخدام المياه في القطاعات المنزلية والصناعية والزراعية، وتطوير خطط مناسبة لمستجمعات المياه لمواجهة التغيرات المتوقعة في المناخ، والتحقيق في جدوى مصادر بديلة لإمدادات المياه، وتحسين المعلومات المتاحة عن الموارد المائية في لبنان وشبكات المياه. وثمة حاجة إلى إطار تكيف وطني لقطاع المياه لإعادة هيكلة إدارة المياه، وتنفيذ تدابير لموارد المياه والبنية التحتية، وتحسين نوعية المياه السطحية والجوفية، وتحسين المساواة في الحصول على إمدادات المياه المستدامة، وتعزيز المعرفة والقدرة على التكيف مع تغير المناخ. وميثاق باريس الدولي حول المياه والتكيف الذي انضم إليه لبنان في خلال مؤتمر باريس ٢١ للمناخ في ديسمبر/كانون الأول ٢٠١٥ من المبادرات التي يمكن أن تقود إدارة المياه في الاتجاه الصحيح.

وبالنسبة إلى الزراعة، تشتمل الخيارات المحتملة لزيادة مرونة المناخ زيادة كفاءة استخدام المياه في الري، وتطوير أنواع وهجائن أكثر تحملاً لارتفاع درجات الحرارة والجفاف، وتغيير توقيت الزراعة والري والحصاد، واعتماد الممارسات الزراعية المستدامة وتقنيات متكاملة لمكافحة الآفات، وتطوير ممارسات إدارة المراعي التي تتكيف مع آثار تغير المناخ، وتزويد المزارعين بمعلومات أفضل وفي الوقت المناسب بشأن توقع الظواهر الجوية المتطرفة. واعترافاً بأهمية التصدي لتغير المناخ في هذا القطاع، أدخلت وزارة الزراعة لأول مرة «الاستجابة إلى آثار تغير المناخ» كأحد دورات العمل الرئيسية ضمن استراتيجيتها للأعوام ٢٠١٥ إلى ٢٠١٩. وتنوي الوزارة مساعدة القطاع الزراعي في مجالات تدخل عدة للتكيف بشكل أفضل مع آثار تغير المناخ والحد من الانبعاثات، وتوجيه أنشطة وزارة الزراعة المتعلقة بتغير المناخ، وإدخال تدابير التكيف من خلال مختلف البرامج التي يتم تنفيذها.

وقد حدّد برنامج التشجير وإعادة التحريج الوطني والخطة الاستراتيجية للتنوع البيولوجي أيضاً مرحلة تحسين مرونة موارد الغابات والتنوع البيولوجي. وتهدف هذه الاستراتيجيات إلى زيادة مساحة الغابات في لبنان من ١٣ إلى ٢٠ بالمئة من مساحة لبنان الإجمالية على مدى ٢٠ عاماً وتطوير خطط التكيف للنظم الإيكولوجية عرضة للتغيرات المناخية وتنفيذها.

أما في مجال الصحة العامة، فسرعان ما أصبحت تدابير التكيف أولوية بعد أن تم تحديدها على أنها من أكثر القطاعات تضرراً من تغير المناخ. وتشمل تدابير التكيف الموصى بها تحسين المعرفة والوعي بالتفاعلات بين تغير المناخ والصحة العامة، وتعزيز نظم رصد آثار تغير المناخ على الصحة العامة والاستجابة لها، وتشجيع الاستراتيجيات المتعلقة بالتنمية، وتعزيز المؤسسات المسؤولة عن الإعداد لآثار تغير المناخ على الصحة العامة والاستجابة لها. وقد وضعت منظمة الصحة العالمية مؤخراً استراتيجية وخطة عمل إقليمية بشأن الصحة والبيئة للأعوام ٢٠١٤ إلى ٢٠١٩ تتناول تغير المناخ باعتباره من الاهداف الرئيسية للاستراتيجية.

وبالنسبة إلى قطاع الكهرباء، تتضمن زيادة المرونة تحسين كفاءة استخدام الطاقة في المباني وشبكات النقل، وتطوير نظم إمدادات الطاقة تكون أقل عرضة للاضطرابات من الأحداث المناخية المتطرفة، وارتفاع متوسط درجات الحرارة، والجوانب الأخرى لتغير المناخ. وقد حددت خطط عمل الكفاءة الوطنية للطاقة التي وضعها مؤخراً المركز اللبناني لحفظ الطاقة ووزارة الطاقة والمياه خارطة طريق للبلاد لبلوغ أهدافه

في مجال كفاءة الطاقة.

يمكن تقليل تعرض المجتمعات الساحلية والنظم الإيكولوجية من خلال وضع وتنفيذ خطط لاستعادة الأنشطة البشرية من المناطق الساحلية التي ستتعرض للارتفاع المتوقع في مستوى سطح البحر، وخلق احتياطيات بحرية ساحلية، وتطوير استراتيجية لحماية رؤوس الأموال والأشخاص الذين لا يحتمل أن ينتقلوا وتنفيذها، وتوفير معلومات أفضل وفي الوقت المناسب لسكان المناطق الساحلية بشأن توقع الظواهر الجوية المتطرفة.

أما بالنسبة إلى قطاع السياحة، فتتضمن الخيارات المحتملة لزيادة المرونة لتغير المناخ تطوير تأمين أفضل وأدوات أخرى على المدى القصير لإدارة المخاطر على السياحة، مثل الاضطرابات الناجمة عن العواصف الساحلية أو عدم تساقط الثلوج في المنتجعات الجبلية، ووضع خطط مناسبة طويلة الأجل لإدارة المخاطر، مثل نقل المرافق السياحية الساحلية بعيداً عن أماكن نشوء العواصف المحتملة والمرافق الشتوية إلى ارتفاعات أعلى، والحد من الضغط على الموارد الطبيعية التي تتأثر بالمناخ والمهمة للسياحة من التآكل والزحف العمراني على سبيل المثال، وتوفير معلومات أفضل وفي الوقت المناسب لقطاع السياحة بشأن توقع الظواهر الجوية المتطرفة.

## الثغرات والمعوقات واحتياجات بناء القدرات المالية والتقنية ذات الصلة

### إعداد التقارير والترتيبات المؤسساتية وترتيبات القياس والإبلاغ والتحقق ذات الصلة

ما زالت التحديات الرئيسية التي تواجه إعداد جردة الغازات الدفيئة، والبلاغات الوطنية، والتقارير المحدثة لفترة سنتين على حالها منذ إعداد الجردة الأولى في البلاد في العام ١٩٩٤، وهي تتعلق أساساً بعدم توفر بيانات الأنشطة وعوامل الانبعاثات وعدم إمكانية الوصول إليها وعدم اتساقها، وكذلك انعدام الإبلاغ والتنسيق بين المؤسسات، وصعوبة تتبع خفض الانبعاثات الذي يتم تحقيقه من خلال تنفيذ إجراءات التخفيف.

وقد لوحظ تقدم في مجال بناء القدرات فحسب، فأنواع الدعم الأخرى لمعالجة المعوقات التقنية والمؤسسية محدودة جداً. التقدم بطيء وتستغرق الترتيبات المؤسساتية وقتاً نظراً للوضع السياسي غير المستقر في البلاد. ونتيجةً لذلك، لا يزال لبنان لا يتمتع بنظام واضح المعالم لجمع البيانات ومعالجتها وضمان الجودة والرقابة وإعداد التقارير والرصد. وثمة حاجة إلى لوائح مناسبة من شأنها أن تحدد الصلاحيات والمسؤوليات في هذا المجال بشكل كامل. وبالإضافة إلى ذلك، فإنّ الاستدامة في إشراك الأفراد المخلصين والأكفاء في مختلف المؤسسات ذات الصلة أمر حاسم لضمان تقديم التقارير ذات نوعية جيدة.

### تنفيذ السياسات والمشاريع

يتطلب تنفيذ المشاريع والسياسات المتعلقة بالمناخ تنسيقاً قوياً بين المؤسسات لدعم القطاعات التي تشتمل على تخطيط وتنفيذ لإجراءات التخفيف والتكيف، كما يتطلب تقييماً لاحتياجات الدعم والإبلاغ عنها (على الصعيدين الوطني والدولي)، وإجراءات القياس والإبلاغ والتحقق ذات الصلة بالتنفيذ. وسيشمل ذلك أيضاً تعميم إجراءات التخفيف والتكيف على صعيد أكبر، وتعزيز العمل المناخي، وتحسين التعاون بين الوزارات، وحشد الدعم للتخطيط والتنفيذ. ويمكن أن تضمن وحدة قياس وإبلاغ وتحقق دائمة في وزارة البيئة لعب دور مماثل. وثمة حاجة كبيرة إلى دعم المجتمع الدولي ليواصل بنجاح الجهود التي تمّ وضعها.

### الفجوات والقيود المالية

ثمة حاجة إلى موارد مالية إضافية لمواصلة تطوير القدرات التقنية والمؤسسية القائمة وتعزيزها من أجل تنفيذ إجراءات المناخ المخطط لها ورصد التقدم المحرز وآثارها على الانبعاثات الوطنية. ليس الدعم المالي المباشر كافياً ومرناً بما فيه الكفاية لضمان الإبلاغ الكامل والكافي وتنفيذ إجراءات التخفيف والتكيف ذات الأولوية على المستوى الوطني. ثمة حاجة ملحة إلى زيادة الأموال المتاحة للبلدان وزيادة المرونة لتشجيع بدء أنشطة جديدة تهدف إلى تحسين الإبلاغ عن إجراءات المناخ وتنفيذها.

# 1 NATIONAL CIRCUMSTANCES

# 1 NATIONAL CIRCUMSTANCES

## 1. Government structure

Since the 1990s, Lebanon has been witnessing a significant growth in environmental governance and related policies and institutions.

### 1.1 The Parliament and the Parliamentarian Committee for Environment (legislative level)

Lebanon's legislative body, represented by the Lebanese Parliament (128 seats), is organized into specialized committees. The Committee for Environment has 12 permanent Members of Parliament. The Committee meets at irregular intervals to discuss and review draft legislation and issues related to the environment, and to oversee the work of the executive body including contract decisions and public expenditure. Discussion issues have included inter-alia the need to upscale the Ministry of Environment's (MoE) resources, air pollution from the transport sector, solid waste disposal sites, road safety, forest fires, water bodies pollution etc.

The Environmental Protection Law (law no. 444/2002) is the overarching legal instrument for environmental protection and management in Lebanon. It revolves around 11 main environmental principles:

- Precaution (cleaner production techniques)
- Prevention (best available technologies)
- Polluter-pays-principle (polluters pay for pollution prevention and control)
- Biodiversity conservation (in all economic activities)
- Prevention of natural resources degradation
- Public participation (free access to information and disclosure)
- Cooperation between central government, local authorities, and citizens
- Recognition of local mores and customs in rural areas
- Environmental monitoring (pollution sources and pollution abatement systems)
- Economic incentives to encourage compliance and pollution control
- Environmental Impact Assessment (EIA) process to control and mitigate environmental degradation

With respect to climate change, apart from law 359/1994 and law 738/2006 relating to the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP) respectively, no major legislation directly addresses climate change in Lebanon. At the moment of drafting of this report, Lebanon has initiated the process of ratifying the Paris Agreement, and the government of Lebanon has issued decree 3987, dated 25 August 2016, which by its virtue, the draft law of the ratification of the Paris Agreement has been forwarded to the Lebanese Parliament for enactment. Lebanon has also participated in the high level signing ceremony at the United Nations in New York in April 22, 2016. In addition to the above, a number of national regulations have addressed issues that could be linked to climate change, such as the reduction of air pollution from transport (law 341/2001), the reduction of energy import by improving access to renewable energies (Council of Ministers, decision no. 13/2004), energy efficiency standards and labels, or other decisions relating to the ratification of conventions such

as the United Nations (UN) Convention on Biodiversity or the UN Convention to Combat Desertification. Additionally, draft laws on the protection of air quality and on energy efficiency are currently being reviewed by the Council of Ministers (CoM) prior to enactment. Once issued, they will positively reflect on mitigation of Greenhouse Gas (GHG) emissions in Lebanon.

### 1.2 The Council of Ministers (executive level)

Headed by the Presidency of the CoM, it enacts regulations in the form of decisions and decrees.

#### *The Ministry of Environment*

The mandate of the MoE, established by law 216/1993 and amended by law 690/2005, requires close coordination with many other relevant ministries, and public and private sector groups (environmental inspection and enforcement, climate change adaptation, sustainable management of natural resources, continuous monitoring of air quality, promotion of hazardous and non-hazardous waste management, etc.).

MoE staff's size (around 86 employees) is still far below the prescribed staff size stipulated in decree 2275/2009 (182 full-time employees). Human resources at MoE are bolstered by cooperation projects with international development partners.

Climate change issues fall under the mandate of the MoE which is the main national coordinator and the UNFCCC focal point. The MoE is responsible for the coordination, compilation and submission of national communications, Biennial Update Reports (BUR) and related GHG inventories. In addition to the present Third National Communication, Lebanon has submitted two national communications to the secretariat of the UNFCCC in 1999 and 2011, and the first BUR in 2015. The MoE also takes leadership in climate change negotiations under the Convention. The size of the delegation has constantly been growing and delegates are developing specific expertise on the various topics.

The management team of the climate change projects is composed of 3 women and one man. The head of the service under which climate change projects fall at the MoE (the Service of Environmental Technology) is a woman. As for gender balance in the delegation, it is also met. In COP21 for example, 15 out of the 35 delegates were women.

#### *The National Council for the Environment*

In addition, the MoE is a member of several intergovernmental councils such as the Higher Council of Urban Planning (member), the National Council for Quarries (chaired by the MoE), the Higher Council for Hunting (also chaired by the MoE) and the Lebanese Standards Institution (LIBNOR).

The council with probably the most comprehensive mandate is the National Council for the Environment (NCE) (decree 8157/2012), also chaired by the MoE. The NCE is made of 14 members representing 7 ministries (the ministries of Environment, Finance, Interior and Municipalities, Agriculture, Public Works and Transport, Energy and Water, and Industry) and 7 non-public entities (Order of Physicians, Order of Engineers and Architects, The Bar Association, Association of Banks, Association of Insurance Companies, representative of Non-Governmental Organizations (NGOs), representative of the academic sector). The

main role of the NCE, as stipulated by the decree, is to provide policy and planning suggestion in the following areas:

- Provision of input in policies and environmental strategies developed by the MoE
- Integration of environmental policy concepts in all development sectors in order to achieve sustainable development
- Incorporation of environmental concepts and guidelines in national plans
- Follow-up of treaties and international conventions and protocols and regional environmental policy commensurate with the public and the needs of the country
- Preparation of plans, programs and projects needed in order to comply with the obligations stipulated in the treaties and international conventions and protocols ratified by Lebanon
- Enactment of the work of the national environmental fund as stipulated in articles 8 to 11 of law 444/2002
- Development of financial incentives to facilitate environmental compliance by the polluting sectors.

***The National Climate Change Coordination Unit (CCCU)***

It is composed of 40 representatives from government agencies, NGOs, academic institutions, regional and international organizations that deal directly or indirectly with climate change. The CCCU's main role is to strategically align all national mitigation and adaptation activities by coordinating and bringing them under the NCE. Technically, this means that the CCCU actively works on:

- Mainstreaming climate change into national and sectoral development plans
- Acting as a platform for exchange of information on project planning and implementation, existing institutional channels and on data needed to compile greenhouse gas inventories
- Increasing Lebanon's engagement in the UNFCCC and KP negotiations through ensuring endorsement by all stakeholders
- Enhancing decision makers and general public's awareness and capacities related to climate change
- Maximizing benefit from international climate change funding opportunities through sound allocation of funds, better communication and coordination, and avoidance of duplication of tasks
- Pushing the climate change agenda on a national level.

In the public sphere, over 50 years have passed since the law of 1953, which recognized equal rights for men and women in elections, voting and candidacy. However, women's rate of participation in political life is still very low, including in candidacy. After 1992, date of the first parliamentary election after the war, the presence of women in the Parliament varied between 2 and 4% (EU, 2010).

## 2. Population profile

Lebanon's population is estimated to be 5,187,027 in 2012, including foreign workers and Palestinian refugees (MoE/UNDP/GEF, 2015f). With a surface area of 10,452 km$^2$, Lebanon's population density is high, with around 496 persons/km$^2$. Around 90% of the population resides in an urban environment (ACAPS, 2013), most of them concentrated in the biggest cities of the country along the coast line. In 2012, only 19% of households were headed by women, usually widows. Despite the fact that access to education is almost equal to men and women, big disparities still exist when it comes to employment. Indeed, 27% of jobs are held by women, most of them in early career stages. Women therefore tend to stop working as they get married and hold a household responsibility. In addition, working women fill only 18% of managerial or senior level positions. Women are almost absent from labour markets of the following sectors: agriculture, army, driving of equipment, construction. Women are usually more present in administrative jobs, or jobs in the health or education sectors. Women's remuneration is usually 6% lower than men (CAS, 2014).

## 3. Geographic profile

Lebanon is located on the eastern basin of the Mediterranean Sea and is characterized by mostly mountainous areas constituted of the following parts (Walley, 2001):

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


**Figure 1:** Geographical location of Lebanon

## 4. Climate profile

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

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

## 5. Economic profile

Lebanon has a free market economy, with the costs of most goods and services determined mainly by supply and demand. The Government of Lebanon (GoL) supports private investment, and public ownership has generally been limited to infrastructure and utilities. The largest sector in Lebanon is commercial trade accounting for 15% of Gross Domestic Product (GDP) in 2012, followed by real estate at 14%. The sector with the lowest contributing share to the GDP is the agriculture, forestry and fishing sector (at 4% in 2012). Lebanon imports more than it exports and is largely dependent on imports for food and fuel. Due to the dependence on imports and services (including banking and tourism), economic productivity is highly influenced by regional and international shocks. Since 2009, the Lebanese economy has witnessed a reduction in growth due to political and security uncertainties. This economic decline has been accelerated by the Syrian crisis and refugee influx, which have had a negative impact on economic growth and service provision (ACAPS, 2013).

Current GDP increased from USD 38 billion in 2010 to an estimated USD 47.1 billion in 2015, and is forecasted to increase to USD 65.7 billion in 2019. However, GDP growth is expected to decline from an average of 7.3% in 2008-2011 to 4% in 2016-2019 (IMF, 2014).

## 6. Energy

The Lebanese electricity sector is run by the Electricité du Liban (EDL), an autonomous state-owned power utility that generates, transmits, and distributes electricity to all Lebanese territories. Most of the electricity is generated through 7 major thermal power plants and 3.5 to 4.5% through hydropower plants. When circumstances permit, direct power is purchased from Syria and Egypt (around 7 to 11%).

Almost all of Lebanon's primary energy requirements are imported, since the country does not have any indigenous energy sources with the exception of a small share of hydropower. Out of the 7 thermal power

plants in Lebanon, 3 operate on Heavy Fuel Oil and 4 on gas diesel oil. The Deir Aamar and Zahrani power plants use the Combined Cycle Gas Turbines (CCGT) and can therefore operate on Natural Gas (NG) once available. Currently, there is no supply of natural gas to Lebanon although a gas pipeline has been connected and a natural gas station has been constructed at the Tripoli installations. Natural gas was only imported for one year during 2010. Recent studies and surveys conducted in the deep offshore Exclusive Economic Zones have shown very promising seismic conditions for hydrocarbon deposits, mainly natural gas with some oil. As a result of that, Lebanon had already started the development phase for the exploration and production era which is expected to have a positive economic impact on the country.

Although available capacity reached 2,670 MW, actual availability of electricity has varied from as low as 1,500 MW to a maximum of 2,000 MW due to several shortcomings. In the case of the thermal plants, these shortcomings include plant failures and rehabilitation work, fuel supply and interruption of imported electricity from both Syria and Egypt. In the case of hydropower, shortcomings include rainfall variations, and subsequently water levels variations (Kabakian et al., 2015). In addition, the transmission and distribution networks face 3 types of problems: technical losses in the range of 15%, non-technical losses (e.g. theft) amounting to 20% and uncollected bills in the range of 5%.

Due to these shortages, power cuts average at around 6 hours/day at the country level, with rationing hours unevenly distributed between cities. The energy not supplied by public utilities is being supplied by privately owned generators. Self-generation plays an essential role in electricity supply and demand in Lebanon, and is estimated at 32-33% of total electricity demand (World Bank, 2009; Osseiran, 2016).

Given the current condition of electricity supply in Lebanon, the share of renewable energy is slowly but steadily increasing. The major contributor to the renewable energy mix in the country is hydropower, producing around 4.5% of the country's total energy production. In addition, Lebanon has a significant wind potential, especially in the north with wind speeds of 7-8 m/sec and an abundant solar resource with an average annual insolation of 1,800-2,000 kWh/m$^2$ (Table 1). Solar water heating is well established in the country. Although technologies for solar power generation are becoming cheaper and more competitive, they are still relatively expensive and are currently only used at the micro level and for specific applications like street lighting, water heating and other municipal use.

**Table 1:** Renewable energy capacity in Lebanon

| | Potential generation capacity (MW) | Available capacity (MWh) |
|---|---|---|
| Wind | 5,408 | 12,139,145 |
| Solar Photovoltaics (PV) | 109,547 | 182,662,073 |
| Concentrated Solar Power (CSP) | 8,065 | 18,274,000 |
| Hydro (existing plants) | 134 | 498,500 |
| Hydro (potential plants) | 371 | 1,370,823 |

Source| MoE/UNDP, 2015a

The Government of Lebanon has set a number of priorities for the development of the energy sector in general, and for the modernization and expansion of the power sector in particular. A policy paper on the energy sector was issued in 2011 to establish a global framework for the electric energy sector in Lebanon. The policy paper includes ten strategic initiatives that are integrated and correlated to remedy most of the existing generation problems of the power sector and set in place the necessary infrastructure needed for a secure and economical transmission and distribution networks. According to the Policy, the power sector will have more than 4,000 MW generation capacity in 2014 and 5,000 MW after 2015, in addition to a reliable transmission and distribution networks, and efficient delivery of electricity to cope with the overall socio-economic development of Lebanon.

## 7. Transportation

### *Land transport*

The land transport sector consists only of road-motorized vehicles, since no appropriate infrastructure for non-motorized vehicles exists (i.e. bicycle lanes, safe storage, and convenient and affordable bike rentals) and the entire rail network is currently derelict (Lebanon used to operate four rail lines).

Road-motorized vehicles rely mainly on personal-owned passenger cars. The 2012 vehicle fleet database shows a total of 1.58 million registered vehicles, with a distribution presented in Figure 2. The age distribution of Passenger Cars (PC) (public and private) illustrated in Figure 3 reflects the old nature of the fleet, with 71% older than 10 years. Moreover, the engine distribution of the PC fleet in 2007 shows that the fleet is mostly inefficient, since 60% of the cars have engine displacements exceeding 2.0 liters, while only 8% have engines less than 1.4 liters (MoE/URC/GEF, 2012).

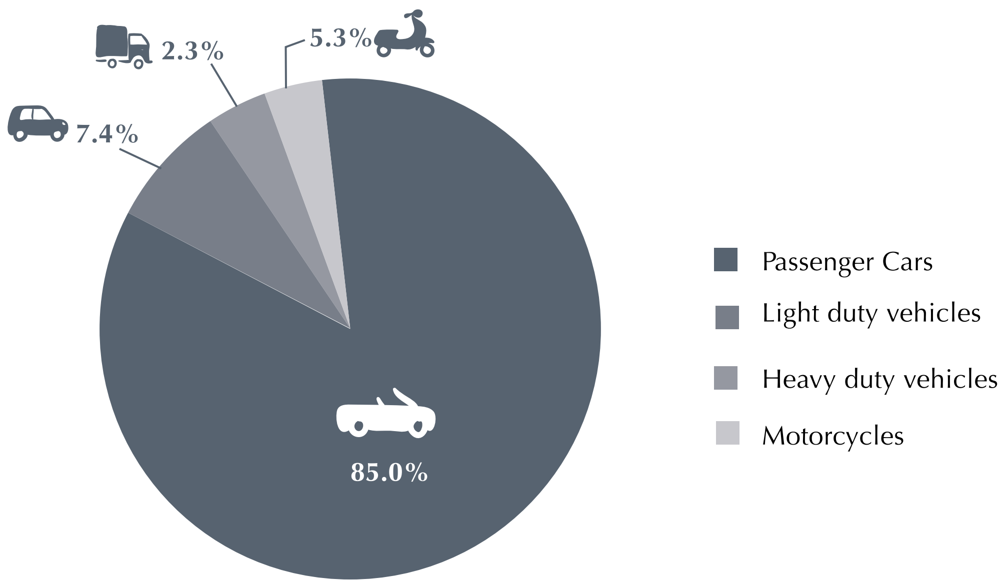



**Figure 2:** The 2012 vehicle fleet distribution in Lebanon per type of vehicle

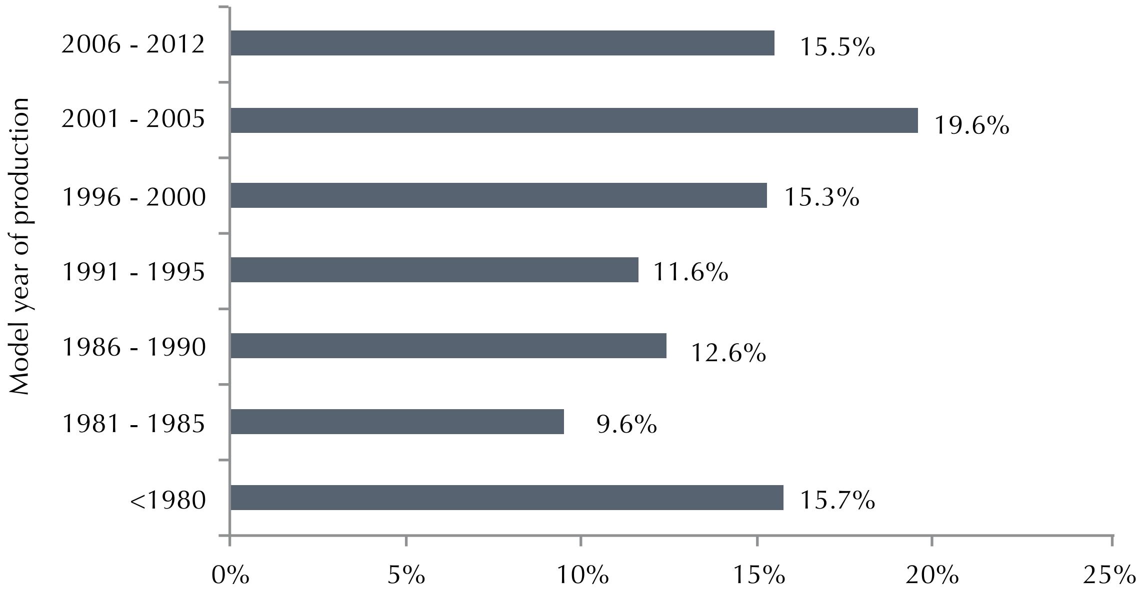



**Figure 3:** Vehicle percentage distribution per model year of production

Mass transport consists of public and private buses, minivans and exclusive and shared-ride taxis, all operating on an ad-hoc basis without any coordination, resulting in very poor occupancy rates of about 1.2 passengers per vehicle for taxis, 6 for vans and 12 for buses (MoE/URC/GEF, 2012). In 2002, the mass transport market share in Greater Beirut Area (GBA) was 31%, clearly illustrating the level of underdevelopment of public transportation in Lebanon. This limited share of the market is mainly due to the impracticality, lack of safety and restricted reach of public transportation compared to the attractiveness of owning a private automobile, an alternative that is still promoted over mass transportation in Lebanon through bank loan facilities and affordable new and used car imports.

This reality is due in large part to the chaotic, inefficient and unreliable management of the transportation sector, preventing the modernization and growth of the system and allowing the market to be controlled by private operators. For example, the system is oversupplied with 50,000 taxi licenses (known as "red plates"), where an estimated 17,000 of these are illegally procured and operated, with a similar situation of poor forecasting and control of the number of shared taxis and minibuses relative to actual market demand.

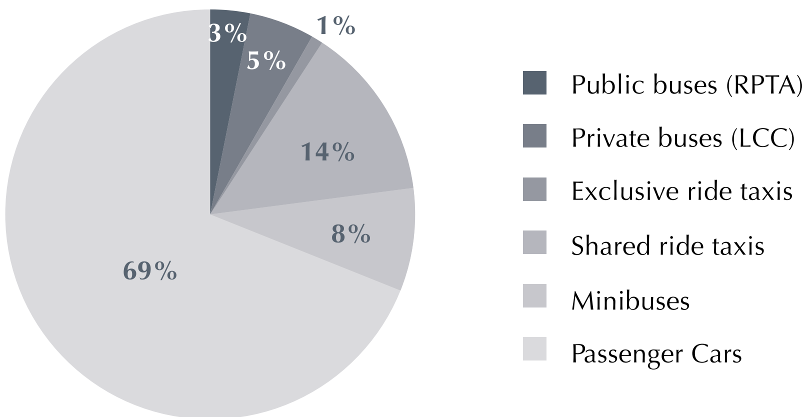



**Figure 4:** Market share of transport systems in GBA in 2002
Source | Baaj, 2002

The Lebanese driving patterns can be characterized by a relatively low driving range with a high rate of congestion and frequent stops at short time intervals. In fact, 50% of trips have a distance lower than 5 km, 25% of stops are below 2 seconds and the total stop time per trip corresponds to more than 15% of travel time. Moreover, observed results reflect the continuous stop-and-go driving patterns, therefore resulting in the inefficient operation of internal combustion engines, and a high rate of fuel consumption and pollutant emissions as a result (MoE/UNDP/GEF, 2015b).

The cost of mobility in Lebanon of a passenger, travelling one kilometer in a passenger vehicle (including externality components of pollution, travel time, congestion and accidents) is around US¢ 48. The most critical indicators were the ones related to excessive energy consumption (mainly fossil fuels) by the passenger transport sector (MoE/UNDP, 2015b).

***Aviation***

Middle East Airlines (MEA) is the national air carrier securing only international flights and Beirut International Airport is the only operational commercial airport in the country. The other remaining airports in Lebanon are reserved for military services. Regarding domestic flights in Lebanon, they show very limited activity since aircrafts are of small propeller engine types, used only for training.

***Marine transport***

Legal harbors in Lebanon are limited to five: Beirut, Tripoli, Saida, Tyre and Jounieh. Beirut and Tripoli are the two largest commercial ports. The port of Beirut hosts around 78% of the incoming ships and the port of Tripoli hosts around 16% (CAS, 2014). The number of yearly incoming ships and oil tankers to Beirut port ranges between 2,000 and 2,400, with a total capacity of around 700,000 containers Total Equivalent Unit (TEU) per year (Beirut port statistics, 2014). Moreover, Beirut port observes transit traffic with an average value of 1.8 million tonnes of goods per year. As for Tripoli, its port hosts around 350 to 450 yearly incoming container and cargo ships, and 50 to 90 oil tankers (Tripoli port statistics, 2014).

The fisheries host a fleet of around 2,860 boats with a yearly catch of around 9,000 tonnes, insufficient to cover the local fish consumption of 35,000 tonnes; consequently, 74% of the fish consumed in Lebanon is imported. About 98% of the fleet is constituted of open woody boats with length less than 12 m (EastMed, 2012). The fleet is old (e.g. average age of 17 years at the port of Tyre) and spread over 44 harbors, most of which requiring major infrastructure maintenance intervention.

## 8. Industry

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

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

The key industrial sectors in Lebanon are food products and beverages, fabricated metal products and other non-metallic mineral products. These constitute 50% of the economic activity of the industries in the country. Other sectors include the chemical sector, furniture manufacturing and electrical machinery manufacturing (Figure 5) (MoI/ALI/UNIDO, 2010).

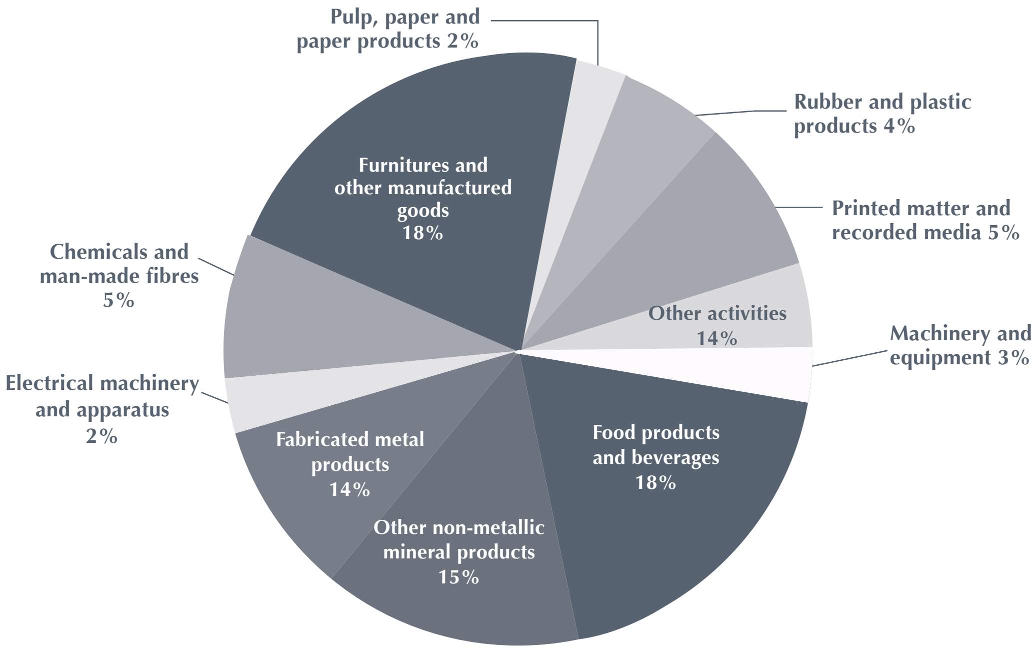



**Figure 5:** Distribution of industrial establishments by economic activity in 2007 in Lebanon

Source | MoI/ALI/UNIDO, 2010

[1] Value of electricity generated by companies for their own consumption was equal to USD 192.3 million and represented 2.8% of the total output. This value is computed based on the cost of the fuel used to generate electricity and not on the market value of electricity. Enterprises generate electricity for their own production, and the latter is considered to be part of industrial output.

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

The MoE is responsible for the environmental compliance of industrial establishments through the implementation of the Environmental Compliance Decree 8471/2012 and its related decisions (202/1, 203/1 & 271/1 - 2013). Depending on the size and type of each industrial establishment, water and air pollution abatement measures have to be undertaken to comply with the decree.

## 9. Solid waste

Data on solid waste generation is not readily available and when it is, information is disaggregated (by site, operator, local authority, etc), decentralized and often reported in hard copy reports making any manipulation and analysis time consuming and difficult. Furthermore, solid waste quantities are generally estimated based on population and generation rate per capita and not on direct weighing and monitoring of collected solid waste from households and institutions. Surveys and assessment conducted for the years 1994 (El Fadel and Sbayti, 2000), 2006 (CDR, 2006), and 2010 (MoE, 2010) produced generation rates for these respective years.

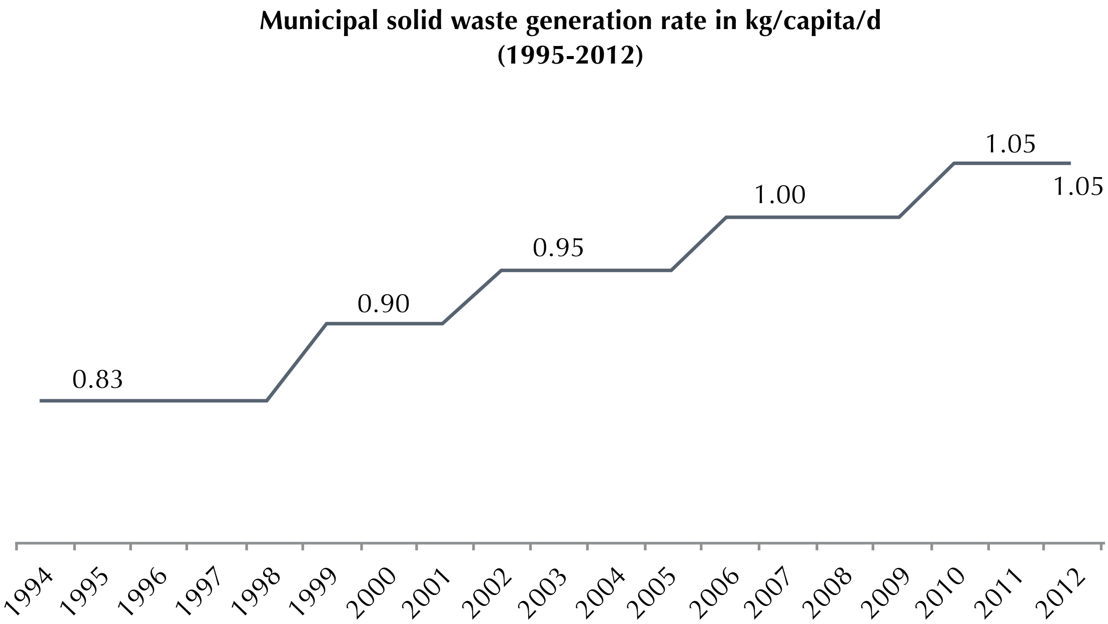



**Figure 6:** Per capita municipal solid waste generation rates for the years 2012-1995 in Lebanon

While solid waste generally refers to municipal, industrial and Health Care Waste (HCW), in Lebanon this segregation is inapplicable due to the absence of a well-defined legislation and more stringent controls. Accordingly, most of the industrial and hazardous wastes are being mixed with the municipal waste. HCW is disposed of in municipal waste bins, with 55-60% of it being autoclaved prior to its disposal, and transferred to landfills or dumpsites.

Three main landfills in Lebanon are currently operational, namely the Naameh landfill, the Zahle landfill, and the Tripoli controlled dumpsite. These "official" solid waste disposal sites in Lebanon have been receiving since 1998 around 55% of the total generated solid waste in Lebanon as shown in Figure 7. The remaining portion of the generated solid waste is partially recycled/composted while the rest is being disposed in open dumpsites by the local authorities such as municipalities and/or Unions of Municipalities.

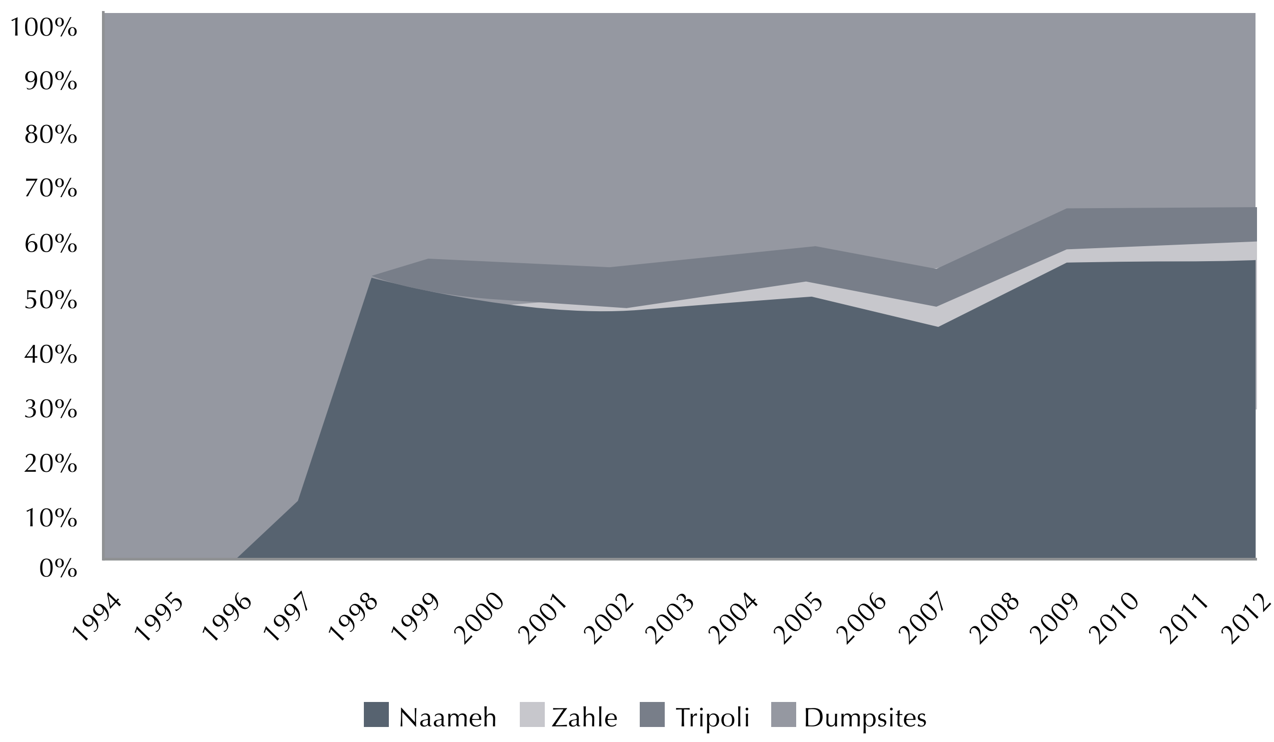



**Figure 7:** Evolution of solid waste final disposal in Lebanon (1994 – 2012)

The Naameh landfill was constructed in 1997 as an emergency to stop the open dumping of waste especially in the Normandy and Bourj Hammoud dumpsites. The Naameh landfill has been operational since then and has received some 10 million cubic tonnes of Municipal Solid Waste (MSW) after sorting and composting. The Naameh landfill is equipped with methane flaring systems and the quantities recovered can reach 4,000 times the levels of the remaining 2 sites.

The Zahle landfill was opened in 2002 in the Bekaa valley in the Caza of Zahle and it was designed and built to receive 150 tonnes per day, serving 15 out of 29 municipalities in the Caza of Zahle. The landfill is complemented by a sorting facility since 2008 but no composting activities are taking place. As for methane recovery, one flaring unit is installed since 2003 where collected gas is directly flared on site. However, the quantity of gas flared is minimal as compared to the Naameh landfill and this is mainly due to the quantity of waste collected in Zahle which is less than 5% of the waste collected in Beirut and Mount Lebanon.

The Tripoli controlled dumpsite is located on the Tripoli seafront and serves the city of Tripoli as well as the neighboring towns with an estimated population of 400,000 inhabitants. The dumpsite is annexed by a sorting facility however it is not operational yet. Methane is recovered and flared by one flaring unit since 2000. Similar to the Zahle dumpsite, the quantity of gas flared is minimal as compared to the Naameh landfill and this is mainly due to the quantity of waste collected in Tripoli which is less than 15% of the waste collected in Beirut and Mount Lebanon.

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

To this date, MSW incineration is not practiced in Lebanon. Only a small quantity of HCW estimated to 3,358-5,037 tonnes per year is being incinerated by hospitals. Starting 2002, and after the enactment of decree 8006 (date 11/6/2002) on the proper management of the HCW in Lebanon, several hospitals and organizations started managing their HCW in an environmentally-appropriate manner. A local Non-Governmental Organization (NGO) called Arcenciel started in 1998 collecting and treating the HCW through autoclaving. As of 2010, Arcenciel is treating 55-60% of the total HCW stream (about 90% of the waste stream in Beirut), collected from 81 public and private hospitals. The remaining portion (around 35- 40%) of the HCW is being incinerated at the hospitals without permits or dumped illegally with MSW.

A number of municipalities have received technical and/or financial assistance from international development organizations to improve their solid waste management services by building small and medium sized solid waste sorting and composting plants. The projects have known limited success due to lack of financing of the operation and maintenance services and lack of technical capabilities of the municipalities to ensure efficient solid waste management.

Assuming 60% occupancy and an average generation rate of 1.0-1.5 kg per bed per day, Lebanon's 164 public and private hospitals (about 15,342 hospital beds) produce daily about 9.2-13.8 tonnes of HCW (about 3,358-5,037 tonnes per year).

In this report, it is considered that around 1.25 Gg per year of HCW is being incinerated (MoE/ELARD, 2004). An extrapolation was used to determine quantities incinerated during the period covered by the study, assuming that Arcenciel started its autoclaving operations in 1998 in Beirut and then it expanded towards the Bekaa region in 2003.

## 10. Wastewater

Currently, most of the generated wastewater is discharged in nearby surface water without prior treatment. Small septic tanks are still widely adopted in rural areas. Industrial wastewater is rarely treated at the industry level prior to its discharge in the environment or in the public sewer network.

The management of wastewater is the responsibility of the Ministry of Energy and Water (MoEW) who developed the National Water Sector Strategy adopted by the GoL in 2012. The strategy sets targets in wastewater management including but not limited to:

- Collection and treatment to at least preliminary level of 95% of generated wastewater quantities by 2020
- Pre-treatment of all industrial wastewater by 2020
- Reuse of 50% of treated wastewater by 2020
- Secondary treatment and reuse of all inland wastewater by 2020 and secondary treatment by 2020 of coastal wastewater where reuse is economically justified

To date, the collection and treatment of wastewater is under the responsibility of the four Water and Wastewater Establishments (WWEs) as per law no. 221 of the year 2000 and its subsequent amendments. However, the WWEs still lack the technical and financial capabilities to efficiently and effectively manage the sector although international donors are providing financial and institutional support.

Although many Wastewater Treatment Plants (WWTPs) were built in the recent years through grants and/or loans, only few of them are currently operational and at various treatment levels due to lack of operation and maintenance services, financing, and lack of technical capabilities of the municipalities or WWEs to ensure efficient wastewater management. Table 2 summarizes the number of treatment plants currently operational in Lebanon.

**Table 2:** Status of wastewater treatment plants in Lebanon

| Location | Total number | Status | | | |
|---|---|---|---|---|---|
| | | Planned | Under construction | Constructed but not operational | Operational |
| Beirut and Mount Lebanon | 9 | 4 | 2 | 2 | Ghadir: preliminary treatment |
| Bekaa | 9 | 2 | 1 | - | Aitanit, Baalbeck, Fourzol, Jib Jannine, Saghbine, Iaat: all secondary treatment |
| North Lebanon | 7 | 3 | - | 4 | 0 |

Source |MoE, 2013

The construction of wastewater network systems is lagging behind. With the exception of Beirut administrative region, all districts have large gaps in the wastewater network connections even though extensive developments to wastewater infrastructure have been made since 1998 with an annual growth of 7.2% on average. The households which are not yet connected to the sewerage system either use septic tanks or cesspools or simply discharge the wastewater directly into the environment.

## 11. Agriculture

Agriculture is a vital part of the Lebanese economy and its social and cultural heritage. Even though the sector's share of the GDP is relatively low (4% in 2012), agriculture employs 20-30% of the active work force and constitutes 17% of the total exports (MoA, 2010a). In rural areas, however, agriculture is reported to contribute up to 80% of the local GDP and represents the major income-earning and employment opportunity (Verner and Breisinger, 2013). In comparison with neighboring countries, agriculture production in Lebanon is characterized by a higher value added per square kilometer, reflecting a higher intensity of production and greater focus on higher value fruits and vegetables (FAO, 2011a). Compared to 1970 when agriculture share of the GDP reached 9% (Kubursi, 1999), agricultural contribution to the GDP has been steadily decreasing due to the post-war economic crisis, urban encroachment that changed the rural landscape of the country, government economic policies favoring other sectors, emigration of young generation of farmers and the switch from farming to higher-paid jobs, and climate change with its concomitant effect on crops, pastures, and water resources.

The total agricultural area is estimated at 638,000 ha (62% of total surface area) (FAO, 2011a). As indicated in Figure 8 below, pastures and meadows constitute approximately 39% of the total area, permanent crops 12%, arable land 11%, and forests 14% of the total surface area of Lebanon.

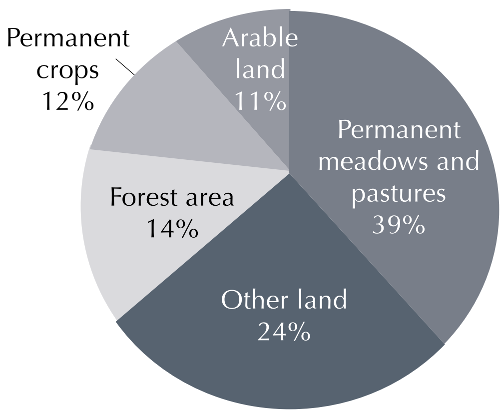



**Figure 8:** Agricultural land use in Lebanon (% of total agriculture area)-2011

Source| FAO, 2011a

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

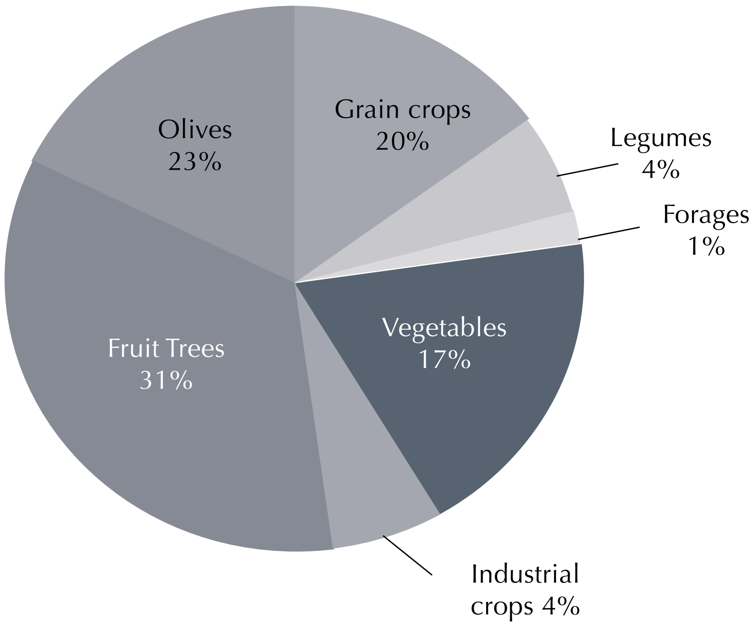



**Figure 9:** Agricultural production in Lebanon

Source| MoA, 2010b

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

1. The Bekaa: Once regarded as the 'bread basket of the Roman Empire", the Bekaa valley is the most important production area and accounts for the highest percentage of seasonal crops (60%) as in cereals, potatoes, and vegetables, and in stone fruits, and grapevine. It also contains the highest percentage of cattle population (43%), sheep (72%), goats (51%) and poultry layers (60%).

2. The north and Akkar plain: Olives, cereals, potatoes, vegetables, cattle and poultry broilers production.

3. South and Nabatieh: Olives, cereals, vegetables, and tobacco production.

4. Mount Lebanon: Fruits, vegetables, poultry broilers, and swine production.

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

### *Animal production*

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

### *Crop production*

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

The most important cereals cultivated are wheat and barley, with some production of forage crops such as alfalfa, vetch, corn, oats, and sorghum. Most of the barley grown in the arid parts of Bekaa (Hermel and El Qaa) is left as pasture for grazing animals. It is anticipated that forage crop production would increase after recent incentives introduced by the MoA to encourage milk and forage production by farmers with small animal holdings.

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

### *Fertilizer use*

Statistics on fertilizer consumption in Lebanon are sporadic and contradictory. The Lebanese customs provide extensive data about imports but these could not be corroborated from the major agricultural importing companies. The amount of fertilizers used in Lebanon has been decreasing since 1994: approximately 122,000 tonnes of total nitrogenous fertilizers were used in 1994, while in 2012 total nitrogenous fertilizers used were approximately 85,000 tonnes. Most of the nitrogenous fertilizers used were Nitrogen-Phosphorus-Potassium (NPK) fertilizer, (17-17-17; and 15-15-15, and other combinations),

Ammonium Sulphate, Ammonium Nitrate and Urea. Application rates of nitrogen fertilizers far exceed the recommended agronomic rates (Al-Hassan, 2011). For example potato growers apply on average 590 Kg N/ha while the suggested agronomic rate is 220 kg N/ha. For vegetables, growers apply the average of 900 kg N/ha while the agronomic rate is 500 kg N/ha. Unfortunately, soil testing for soil nutrient content is not widely practiced and growers apply nitrogen rates based on experience or on the recommendation of agents from fertilizer distributors.

## 12. Land use, land use change and forestry

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

Several initiatives have been conducted to document and map land cover attributes in Lebanon. Accordingly, the first land cover attributes were produced in the form of a topographic map (scale 1:20,000) in 1961 by the Lebanese army in partnership with the French "Institut Géographique National". A land use/ land cover map of Lebanon was produced by the Ministry of Environment in cooperation with the National Center for Remote Sensing of the Centre National de Recherche Scientifique (CNRS) in 2002. This involved the use of satellite remote sensing data acquired in 1998. The final map disaggregated land use and land cover into seven main categories and 23 subcategories. According to this map, Lebanon's forested lands covered 2,588 $km^2$ while the artificial/built up area covered 648 $km^2$. An updated version of the 1998 land cover/ land use map was recently completed by the CNRS using satellite remote sensing data acquired in 2005. In 2004, the CDR published the National Land Use Master Plan for Lebanon. The Master Plan was approved by the Council of Ministers in 2009 (decree 2366 dated 20-06-2009).

The first national forest resources assessment was done in 2005 by the MoA with the assistance of the Food and Agriculture Organization (FAO). The results showed that forests occupied around 13% of the total area of the country. In addition, 10% of the Lebanese territory was found to be covered by other wooded land (MoE/UNDP/ECODIT, 2011; FAO, 2010). Broadleaved forest made up 57% of the total forest cover whereas coniferous forests made up 32%, and the other 11% are mixed forests. The most abundant forests were oak forests covering 52% of total forested areas, while pine forests made up 15% and juniper about 9%. Cedar and fir forests were much less abundant but nonetheless they represent habitats to many endemic and threatened plant species (MoE/UNDP/ECODIT, 2011; FAO, 2005).

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

The problem of forest fires in Lebanon is complex. At the administration level, it is a problem having several authorities involved and a problem of forest policy and legislation, as much as it is a problem of equipment and capacity building. Despite the increased efforts, fire issues increasingly threaten forest ecosystems and economic development in Lebanon. Accordingly, a National Strategy for Forest Fire Management (AFDC/MoE, 2009) was developed and endorsed by the CoM in 2009 (decision no. 52/2009). The aim of this strategy was to reduce the risk of intense and frequent forest fires whilst allowing for fire regimes that are socially, economically and ecologically sustainable. Until present, data on fire occurrence and affected surfaces in Lebanon is still not mutually consistent, homogenized and unified at the national level. However, an attempt has been made in 2008 to adopt the forest fire common ID card based on the CoM decision no. 256 dated on 1/3/2008.

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

In an attempt to tackle deforestation and to preserve what is left of natural areas, Lebanon has created 10 nature reserves, 3 biosphere reserves, 16 protected forests, 16 protected natural sites/landscapes, 4 Ramsar sites, 5 world heritage sites, and 15 important bird areas (MoE/UNDP/ECODIT, 2011). Reforestation and afforestation combined with the implementation of Lebanon's National Strategy for Forest Fire Management are some of the main activities aimed at maintaining and increasing Lebanon's forest cover. During the past decade, Lebanon has initiated a number of programs/initiatives to restore forested lands: 1) the development of the National Reforestation Plan (NRP) by the MoE in 2001, 2) the development of the National Action Plan to Combat Desertification by the MoA in 2003, 3) the development of the project "Safeguarding and Restoring Lebanon's Woodland Resources" to complement what has been started under the NRP in 2009, 4) the launching of Lebanese Reforestation Initiative (LRI) in 2012 with the support of the International Program of the US Forest Service to provide needed support in large-scale reforestation activities across the county, 5) the launching of the project "planting four million forest trees" by the MoA in 2012 and 6) the simultaneous implementation of several initiatives by local NGOs.

## 13. Tourism

The travel, tourism and hospitality industry is a significant contributor to the Lebanese economy. Figure 10 shows variation of the direct and indirect contributions of the tourism sector to Lebanon's GDP from 2000 to 2012. The direct contribution figure takes into account the activities of hotels, restaurants and leisure services directly receiving income from tourists, in addition to travel agents, airlines and other transportation services. The indirect contribution to the macro-economy is much higher when other services linked to tourism are considered; these include purchases and procurement conducted by tourism businesses (construction, grocery suppliers, equipment suppliers, etc.) (MoT/USAID/DAI, 2014).

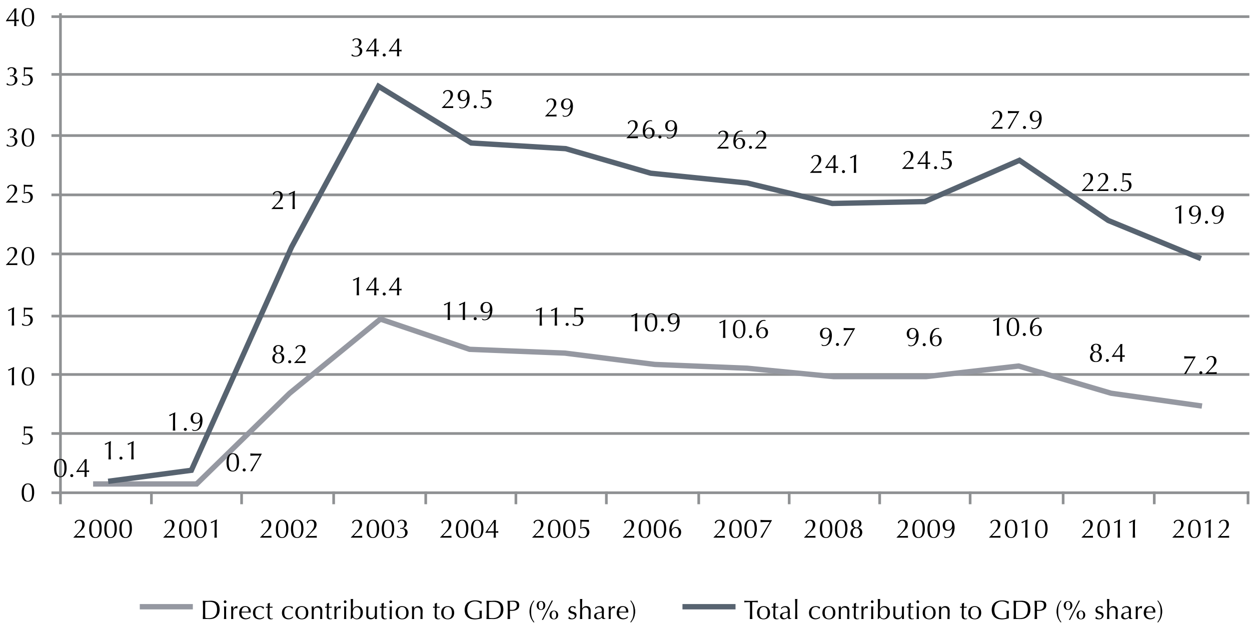



**Figure 10:** Direct and indirect contribution of the tourism sector to Lebanon's GDP from 2000 to 2012

Source | Adapted from MoT/USAID/DAI, 2014

There is a wide variety of touristic attractions and activities in Lebanon, and tourism development has been rather fast depending on the political and regional stability throughout the years. Nonetheless, environmental protection and the impacts of climate change may also be important factors in determining the sustainability of the development of this sector (Riebe, 2011).

Over history, many civilizations have crossed the land of Lebanon, and their traces are dispersed throughout the country. Along the Lebanese coast for example, remnants of the Phoenician civilization can be found in the cities of Byblos, Tyre, Sidon and Tripoli. During the summer season, the Lebanese

coast is home for many beach resorts and water activities (surfing, snorkeling, diving, etc.). Lebanon is also a winter destination with skiing and mountain activities. In fact, some villages have only developed around this type of tourism and they economically depend on the winter skiing season. The 440 km long "Lebanon Mountain Trail" was established in 2007 providing a hiking trail from north to south along with camping and eco-lodge accommodations along the rural villages of the trail (Riebe, 2011).

Based on the above, the touristic attractions in Lebanon therefore depend a lot on weather conditions, which have been unstable as a result of climate change. In addition, the latter cannot be contained to only weather changes, its impacts reach the complex linkages in ecosystems, potentially affecting fauna and flora in the country. However, tourists with a more urban focus still converge to Beirut for its shopping and nightlife, medical services will continue to increase in demand (Riebe, 2011).

The importance of domestic tourism in Lebanon is noteworthy. Unfortunately, there are no data available to measure how many Lebanese locals, or expatriates in Lebanon are actually touring around Lebanon and staying in rural areas for tourism purposes. Information about where tourists go in general is also incomplete or missing, which constitutes a big challenge in terms of understanding the dynamics of the sector. It is however believed that domestic tourism is usually less affected by the political situation and international travel bans (MoT/USAID/DAI, 2014). Nonetheless, very little work seems to be done to comprehensively understand the impacts of climate change on the touristic activities and areas.

## 14. Water

The National Water Strategy, published by the Ministry of Energy and Water in 2012 (MoEW, 2010a), states that the Lebanese water sector is facing shortcomings both on the infrastructure and management fronts. The production is hindered by limited resources with suboptimal exploitation coupled with a significant growth of demand. The transmission and distribution systems are inefficient and poorly maintained causing high losses of water and interruption of supply. On the management side, there is not much focus on water demand management, weak coordination between agencies mandated to manage the water sector, inconvenient water tariffs, and limited conservation and pollution protection activities.

While all of the above constitute significant stress on the water sector in Lebanon, climate change and its adverse impacts are increasing this pressure. Figure 11 illustrates the current status of the water balance in Lebanon. It reveals that renewable water resources per capita are already slightly below scarcity threshold, with projected decrease in the coming years.

Surface water resources are largely exploited but with limited storage, while significant stress is put on groundwater mainly through private wells. Irrigation is the largest water consumer in Lebanon (61%) with low efficiencies, as open channels still constitute the majority of the networks (70.4%, followed by 23.4% for sprinkler and only 6.2% for drip irrigation). Details are presented in Table 3.

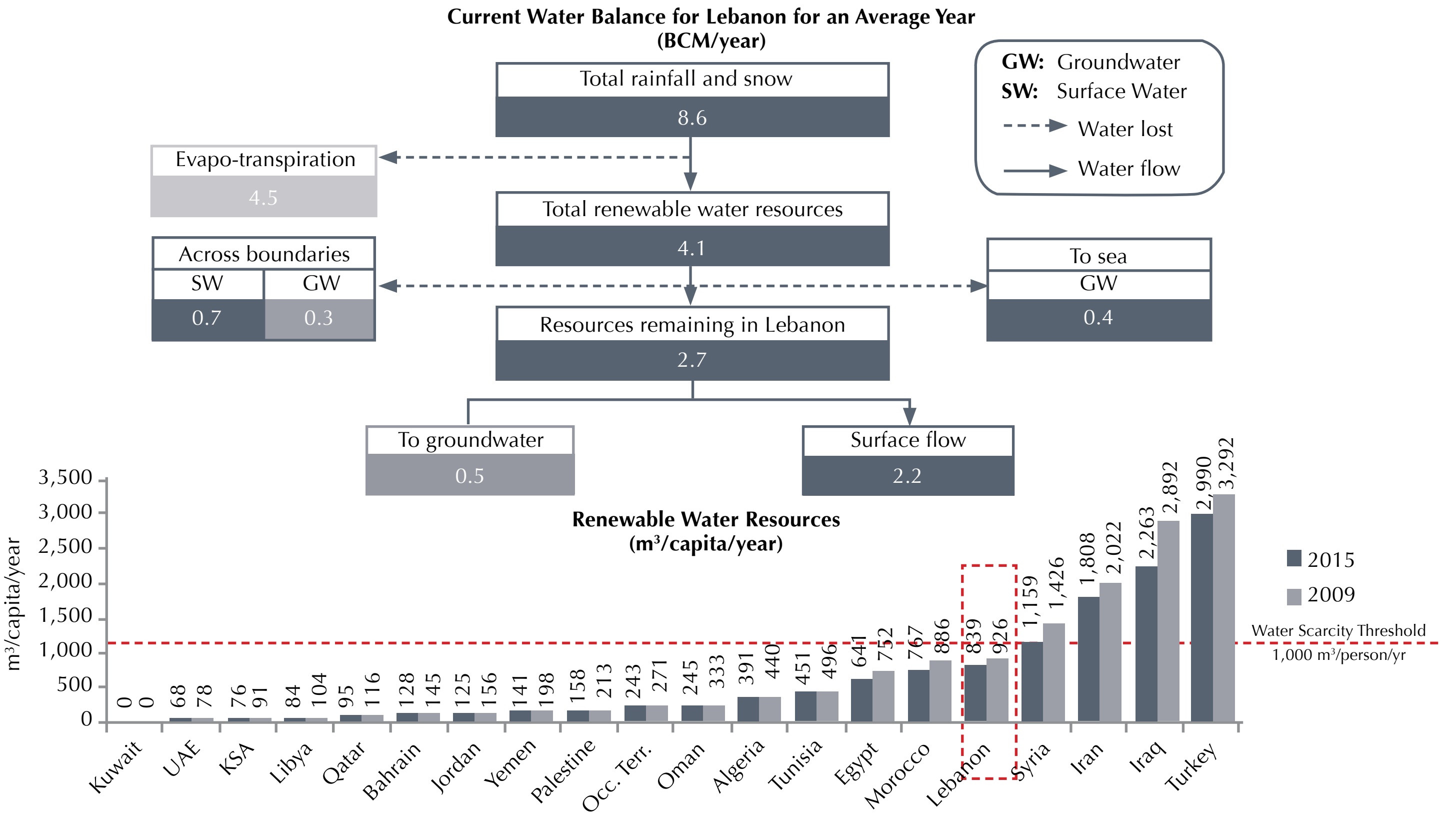



**Figure 11:** Current water balance for Lebanon for an average year

Source | MoEW, 2010a

## **Table 3:** Details on main sources of water in Lebanon

| | |
|---|---|
| Surface Water | • More than 2,000 springs exist all over Lebanon with varying flows around the year.<br>• Total yield exceeds 1,200 MCM in an average year, with less than 200 MCM available during the dry summer months.<br>• Existing surface water resources (springs) are currently being exploited to a large extend by WWEs. Limited optimization by around 1% could be achieved per year for the coming 10 years. |
| Groundwater | • Around 650 governmental wells supply WWEs throughout the country with potable water. Total volume used in 2009: exceeds 270 MCM.<br>• More than 43,000 private wells are used for potable water and agriculture. Total volume used in 2009 is probably higher than 440 MCM. Private wells serve only a portion of the population.<br>• Despite strict policies, no major reduction in extractions of groundwater were planned until 2015. It is planned that between 2015 and 2024 private groundwater extractions will be gradually reduced at a rate of 6% per year with increasing reliance on public wells.<br>• Ultimately, withdrawals from aquifers should not exceed natural replenishment rate, i.e. 500 MCM/year. |
| Surface storage | • Mainly concentrated in 2 dams (Qaraoun and Chabrouh) with a total capacity of 235 MCM. |
| Non-conventional water | • The average rate of wastewater treatment reached 4% in 2009. No reuse is being currently practiced.<br>• Limited desalination is done by private sector and EDL (5.5 MCM).<br>• Additional flows are expected to exist. They have not been modeled for lack of data. |

Source | Adapted from MoEW, 2010a

## 15. Public health

Chronic and degenerative diseases seem to be on the rise in Lebanon. There is evidence that lifestyle related diseases such as cardiovascular disease, gastrointestinal ulcer, chronic obstructive lung disease, musculoskeletal disease, depression and cancer are increasing (WHO, 2010).

Lebanon is facing a variety of environmental health problems resulting from the years of war, including water pollution, air pollution, inadequate solid waste management and uncontrolled use of pesticides for agriculture (WHO, 2010). Research suggests that environmental hazards are responsible for about 24% of the total burden of disease (including more than 1 million deaths and 38 million Disability-Adjusted Life-Years (DALYs) lost each year) in the Eastern Mediterranean Region (EMR) (WHO, 2015). The health impact of environmental risks relates to both communicable diseases and non-communicable diseases in all three groups of countries in the Eastern Mediterranean Region. Lebanon is classified among group 2 of countries of the Eastern Mediterranean region where 44% of EMR population resides (middle income countries with reasonable health service delivery infrastructure, still facing constraints in terms of availability of resources) with a reported annual environmental burden of disease of 39.3 DALYs per 1,000 capita corresponding to an overall GDP-based cost of USD 71.5 billion per year. In group 2 countries, main environmental risk factors include water and sanitation, air pollution, and exposures to chemicals and wastes (WHO, 2015).

Significant efforts were deployed by the GoL to address the detrimental effect on the health system structure caused by the long lasting civil war of the 1970s and the 1980s. The latter allowed the rapid and unregulated growth of the private for profit high technology health sector. The structure and organization of the public health system was therefore weakened. Despite the volatile political and security situation, the public health sector reform is slowly regaining its stewardship function. However, the health outcomes do not compare favorably to other countries with similar public health spending, which proves that the efficiency of the system is still challenged (WHO, 2010).

The Ministry of Public Health remains the insurer of last resort for around 50% of the population. Lebanese nationals have access to health services through six main funds: mandatory social insurance for employees in the formal sector, medical services of the Army and the other uniform staff, the cooperative of civil servants, a few social mutual funds and a private voluntary insurance provider. The contribution of the covered citizen is estimated at 44%, down from 69% in 1998. However, this share is still considered high (WHO, 2010).

The current financing structure is characterized by the fragmentation of public funds, which leads to a bigger focus on curative care and less focus on prevention and public health management. Government spending on health constitutes 6% of its fiscal budget (WHO, 2010).

## 16. Climate action, institutional arrangements and MRV system

The lack of institutional memory from compiling previous inventories, difficulties in sharing data between agencies, and a greater involvement from the private sector (where an important part of the data is available, in addition to a significant potential of mitigation actions) are identified as the major challenges facing the GoL to track and report climate action. Therefore, the MoE has been focused on designing a national-level system that will provide more sustainable and structured data collection, maintenance, archiving, reporting and action implementation processes. Progress is highlighted in the subsequent sections.

### 16.1 Introducing new incentives, teaming up with the private sector

***Minister of Environment's decision 99/1***

The Minister of Environment's decision 99/1 of April 2013 provides incentives for direct reporting of GHG emissions and related activity data to the MoE by the private sector, namely commercial, institutional and industrial enterprises. In exchange for their cooperation, reporting companies are awarded a reporting certificate signed by the Minister. This initiative was developed with the support of the Low Emission Capacity Building (LECB) Programme, managed by the United Nations Development Programme (UNDP) funded by the European Commission, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Australian Government.

The MoE uses the information collected through the decision 99/1 process to verify disaggregate data used in the national GHG inventory, specifically in the energy sector. Indeed, the energy data currently available is the aggregate energy consumption in the country. However, in order to use both the reference and sectoral approaches in calculation of GHG emissions from the energy sector, disaggregated data on energy consumption should be available. Decision 99/1 is a first attempt to categorize this consumption.

In addition, the Minister of Environment's decision 99/1 ensures a sustainability in reporting by establishing a continuous flow of information for GHG emissions reporting, which replaces the rather ad hoc and sector-specific existing processes.

***Lebanon Climate Act***

In cooperation with Lebanon's Green Mind (NGO), the Central Bank of Lebanon, the Association of Lebanese Industrialists and the Association of Chambers of Commerce, Industries and Agriculture, the Ministry of Environment has established the "Lebanon Climate Act" (LCA), which is a network of companies and institutions actively engaged in the fight for climate change in harmony with the post-Paris climate spirit. The LCA aims to catalyze the involvement of the private sector in the wider climate change community. It provides a space for businesses to showcase and support climate action, through transparent concrete initiatives and multi-stakeholder approaches

and thus, contribute in a sustainable and profitable manner to a strong and effective response to climate change.

Seventy-two companies have already joined the Lebanon Climate Act, demonstrating their ongoing engagement to climate action, just like governments did by adopting the Paris Agreement and nationally determining their contributions to international climate efforts. By joining the Act, companies will set actions to reduce their environmental and carbon footprint, increase low-carbon investments, deploy more clean energy, and build more sustainable businesses and communities to tackle climate change. These companies are expected to participate and abide by decision 99/1, hence increasing the volume of institutions reporting both their GHG emissions and mitigation projects.

## 16.2 Benefiting from existing formal procedures

In Lebanon, the private sector has traditionally been reluctant to provide information directly to the MoE. In addition, collecting data on a regular basis and maintaining and archiving the information requires dedicated financial and human resources. However, due to the current institutional limitations of the MoE, joining efforts with other ministries and benefiting from existing established reporting mechanisms became a necessity to guarantee the sustainability of Measuring, Reporting and Verifying (MRV) arrangements.

### *Cooperation with the Ministry of Industry*

In Lebanon, the MoI is responsible for certifying industrial businesses to allow import and export of their products. Therefore, industrial establishments apply annually to the MoI to register and renew their ‘industrial certificate’. The application involves responding to a list of basic questions about the business’ operations.

Taking advantage of this frequent reporting of the industrial sector, the MoE succeeded in requesting GHG inventory activity data from industries as part of the information they need to provide to renew their license. A Memorandum of Understanding was signed between both ministries to institutionalize this cooperation and secure systematic annual sharing of data.

### *Cooperation with the Ministry of Finance*

The MoE is currently exploring the possibility of replicating the joint reporting system established at the MoI with the Ministry of Finance by requesting commercial, institutional and industrial entities to report additional information related to GHG emissions as part of their annual Value Added Tax (VAT) declaration via the already established online system. At the time of the drafting of the present report, a trial platform (not yet available to the public online) is being studied by the teams of both ministries.

### *Environmental compliance decree (8471-2012)*

The MoE is also implementing a process through the decree on Environmental Compliance of Establishments that could provide valuable activity data. The decree defines the responsibilities of the private and public sectors in complying with national emissions standards and stipulates the preparation and reporting of regular environmental audits to the MoE. A certificate of compliance will be issued to entities complying with the requirements. This decree provides an opportunity to include the reporting of GHG emissions in environmental audits in order to unify and verify data collection.

## 16.3 From NAMAs to INDCs and the governing MRV system

In 2009, Lebanon presented to the international community the country's voluntary target of introducing 12% renewable energy in the national energy mix. Since then, momentum has endured and Lebanon is well on its way to producing advanced Nationally Appropriate Mitigation Actions (NAMAs) to help meet its renewable energy target, and raised the ambition of the latter to 15% (unconditional) – 20% (conditional) through a comprehensive Intended Nationally Determined Contribution (INDC).

### *Nationally Appropriate Mitigation Actions*

In 2013, the Ministry of Environment was appointed by the CoM as the official national coordinator for NAMAs in Lebanon and in 2014, the Ministry of Environment issued decision 196/1 that established and officiated a mechanism for approving and submitting NAMAs to the UNFCCC NAMA registry (Table 4). The purpose of this mechanism is to record the demand for international support for the implementation of NAMAs and to facilitate the matching of financial resources, technology and capacity building support with these measures.

**Table 4:** NAMA process in Lebanon

| |
|---|
| **Step 1: GHG emission inventories and assessment of presiding framework conditions**<br>Identification of the main GHG emission sources and sectors and preparation of baseline and Business-As-Usual (BAU) scenarios for the different sectors. |
| **Step 2: NAMA identification and scoping**<br>Identification of opportunities for mitigation actions that can be packaged as potential NAMAs for Lebanon based on their emission reduction potential, associated costs at both national and sectoral levels, co-benefits, and feasibility of implementation. |
| **Step 3: NAMA prioritization and selection**<br>Prioritization of the most feasible options to be further elaborated according to specific selection criteria and based on a national consensus. |
| **Step 4: NAMA preparation**<br>Development of fully detailed NAMA proposals by concerned ministries/institutions and submission to the MoE to be a basis for negotiation of support and implementation conditions between the government and sources of support. |
| **Step 5: NAMA registry**<br>After approval of the MoE and the NCE, submission of NAMA proposals to the registry. |
| **Step 6: Implementation and MRV**<br>Implementation of the NAMA within the relevant sectors once funding is secured and terms of the implementation agreed upon with the supporting countries. |

Two NAMA proposals from the MoE tackling solid waste management and promoting fuel efficient and hybrid vehicles, have been developed and finalized in 2016 through the UNDP LECB Programme. With a nod to sustainability during the initial selection process, it was also made clear that NAMAs outside the initial short list can and should be developed in the future, as long as they pass the agreed criteria. Indeed, the MoA has started developing a forestry NAMA, bringing the total number of NAMAs currently under development up to 3. Once ready, these NAMAs will be submitted to the NAMA Registry, seeking funds for implementation.

### *Intended Nationally Determined Contribution*

Lebanon presented its INDC in September 2015 in a situation of development challenges, including, amongst other issues, a lack of security due to regional turmoil and a high level of poverty. Adaptation has been highlighted as a priority for Lebanon, a developing country with scarce water resources and high population density in the coastal areas. The government of Lebanon also recognized that the more sustainable its development path is, the easier it will be to build resilience to climate change impacts.

National as well as sectoral planning has addressed these challenges through the development of a number of low-carbon and adaptation strategies. These strategies take a long-term view, considering for example a full restructuring of the power sector between 2011 and 2030. Lebanon's INDC builds on these strategies. The country is, however, not able to provide the resources necessary to implement these strategies completely on its own. International support is required to fully implement and track the existing adaptation and mitigation strategies and to further mainstream adaptation and mitigation throughout the economy. With regard to mitigation, the INDC has set two targets: the first representing the country's own contribution ("unconditional target"), the second offering a wider mitigation target conditional on receiving international support ("conditional target") (Table 5). With this INDC, the government of Lebanon strives to both build resilience and improve adaptation as it lowers emissions, and therefore take advantage of the synergies between adaptation and mitigation.

**Table 5:** Summary of Lebanon's INDC mitigation target

| | |
|---|---|
| Unconditional Target | • A reduction of 15% compared to the Business-As-Usual (BAU) scenario in 2030<br>• 15% of the power and heat demand in 2030 is generated by renewable energy sources.<br>• A 3% reduction in power demand through energy-efficiency measures in 2030 compared to the demand under the BAU scenario |
| Conditional Target | • A reduction of 30% compared to the BAU scenario in 2030<br>• 20% of the power and heat demand in 2030 is covered by renewable energy sources.<br>• A 10% reduction in 2030 in power demand through energy-efficiency measures compared to the demand under the BAU scenario |

*Measuring, Reporting and Verifying*

The establishment of a permanent climate change and MRV unit to better assess the progress and the gaps of national initiatives, among which those related to the implementation of the INDC is crucial for the grounding of any MRV system. The unit would be managed by a dedicated team at the MoE and would include shared staff with other ministries such as the Ministries of Finance, Energy and Water, Industry, Agriculture, etc. The unit will also be responsible for looking exclusively at climate related activities and monitoring and evaluating the work of a wide range of national stakeholders. This will allow a better understanding of common objectives across institutions and will prioritize effective climate change policy actions.

Stakeholders have initiated in July 2016 their extensive consultative work to transform Lebanon's INDC into a legally binding Nationally Determined Contribution (NDC). By the time the ratification process of the Paris Agreement is completed, elements of the INDC presented above, although not envisaged, may be reviewed and modified as the action plan for implementation becomes clearer with every round of national consultations.

# 2 NATIONAL GREENHOUSE GAS INVENTORY

# 2 NATIONAL GREENHOUSE GAS INVENTORY

## 1. Introduction

In accordance with Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), parties are required to develop and report national inventories on national emissions and removals of Greenhouse Gases (GHG) using comparable methodologies. As a Non-Annex I Party to the UNFCCC, Lebanon has already presented 3 national greenhouse gas inventories with base years of 1994, 2000 and 2011 (MoE/UNDP/GEF, 1999; MoE/UNDP/GEF, 2011; MoE/UNDP/GEF, 2015).

This chapter summarizes Lebanon's anthropogenic greenhouse gas emissions ($CO_2$, $CH_4$, $N_2O$) by sources and removals by sinks for the year 2012 in addition to the precursors (CO, NOx, $SO_2$, and NMVOCs). It also presents the trend analysis of the national GHG inventory for the period 1994 to 2012, with a revision of the results of previous inventories to allow consistency of information.

**Table 6:** GHG emissions and removals sources

| | **Sources of emissions** |
|---|---|
| Energy | Emissions associated with the combustion of fossil fuels from mobile sources such as road transport, and domestic navigation and aviation and stationary sources such as electricity production and heat generation from power plants, private generators, and the industrial, residential and commercial sectors |
| Industrial processes | Emissions produced from industrial activities and production processes which chemically or physically transform materials. |
| Agriculture | Emissions released from the microbial decay or burning of plant litter and soil organic matter, from the fermentative digestion of ruminant livestock, from stored manures, and from the microbial transformation of nitrogen in soils and manures. |
| Land use, land use change and forestry | Changes in carbon stock associated with changes in land use in forestland, cropland, grassland, wetlands and settlements in addition to emissions caused by disturbances such as forest fires. |
| Waste | Emissions generated from solid waste disposal, incineration and open burning as well as wastewater disposal and treatment. |

## 2. Methodology

The inventory is based on the Revised 1996 Intergovernmental Panel on Climate Change (IPCC) guidelines for National Greenhouse Gas Inventories and on the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories that provided methodologies for calculating national inventories and estimating uncertainties and the Good Practice Guidance for Land use, Land-use Change and Forestry (IPCC, 1997 and IPCC, 2000 and IPCC, 2003). The UNFCCC Non-Annex I Greenhouse Gas Inventory System, Version 1.3.2. was used as the software model for calculation

The tier 1 approach was employed in most of the calculation of sectoral emissions since no country-specific emission factors were available for the adoption of a higher tier methodology. Despite the lack of data, a tier 2 methodology was used in the following subcategories:

- Transport, road transport: the tier 2 methodology was based on the number of vehicles per category and their activity in terms of distance and/or fuel consumption.
- Industrial processes, cement production: the tier 2 methodology was used to calculate $CO_2$ emissions based on detailed information on clinker composition and technology used.
- Land Use, Land Use Change and Forestry (LULUCF): the approach 3 was adopted using change detection mapping, which allowed the generation of detailed data about land use and land use change. In addition, country-specific emission/removal factors were derived from global databases, surveys and expert consultations.

The sectoral activity data were collected from primary sources such as ministries and governmental research institutions and from secondary sources such as international organizations and scientific publications (Table 7). Proxy data, interpolations, extrapolation and estimations were used in the cases of data unavailability.

**Table 7:** Sources of activity data

| Activity data | Main sources of data |
|---|---|
| Energy | Ministry of Energy and Water<br>Ministry of Public Works and Transport<br>International Energy Agency<br>Directorate General of Civil Aviation<br>Ministry of Interior and Municipalities- Traffic, Truck and Vehicle Management Authority<br>Fuel importers |
| Industrial processes | Ministry of Industry<br>Ministry of Economy and Trade<br>Ministry of Agriculture<br>Industries' Syndicates |
| Agriculture | Ministry of Agriculture<br>Directorate General of Customs<br>Food and Agriculture Organization<br>Lebanese Syndicate of Cattle Importers |
| Land-use, land use change and forestry | Ministry of Agriculture<br>Food and Agriculture Organization<br>Satellite Imageries |
| Waste | Ministry of Environment<br>Central Administration of Statistics<br>Council for Development and Reconstruction<br>Waste contractors |

It is to be noted that stakeholder consultation meetings were held for the calculation of the inventory of each sector, in addition to the identification and design of mitigation options and vulnerability assessment. Gender balance in participation to these meetings was almost always met. From the inception meeting of the Third National Communication (8 out of the 13 participants were women), to other sectoral consultation meetings (the LULUCF focus group meeting had 10 women out of 20 participants; the consultations of the vulnerability chapter included 11 women out of 23 experts).

## 3. Lebanon's greenhouse gas inventory in 2012

In 2012, Lebanon emitted 26,333 Gg $CO_2$eq. with the most significant greenhouse gas being carbon dioxide, primarily produced from the burning of fossil fuels. The main contributor to greenhouse gas emissions is the energy production sector with 53% of GHG emissions, followed by the transport sector (23%), waste sector (10.7%) and industrial processes (9.7%). $CO_2$ removals from the land use, land-use change and forestry category amounted to -3,145 Gg $CO_2$, bringing Lebanon's net emissions down to 23,188 Gg $CO_2$eq.

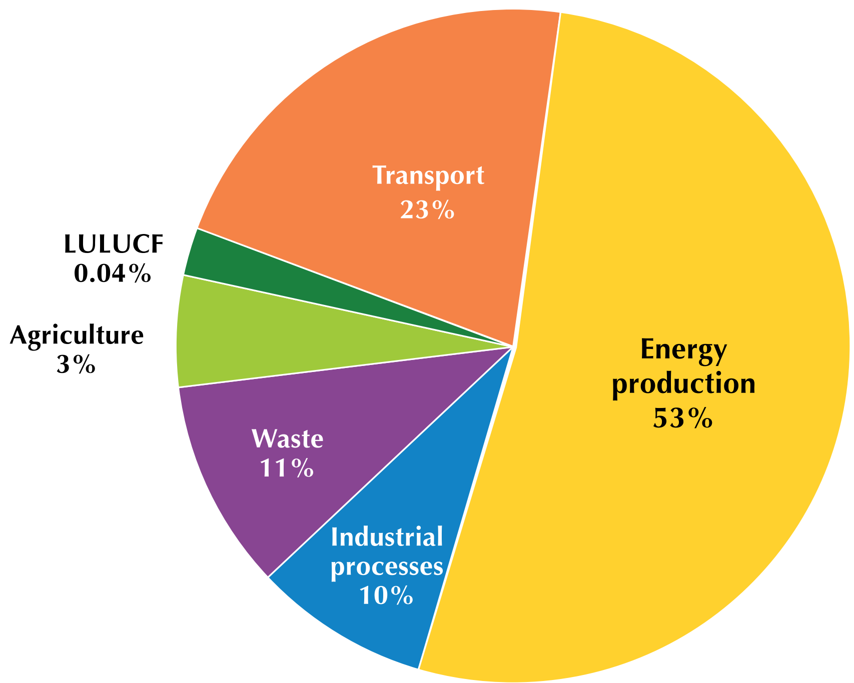



**Figure 12:** Lebanon's greenhouse gas emissions by source for the year 2012

Carbon dioxide is the main emitted gas with 85% of emissions in 2012, while $CH_4$ and $N_2O$ constitute 11.3% and 3.7% respectively. The main contributors of $CO_2$ emissions are energy production and transport with 62% and 26% respectively whereas the waste sector constitutes the main source of $CH_4$ emissions (90%) and agriculture the main source of $N_2O$ (66%).

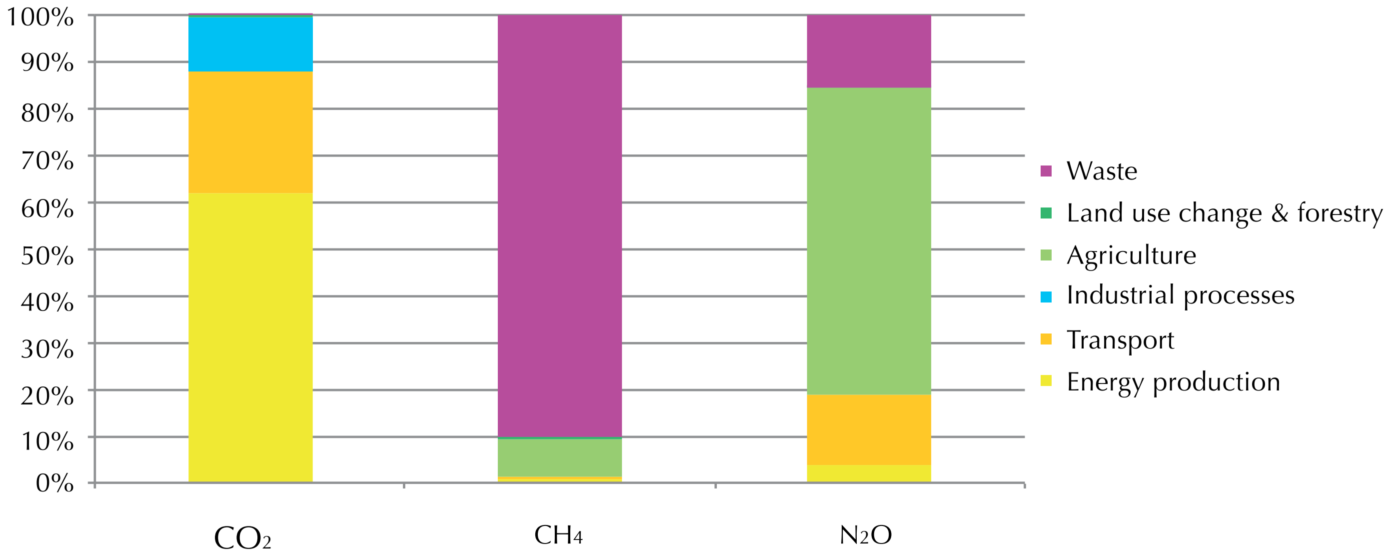



**Figure 13:** Greenhouse gas emissions by gas

Table 8 presents an overview of Lebanon's GHG emissions by category and subcategory for the year 2012. In order to allow the aggregation and total overview of national emissions, emissions of $CH_4$ and $N_2O$ were converted to $CO_2$ equivalent using the 1995 IPCC Global Warming Potential (GWP) values based on the effects of greenhouse gases over a 100-year time horizon ($N_2O$ = 310, $CH_4$ = 21).

**Table 8:** Lebanon's national GHG inventory of anthropogenic emissions by sources and removals by sinks for the year 2012

| Greenhouse gas source and sink categories | $CO_2$ emissions | $CO_2$ removals | $CH_4$ | $CH_4$ | $N_2O$ | $N_2O$ | Total |
|---|---|---|---|---|---|---|---|
| | Gg | Gg | Gg | Gg $CO_2$eq. | Gg | Gg $CO_2$eq. | Gg $CO_2$eq. |
| **Total national emissions & removals** | **22,402.38** | **-3,145.06** | **141.10** | **2,963.18** | **3.12** | **967.33** | **26,332.90** |
| **1 Energy** | **19,736.19** | | **2.11** | **44.31** | **0.58** | **179.80** | **19,960.30** |
| Fuel combustion | 19,736.19 | | 2.11 | 44.31 | 0.58 | 179.80 | 19,960.30 |
| Energy industries | 7,296.67 | | 0.30 | 6.30 | 0.06 | 18.60 | 7,321.57 |
| Manufacturing industries and construction | 3,331.34 | | 0.08 | 1.68 | 0.03 | 9.30 | 3,342.32 |
| Transport | 5,811.95 | | 1.22 | 25.62 | 0.46 | 142.60 | 5,980.17 |
| Other sectors | 3,296.22 | | 0.51 | 10.71 | 0.03 | 9.30 | 3,316.23 |
| Fugitive emissions from fuels | NO | | NO | NO | | NO | - |
| **2 Industrial processes** | **2,557.05** | | **0.00** | **0.00** | **0.00** | **0.00** | **2,557.05** |
| Mineral products | 2,557.05 | | | | | | **2,557.05** |
| Chemical industry | NE | | NE | NE | NE | NE | - |
| Metal production | NE | | NE | NE | NE | NE | - |
| Other production | NA | | NA | NA | NA | NA | - |
| Production of halocarbons & sulphur | | | | | | | |
| Consumption of halocarbons and sulphur | | | | | | | |
| **3 Solvent & other product use** | **NE** | | | **NE** | **NE** | **NE** | - |
| **4 Agriculture** | | | **11.32** | **237.72** | **2.06** | **638.60** | **876.32** |
| Enteric fermentation | | | 9.55 | 200.55 | | | 200.55 |
| Manure management | | | 1.77 | 37.17 | 0.49 | 151.90 | 189.07 |
| Rice cultivation | | | NO | NO | | | 0.00 |
| Agricultural soils | | | | | 1.57 | 486.70 | 486.70 |
| Prescribed burning of savannas | | | NO | NO | NO | NO | - |
| Field burning of agricultural residues | | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **5 Land-use, land use change and forestry** | **108.11** | **-3,145.06** | **0.05** | **1.05** | **0.00** | **0.19** | **109.34** |
| Changes in forest and other woody biomass stocks | 0.00 | | | | | | 0.00 |
| Forest and grassland conversion | NO | NA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Abandonment of managed lands | | NO | | | | | - |
| $CO_2$ emissions & removals from soil | 0.0 | 0.00 | | | | | 0.00 |
| **6 Waste** | **1.05** | | **127.62** | **2,680.10** | **0.48** | **148.75** | **2,829.89** |
| Solid waste disposal on land | 0.00 | | 108.24 | 2,273.04 | | 0.00 | **2,273.04** |
| Wastewater handling | | | 19.38 | 407.06 | 0.48 | 148.75 | **555.81** |
| Waste incineration | 1.05 | | 0.00 | 0.00 | 0.00 | 0.00 | **1.05** |

NA: Not Applicable – NE: Not Estimated – NO: Not Occurring
Numbers reflect rounding

## 3.1 Key category analysis

Key category analysis is performed for both results including and excluding LULUCF in accordance with GPG 2000 guidelines. Key categories under the guidelines are sectors whose emissions when summed in descending order of magnitude, add up to 95% of total greenhouse gas emissions.

Accordingly, the category contributing the most to Lebanon's emissions is energy, which occupies 10 out of the 15 key categories. Fuel consumption in road transport (gasoline) and energy industries (diesel and heavy fuel oil) alone account for 44% of total emissions in 2012. Cement production, solid waste disposal, agricultural soils and wastewater handling have also been identified as key categories, as presented in Table 9.

**Table 9:** Key category analysis for 2012

| Sector | Source categories | Greenhouse gas | Emission estimate (Gg $CO_2$eq.) | Level assessment (%) | Cumulative total (%) |
|---|---|---|---|---|---|
| Energy | Mobile combustion: road vehicles (Gasoline) | $CO_2$ | 4,384 | 17% | 17% |
| Energy | Energy industries (Diesel oil) | $CO_2$ | 4,195 | 16% | 33% |
| Energy | Energy industries (Heavy fuel oil) | $CO_2$ | 3,042 | 12% | 44% |
| Industrial processes | Cement production | $CO_2$ | 2,551 | 10% | 54% |
| Waste | Solid waste disposal sites | $CH_4$ | 2,273 | 9% | 62% |
| Energy | Other sectors: Commercial/ Institutional (Diesel oil) | $CO_2$ | 2,166 | 8% | 71% |
| Energy | Manufacturing industries and construction (Diesel oil) | $CO_2$ | 2,064 | 8% | 79% |
| Energy | Mobile combustion: road vehicles (Diesel oil) | $CO_2$ | 1,420 | 5% | 84% |
| Energy | Manufacturing industries and construction (Petroleum coke) | $CO_2$ | 797 | 3% | 87% |
| Energy | Other sectors: Residential (LPG) | $CO_2$ | 516 | 2% | 89% |
| Agriculture | Agricultural soils (direct and indirect) | $N_2O$ | 487 | 2% | 91% |
| Waste | Wastewater handling | $CH_4$ | 408 | 2% | 92% |
| Energy | Manufacturing industries and construction (Heavy fuel oil) | $CO_2$ | 377 | 1% | 94% |
| Energy | Other sectors: Residential (Diesel oil) | $CO_2$ | 262 | 1% | 95% |

## 4. GHG emissions by sector

### 4.1 Energy

In 2012, the energy sector's greenhouse gas emissions were estimated at 19.9 million tonnes $CO_2$eq., representing around 76% of the total greenhouse gas emissions in Lebanon, which reflects Lebanon's heavy reliance on imported petroleum products to meet its energy requirements. Energy is mainly responsible for carbon dioxide emissions (98.88%), and public power generation (referred to as energy industries) is the main source of emissions, followed by land transport.

Emissions from the energy sector are mainly generated by the combustion of fossil fuel (gasoline, gas/diesel oil, fuel oil, jet kerosene, Liquefied Petroleum Gas (LPG), and petcoke) which are divided in two main categories, according to the IPCC methodology:

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

**Table 10:** Energy sector - stationary combustion subcategories

| |
|---|
| **Energy industries** comprise emissions from fuel combustion for electricity generation from main electricity producers, mainly public entities. In Lebanon, this category includes all thermal power plants of Electricité du Liban. |
| **Manufacturing industries and construction** comprise emissions from combustion of fuels for electricity or heat generation for own use in industries. In Lebanon, emissions from community-based generators are accounted under this category. |
| **Transport** comprises emissions from gasoline and diesel oil combustion in road transport, civil aviation and domestic navigation. Emissions from international aviation and navigation are not accounted under national emissions, but are reported separately as international bunkers. |
| **Commercial, institutional sector** comprise emissions from fuel combustion for electricity generation, space heating and cooking activities in commercial, institutional buildings. |
| **Residential sector** comprise emissions from fuel combustion for space heating and cooking activities. |
| **Agriculture, forestry and fisheries** comprise both stationary and mobile emissions from fuel combustion in agriculture, forestry and fishing. Related activities include fish farms, water pumps, grain drying, agricultural greenhouses, traction vehicles on farmland and in forest in addition to inland, coastal and deep-sea fishing. |

**Table 11:** GHG emissions from energy by source category and gas for 2012

| Categories | Emissions | | | |
|---|---|---|---|---|
| | $CO_2$ (Gg) | $CH_4$ (Gg) | $N_2O$ (Gg) | Total (Gg $CO_2$eq.) |
| **Total energy** | 19,736.19 | 2.11 | 0.58 | 19,960.30 |
| Energy industries | 7,296.67 | 0.30 | 0.06 | 7,321.57 |
| Manufacturing energy and construction | 3,331.34 | 0.08 | 0.03 | 3,342.32 |
| Transport | 5,811.96 | 1.22 | 0.46 | 5,980.17 |
| Other sectors | 3,296.22 | 0.51 | 0.03 | 3,316.23 |
| *Commercial/Institutional* | 2,273.58 | 0.31 | 0.02 | 2,286 |
| *Residential* | 778.44 | 0.16 | 0.01 | 785 |
| *Agriculture/Fishing/Forestry* | 244.20 | 0.04 | 0.00 | 245 |

*Numbers may reflect rounding.*
*Details on activity data, emission factors and calculation methodology are available in MoE/UNDP/GEF, 2015a and MoE/UNDP/GEF, 2015b*

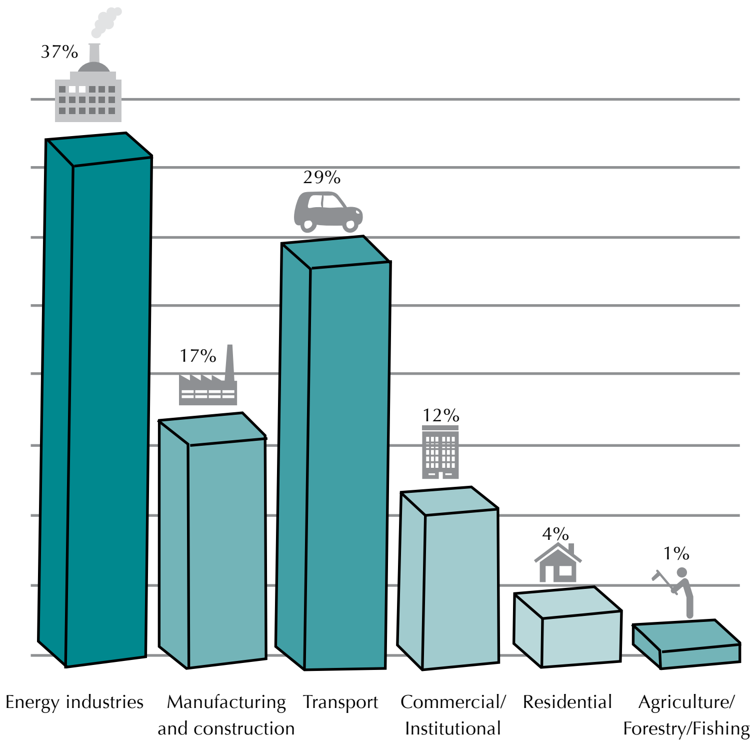



**Figure 14:** Contribution of energy emission sources to the sector's total for 2012

### *Energy industries*

The energy sector in Lebanon relies mainly on fossil fuel combustion for meeting the bulk of energy requirements of the country. More than 87% of imported fuel oil and 40% of imported gas diesel oil are used in thermal power plants for public electricity generation, thus making energy industries, the main source of emissions with around 37% of the energy sector's emissions and 28% of total national emissions. Due to the age, low efficiency and low maintenance of the thermal power plants, the energy sector is characterized by a high emission intensity of 847 tonnes $CO_2$eq. per GWh of electricity produced as an average (emissions from power plants, at gate).

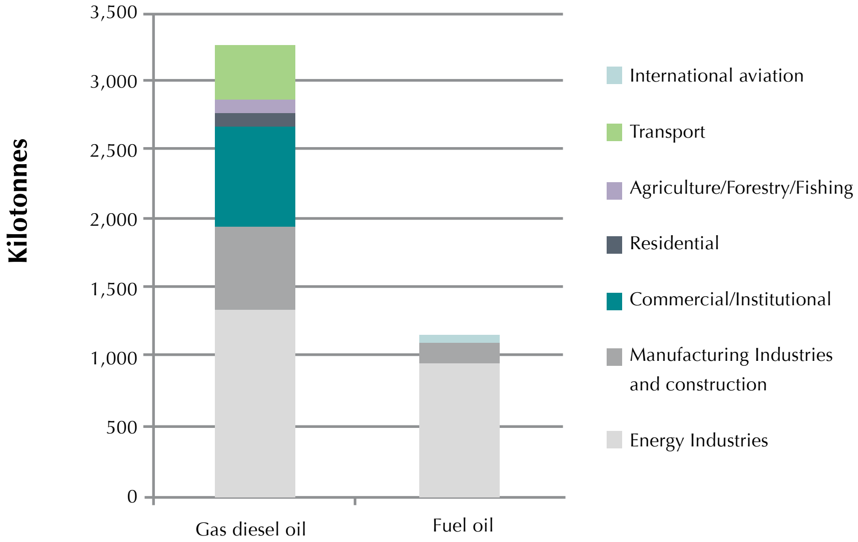



**Figure 15:** Amount of gas diesel oil and fuel oil consumed per subcategory in 2012

**Table 12:** Fuel consumption and GHG emissions from energy industries in 2012

| Fuel type | Quantity (1,000 tonnes) | Net Calorific Values (TJ/1000 tonnes) | Emission factor (tC/TJ) | Fraction of Carbon oxidized | Fraction of Carbon stored | $CO_2$ emissions (Gg $CO_2$) |
|---|---|---|---|---|---|---|
| Heavy fuel oil | 988.36 | 40.19 | 21.1 | 0.99 | 0 | 3,042.44 |
| Gas diesel oil | 1,320.20 | 43.33 | 20.2 | 0.99 | 0 | 4,194.56 |
| Lubricants | 40.9 | 40.19 | 20 | 0.99 | 0.5 | 59.67 |

### *Transport*

Transport is also considered a main source of emissions in Lebanon, emitting in 2012 about 5,980 Gg $CO_2$eq., with road transport accounting for 99% of emissions. Indeed, with a modest domestic aviation and navigation activity, road transport constitutes the leading source of GHG emissions, consuming all gasoline and 14%[2] of gas diesel oil imported to Lebanon. The contribution of the

different vehicle categories to emissions of direct GHG emissions shows that passenger private cars contribute the most, followed by heavy duty vehicles. For the first time, the tier 2 methodology was used to calculate emissions from transport, taking into account all categories of vehicles (Table 14) and the level of emission control technology in each vehicle. Further details on the methodology used and emission results are available on MoE/UNDP/GEF, 2015b.

**Table 13:** Reporting categories investigated in the inventory of the Lebanese transport sector

| Reporting categories | Description | Remarks | Methodology |
|---|---|---|---|
| Aviation | Military helicopters; civil, commercial aircrafts; and private jet- and propeller-type aircrafts. | Emissions from military aircrafts are not calculated due to the confidentiality of activity data. | Civil, private and commercial aircrafts emissions are calculated based on the tier 1 methodology. |
| Maritime transport | Domestic navigation between local ports, fisheries and international navigation. | Emissions from military navigation are not calculated due to the confidentiality of activity data.<br>Emissions from fisheries are not reported under this category. They are rather reported under the agriculture/forestry/fisheries category of the energy sector. | International navigation from marine bunkers and national navigation from fishing boats and yachts were calculated based on the tier 1 methodology. |
| Road transport vehicles | Motorcycles, passenger cars, vans, buses and trucks. | Road transport is the only mobility mean considered under land transport as the entire rail network is derelict. | Emissions are estimated using the tier 2 methodology. |

GHG emissions from domestic aviation are not significant contributing only to 0.12% of emissions from transport. In Lebanon, domestic flights consist of the limited usage of small propeller-type aircrafts, used only for training. The fleet includes around 5 Cessna aircrafts operating on gasoline with an annual consumption ranging between 2 and 3 ktonnes.

As for maritime transport, due to national security issues, no data was made available on the fuel consumption for military navigation, therefore emissions are limited to the activity of fishing boats, which is accounted under the category agriculture/forestry/fisheries, and consequently, their emissions are not reported under the transport sector.

[2] 14% is the average percent of Diesel Oil (DO) consumption of the fleet in Lebanon (total DO-fuel vehicles/DO consumption per vehicle) for the period 2005-2012.

**Table 14:** Description of the vehicles categories used in the calculation of road transport emissions

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

**Table 15:** Fuel consumption and GHG emissions from the transport sector in 2012

| | Fuel type | Quantity (1,000 tonnes) | $CO_2$ emissions (Gg $CO_2$) |
|---|---|---|---|
| Road Transport | Gasoline | 1,682.00 | 5,804.00 |
| | Gas diesel oil | 457.63 | |
| National aviation | Gasoline | 2.50 | 7.68 |

### *Manufacturing industries and construction*

Activities related to manufacturing industries and construction are considered important sources of GHG emissions, mainly caused by the high consumption of residual fuel oil, gas diesel oil and LPG for electricity and heat production in addition to the consumption of petroleum coke in cement industries. Combustion of these fuels generated 3,342 Gg $CO_2$eq. in 2012, comprising 16.7% of total emissions from the energy sector, and 12.3% of total national GHG emissions.

In fact, 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. Since no data is available on the amount of fuel used in industries to produce electricity, it is assumed that the gap between public electricity supply and demand in Lebanon is being met at 80%, by manufacturing industries, in addition to community-based generators and commercial institutions' generators.

### *Other sectors*

In 2012, fuel combustion in the commercial/ institutional sector (hotels, schools, universities, retail shops, commercial centers, etc.), residential sector and agriculture/ forestry/ fisheries emitted 3,316.23 Gg of $CO_2$eq. Different types of fuel are considered under this category and are used for electricity generation, cooking, water and space heating, fishing and other related activities.

However, fuel used for electricity generation is the main source of GHG emissions from this subcategory. Indeed, due to constant power shortages, community-based back-up generators have flourished in Lebanon, supplying electricity to households and commercial institutions during cut-off hours, which range from 3 to 15 hours a day depending on the region.

**Table 16:** Fuel consumption and GHG emissions from manufacturing industries and construction in 2012

| Fuel type | Quantity (1,000 tonnes) | Net Calorific Values (TJ/1000t) | Emission factor (tC/TJ) | Fraction of Carbon oxidized | Fraction of Carbon stored | $CO_2$ emissions (Gg $CO_2$) |
|---|---|---|---|---|---|---|
| Heavy fuel oil | 122.53 | 40.19 | 21.1 | 0.99 | 0 | 377.18 |
| Gas diesel oil | 649.66 | 43.33 | 20.2 | 0.99 | 0 | 2,064.11 |
| LPG | 31.55 | 47.31 | 17.2 | 0.99 | 0 | 93.19 |
| Petroleum coke | 257.5 | 31 | 27.5 | 0.99 | 0 | 796.85 |

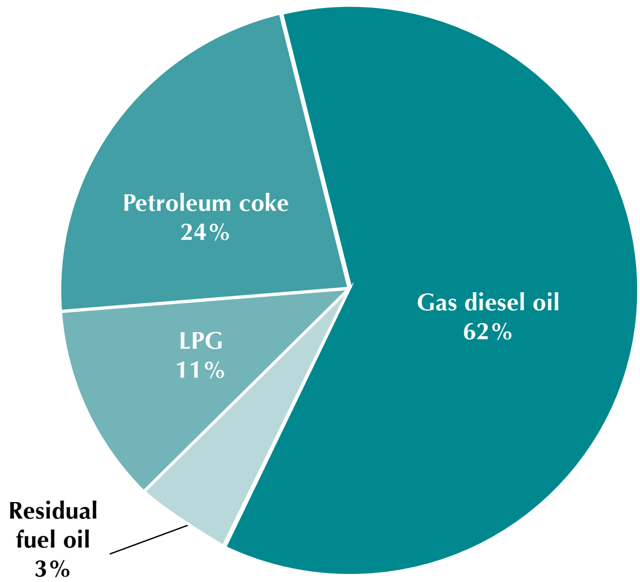



**Figure 16:** Share of GHG emissions by fuel type under manufacturing industries and construction

### *Comparison between the sectoral approach and the reference approach*

According to the IPCC guidelines, carbon dioxide emissions from the energy sector should be calculated using both the reference and the sectoral approach. The reference approach is based on detailed data on primary energy consumption, which leads to the calculation of apparent consumption of fuel, while the sectoral approach is based on a detailed disaggregation of energy consumption by sector and fuel for the calculation of $CO_2$ emissions. The application

of the reference approach can be considered as a quality control procedure, as the deviation of estimations should not be significant (deviations in the order of ±2%).

In Lebanon, carbon dioxide emissions for the energy sector are calculated according to the two methodologies. The difference between the 2 approaches is -3.76%, which is slightly above the threshold defined by the IPCC guidelines. The existing difference results mainly from statistical differences in fuel consumption and the use of tier 2 methodology in the transport sector.

**Table 17:** Fuel consumption and GHG emissions from other sectors in 2012

| Fuel type | Commercial/institutional | | Residential | | Agriculture/forestry/fisheries | |
|---|---|---|---|---|---|---|
| | Quantity (1,000 tonnes) | $CO_2$ emissions (Gg $CO_2$) | Quantity (1,000 tonnes) | $CO_2$ emissions (Gg $CO_2$) | Quantity (1,000 tonnes) | $CO_2$ emissions (Gg $CO_2$) |
| Gas diesel oil | 681.75 | 2,166.07 | 82.56 | 262.31 | 76.86 | 244.20 |
| LPG | 36.4 | 107.52 | 174.73 | 516.13 | | |

**Table 18:** Difference between the reference and sectoral approach for 2012

| | $CO_2$ emissions (Gg) | Difference |
|---|---|---|
| Reference approach | 20,506.94 | -3.76% |
| Sectoral approach | 19,736.19 | |

### *International bunkers*

For international bunkers, the total direct GHG emissions from aviation and marine amounted to 738 Gg of $CO_2$ in 2012. Around 88% of these direct GHG emissions originated from international aviation. As per the IPCC guidelines, emissions from international aviation and maritime transport (also known as international bunker fuel emissions) should be calculated as part of the national GHG inventories of Parties, but should be excluded from national totals and reported separately. These emissions are not subject to the limitation and reduction commitments under the Convention.

**Table 19:** Direct GHG emissions from international bunkers for 2012

| Category | $CO_2$ emissions (Gg) |
|---|---|
| Aviation bunkers | 654 |
| Marine bunkers | 83 |

*Numbers may reflect rounding.*

## 4.2 Industrial processes and products use

Emissions from industrial processes in Lebanon were estimated at 2,557 Gg $CO_2$ in 2012, representing 9.7% of national emissions. Cement industries are the main contributors to GHG emissions from this sector (over 99%), since Lebanon does not have other mineral, chemical and metal industries that emit greenhouse gases (Table 20). The Lebanese industrial sector is characterized with small to medium enterprises that generate more air pollutants (mainly NMVOCs and $SO_2$) than greenhouse gas emissions.

**Table 20:** Potential emissions from industrial processes

| Categories | $CO_2$ | $CH_4$ | $N_2O$ | $NO_x$ | NMVOC | CO | $SO_2$ | PFC | $SF_6$ | HFC |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mineral products** | | | | | | | | | | |
| Cement production | x | | | | | | x | | | |
| Lime production | x | | | | | | x | | | |
| Limestone and dolomite use | x | | | | | | | | | |
| Soda ash production and use | x | | | | | | | | | |
| Asphalt roofing | | | | | x | x | | | | |
| Road paving with asphalt | | | | x | x | x | x | | | |
| Other (glass production, concrete pumice stone) | x | | | x | x | x | x | | | |
| **Chemical industry** | | | | | | | | | | |
| Ammonia production | x | | | x | x | x | x | | | |
| Nitric acid production | | | x | x | | | | | | |
| Adipic acid production | | | x | x | x | x | | | | |
| Urea production | | | x | | | | | | | |
| Carbide production | x | x | | | x | x | x | | | |
| Petrochemicals | | x | x | | x | | x | | | x |
| **Metal production** | | | | | | | | | | |
| Iron, steel and ferroalloys production | x | x | | x | x | x | x | | | |
| Aluminium foundries | x | x | | x | x | x | x | x | x | |
| Magnesium | | | | x | x | x | x | | x | |
| **Other** | | | | | | | | | | |
| Pulp and paper | | | | x | x | | | | | |
| Food and drink | | | | | x | | | | | |
| Production of Halocarbons and Sulphur Hexafluoride | | | | | | | | x | x | x |
| Consumption of Halocarbons and Sulphur Hexafluoride | | | | | | | | x | x | x |

Source| IPCC, 1997

Cement industries have generated around 2,550 Gg $CO_2$ in 2012, mainly due to significant amount of clinker that was produced during this year to cope with the booming in the construction activities in Lebanon. Indeed, according to data from the Lebanese Order of Engineers, the surface area of new construction permits reached 16.5 million $m^2$ in 2011, constituting an increase of 144.8% from the 6.7 million $m^2$ in 2000.

GHG emissions from other industrial activities are negligible and are mainly generated from lime production (2.76 Gg $CO_2$) and the use of soda ash (3.6 Gg $CO_2$). Lime production is not a major industrial activity in Lebanon although it does contribute to GHG emissions from its manufacturing processes. There is only one plant that produces lime as a final product. The remaining production is covered in cement industries and used directly in the manufacturing process. Therefore, their related emissions are accounted for under cement and not lime production.

As for emissions originating from the use of soda ash, these are mainly caused by glass manufacturing, soap and detergents manufacturing as well as water treatment. No disaggregate information is available to allocate emissions to each of these industries.

**Table 21:** Industrial production and GHG emissions in 2012

| Industrial process | Quantity (tonnes) | Emission factor (tonnes $CO_2$/tonnes product) | $CO_2$ emissions (Gg $CO_2$) |
|---|---|---|---|
| Clinker production | 4,903,268 | 0.52 | 2,550.68 |
| Lime production | 3,500 | 0.79 | 2.7 |
| Soda ash use | 8,685 | 0.415 | 3.6 |

*Details on activity data, emission factors and calculation methodology are available in MoE/UNDP/GEF, 2015c*

Emissions from some categories were not estimated due to the absence of reliable activity data (namely glass production and phosphate fertilizers). However, it is assumed that these will not impact highly the overall GHG emissions from the sector, as the quantity produced is believed to be minimal compared to the highest emitter, i.e., cement industries. On the other hand, emissions from the consumption of halocarbons and $SF_6$, which have a high Global Warming Potential (GWP), may significantly affect the overall emissions from the sector in terms $CO_2$ equivalent, even with small quantities. However, national consumption of halocarbons and $SF_6$ could not be determined for this inventory due to absence of national data.

## 4.3 Agriculture

In 2012, agricultural activities in Lebanon contributed to 3.3% of national emissions, with 876.32 Gg $CO_2$eq. Emissions of greenhouse gases in Lebanon originate mainly from agricultural soils (55%) and from domestic livestock through enteric fermentation (23%) and manure management (22%). In this report, it is assumed that burning of agricultural residues is not practiced anymore in Lebanon, at least during the period 2005-2012, therefore emissions of $CO_2$ did not occur from this sector.

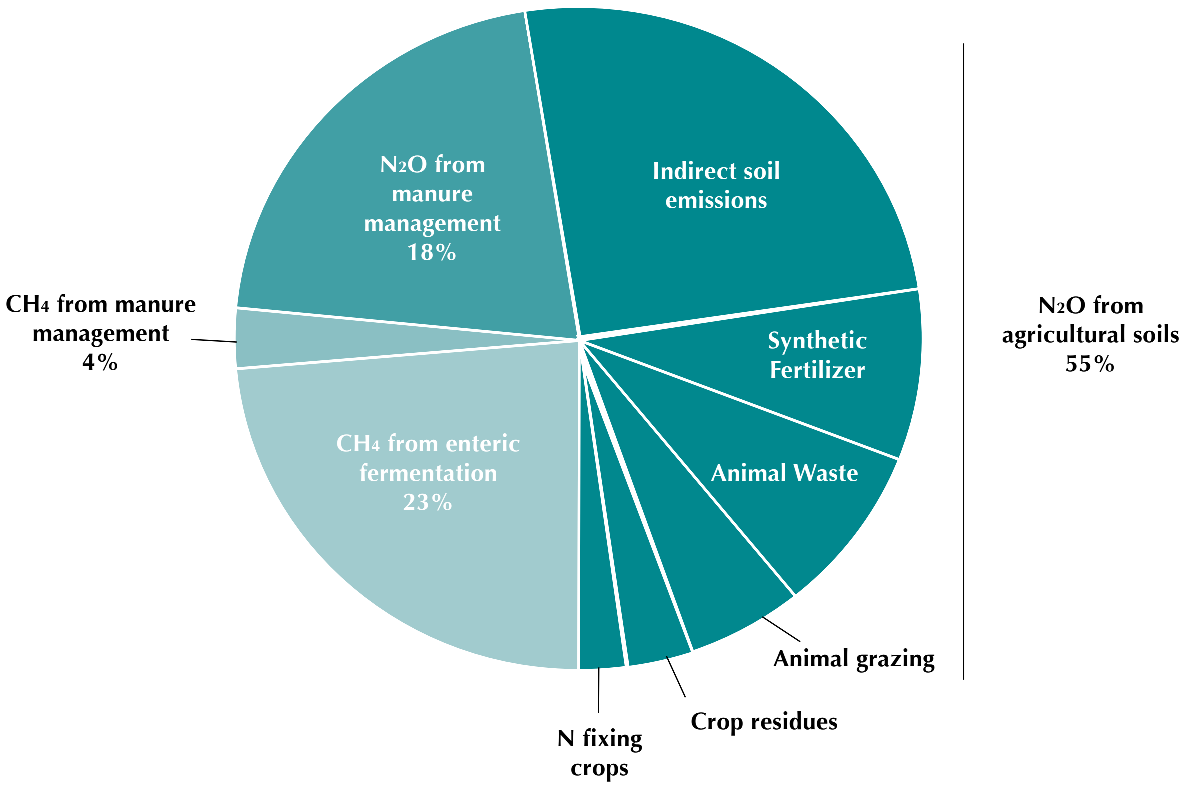



**Figure 17:** Sources of GHG emissions from the agricultural sector in Lebanon

**Table 22:** GHG emissions by agricultural source

| Source of emissions | $CH_4$ emissions (Gg $CO_2$eq.) | % total from agriculture | $N_2O$ emissions (Gg $CO_2$eq.) | % of total from agriculture |
|---|---|---|---|---|
| Agricultural soils | - | - | 486.7 | 55% |
| Enteric fermentation | 200.55 | 23% | - | - |
| Manure management | 37.17 | 4% | 151.9 | 18% |
| Total emissions from agriculture (Gg $CO_2$eq.) | | | | 876.32 |

*Details on activity data, emission factors and calculation methodology are available in MoE/UNDP/GEF, 2015d*

### *Agricultural soils*

Emissions of $N_2O$ from agricultural soils are primarily due to the microbial processes of nitrification and denitrification in the soil. They can either be direct emissions from the application of nitrogen compounds to the soil, or indirect from the transformation of nitrogen compounds in the air and water or from animal grazing.

Direct emissions from agricultural soils originate from 4 sources: the application of synthetic nitrogen fertilizers, crop residues and animal manure to soils in addition to biological nitrogen fixation in crops. Direct emissions from agricultural soils represent 26% of total emissions from agriculture and are mainly a result of the use of synthetic fertilizers (11%) and animal waste (9%) in the soil.

Indirect emissions from agricultural soils are due to the transformation of Nitrogen compounds into $N_2O$, mainly caused by the atmospheric deposition of $NH_3$ and NOx and the leaching and runoff of nitrogen. Atmospheric deposition of nitrogen compounds fertilizes soils resulting in enhanced biogenic $N_2O$ formation while the leached nitrogen enters the groundwater, riparian areas, and rivers where it enhances biogenic production of $N_2O$. Indirect emissions in 2012 from leaching constitute a larger fraction (83%) than atmospheric deposition (17%).

Emissions from animal grazing are not significant due to the decline of pasture productivity in the country and the reduction in grazing sheep and goat populations, especially with the drier conditions that Lebanon is experiencing due to climate change.

As shown in Table 23, total emissions from agricultural soils amounted to 486.7 Gg $CO_2$eq. representing 55% of total agricultural emissions in 2012. Almost 48% of total $N_2O$ emissions from soils are due to direct emissions, while indirect emissions are 39%, and emissions from grazing are 13%.

**Table 23:** Total emissions from agricultural soils and its subcategories

| Agricultural soils | Gg $CO_2$eq. | % total |
|---|---|---|
| Total direct emissions | 232.50 | 48% |
| Total indirect emissions | 189.99 | 39% |
| Emissions from animal grazing | 65.10 | 13% |
| Total emissions[1] | 486.70 | |

*[1] Total emissions may not match the sum of individual categories due to rounding errors*

### *Enteric fermentation in domestic livestock*

Methane from enteric fermentation is produced by herbivores as a by-product of the digestive process. The amount of enteric methane emitted is driven primarily by the number of animals, the type of the digestive system and the type and amount of feed consumed. Cattle are usually an important source of $CH_4$ because of their large population and high $CH_4$ emissions rate due to their ruminant digestive system. In Lebanon, $CH_4$ emissions from dairy and non-dairy cattle account for 62% of emissions and from sheep and goats 34%.

**Table 24:** Livestock and methane emissions from enteric fermentation in 2012

| Species | Animal population (heads) | Emission factors (kg $CH_4$/head/year) | $CH_4$ emissions (Gg) |
|---|---|---|---|
| Dairy cattle | 42,000 | 100 | 4.20 |
| Non-dairy cattle | 36,900 | 48 | 1.77 |
| Sheep | 258,000 | 5 | 1.29 |
| Goats | 398,000 | 5 | 1.99 |
| Camels | 450 | 46 | 0.02 |
| Horses | 3,650 | 18 | 0.07 |
| Mules and asses | 20,000 | 10 | 0.20 |
| Swine | 7,800 | 1 | 0.01 |
| Poultry | 17,166,450 | 0 | 0.00 |
| Total $CH_4$ (Gg) | | | 9.55 |
| Total $CO_2$eq. (Gg) | | | 200.55 |

### *Manure management*

The management of animal manure emits significant amounts of methane and nitrous oxides. In 2012, these emissions contributed to 189.07 Gg of $CO_2$eq., which constitutes 21.6% of the GHG emissions from the agriculture sector. Nitrous oxide emissions represent 80% of these emissions (151.9 Gg $CO_2$eq.), while methane emissions represent 20%.

Methane emissions are produced as a result of the decomposition of manure under anaerobic conditions, which often occurs when a large number of animals are managed in a confined area.

Nitrous oxide emissions are produced during the storage of manure, where nitrogen is converted into $N_2O$ and released into the atmosphere. These emissions depend largely on how the manure for each animal species is managed. In Lebanon, it is estimated that cattle manure is largely managed in solid storage and drylot, whereas sheep and goats manure is distributed between pasture, range, paddock (67%), solid storage and drylot (33%). Poultry manure is mainly managed with bedding (77%) and to a lesser extent without bedding (19%) (traditional chicken manure is included under pasture, range and paddock). Note that emissions from daily spread and from pasture, range and paddock are considered under emissions from agricultural soils and therefore not included in the calculations of $N_2O$ emissions from manure management.

**Table 25:** Types of manure management systems

| | |
|---|---|
| Anaerobic lagoons | Anaerobic lagoon systems are characterized by flush systems that use water to transport manure to lagoons. The manure resides in the lagoon for periods from 30 days to over 200 days. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields. |
| Liquid/slurry system | These systems are characterized by large concrete lined tanks built into the ground. Manure is stored in the tank for 6 or more months until it can be applied to fields. To facilitate handling as a liquid, water may be added to the manure. |
| Solid storage | Manure is collected in solid form by some means such as scraping. It is stored in bulk for a long period of time (months) before any disposal. |
| Drylot | In dry climates, animals may be kept on unpaved feedlots where the manure is allowed to dry until it is periodically removed. Upon removal, the manure may be spread on fields. |
| Poultry manure with bedding | Manure is excreted on floor with bedding. Birds walk on waste. |
| Poultry manure without bedding | Manure is excreted on floor without bedding. Birds do not walk on waste. |
| Daily spread | Manure is collected in solid form by some means such as scraping. The collected manure is applied to fields regularly (usually daily). |
| Pasture, range and paddock | The manure from pasture and range grazing animals is allowed to lie as is, and is not managed. |

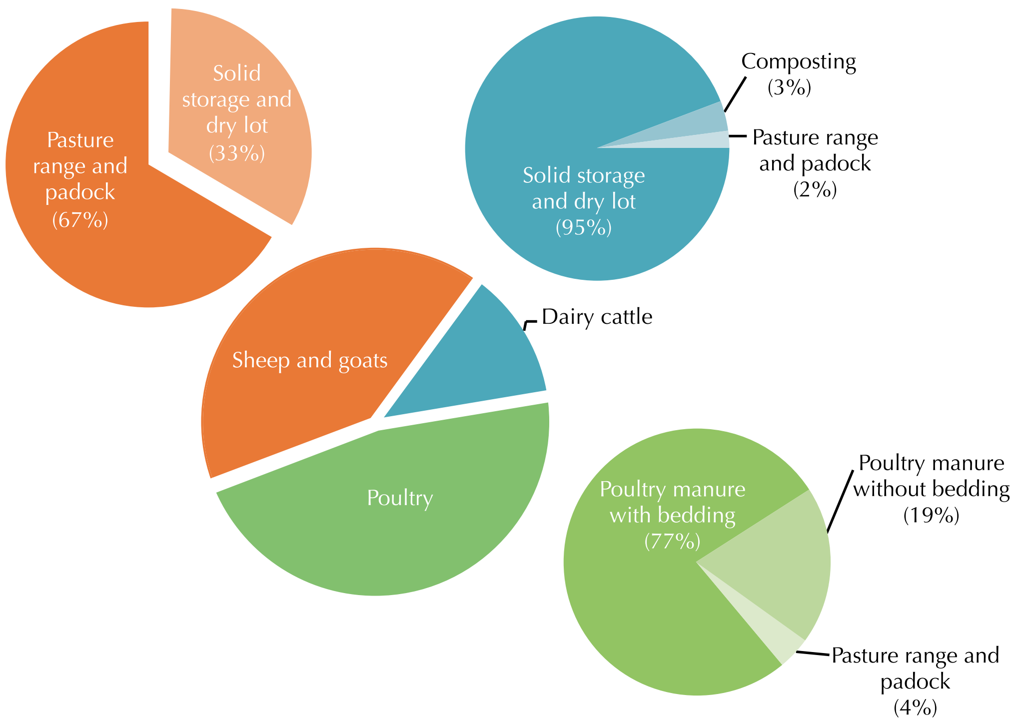



**Figure 18:** Manure management systems utilized for major animal species

**Table 26:** Amount of nitrogen excreted from animals in different manure management systems in 2012

| Manure Management System (MMS) | Amount of Nitrogen kg N/year | Emission factor for each MMS (kg $N_2O$-N/kgN) | Emissions in kg $N_2O$ |
|---|---|---|---|
| Anaerobic lagoons | 29,400.00 | 0.001 | 46.20 |
| Liquid system | 14,700.00 | 0.001 | 23.10 |
| Solid storage and dry lot | 7,362,906.03 | 0.02 | 231,405 |
| Poultry manure without bedding | 1,956,975.41 | 0.005 | 15,376 |
| Poultry manure with bedding | 7,892,684.18 | 0.02 | 248,055 |
| Total | 17,256,665.62 | | 494,906 |
| Daily spread | 41,880.00 | Emissions are considered under agricultural soils and therefore not included in the calculations of $N_2O$ emissions from manure management | |
| Pasture, range and paddock | 6,709,034.82 | | |

## 4.4 Land use, land use change and forestry

The Land Use, Land Use Change (LULUCF) is an inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities. The changes in the use of land have impacts on the global carbon cycle and as such, can add or remove carbon from the atmosphere, influencing climate. Accordingly, this inventory examines changes in carbon stocks from biomass losses and increments and from variation in soil carbon stocks from the different land use change categories.

**Table 27:** Causes of GHG emissions and removals reported for LULUCF in Lebanon.

| Biomass losses | Biomass increments | Increase in soil carbon stocks and litter |
|---|---|---|
| - Forest converted to settlement<br>- Grassland converted to settlement<br>- Cropland converted to settlement<br>- Burned forest lands<br>- Burned cropland(perennial crops)<br>- Burned grassland<br>- Fuelwood gathering from forests | - Growth of forest lands<br>- Growth of cropland (perennial crops)<br>- Growth of lands converted to forests or plantations (afforestation) | - Afforestation |

In 2012, LULUCF acted as a greenhouse gas sink in Lebanon, with net removals equal to -3,145 Gg $CO_2$. Indeed Lebanon's forest cover still represents a significant $CO_2$ sink, although a downward

trend in sink capacities has been observed in recent years due to deforestation, forest fires and most importantly, urbanization.

Greenhouse gas removals are mainly attributed to the growth of forest plantations from existing forest lands (about -2,151.7 Gg $CO_2$), and existing croplands (-914.4 Gg $CO_2$) complemented by afforestation activities (-78.95 Gg $CO_2$). Wildfires ($CH_4$ and $N_2O$ emissions), urbanization and fuelwood gathering contribute to decreasing the removal potential of the LULUCF sector 109.41 Gg $CO_2$eq. in 2012.

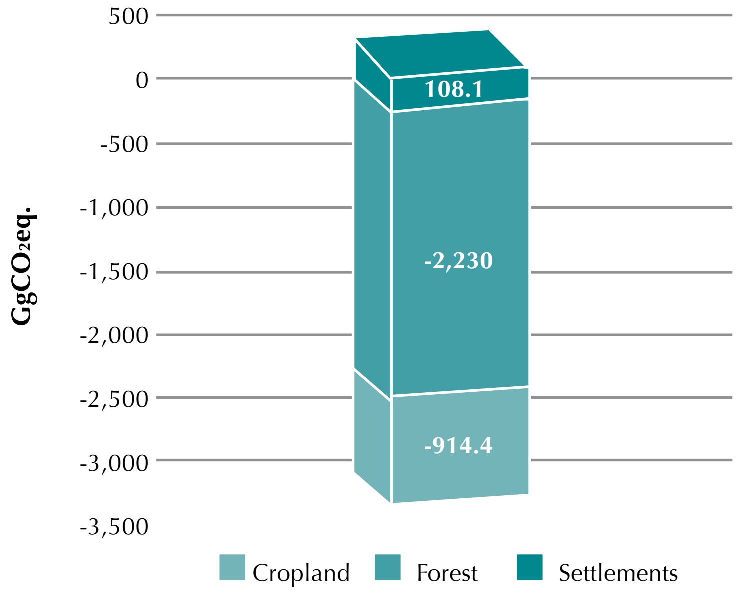



**Figure 19:** $CO_2$ emissions/removals by category in 2012

A new methodology (IPCC, 2003) was adopted for the calculation of emissions/removals from LULUCF based on recent available data and a more detailed approach. The improvement in the methodology for activity data collection (the use of periodical and sometimes multi-temporal satellite and remote sensing data) resulted in country-specific estimates in comparison with previous inventories, which used rough estimates from global and national databases and literature. The representation of most land-use areas and land conversions was done following the approach 3 which is a tier 3 level methodology that is the most complex, accurate and spatially explicit calculation method available. Data was collected using satellite remote sensing (5 SPOT imagery -2.5 m and 30 Landsat TM and ETM+ imagery -25 m) and Geographic Information System (GIS) techniques, literature reviews, and surveys. Details on activity data, emission factors and calculation methodology are available in MoE/UNDP/GEF, 2015e.

**Table 28:** Lebanon's GHG emissions/removals summary from the LULUCF sector for 2012

| | $CO_2$ emissions Gg | $CO_2$ removals Gg | $CH_4$ emissions Gg | $N_2O$ emissions Gg | Total emissions Gg $CO_2$eq. |
|---|---|---|---|---|---|
| **Land use, land use change and forestry** | **108.10** | **-3,145.06** | **0.05** | **0.0007** | **-3,035.71** |
| **A. Forest land** | **0.00** | **-2,230.65** | **0.048** | **0.0006** | **-2,229.46** |
| 1. Forest land remaining forest land | | -2,151.70 | | | -2,151.70 |
| 2. Land converted to forest land | | -78.95 | | | -78.95 |
| **B. Cropland** | **0.00** | **-914.41** | | | -914.35 |
| 1. Cropland remaining cropland | | -914.41 | | | -914.41 |
| 2. Land converted to cropland | | | | | |
| **C. Grassland** | **0.00** | **0.00** | **0.002** | **0.0001** | 0.06 |
| 1. Grassland remaining grassland | | | | | |
| 2. Land converted to grassland | | | | | |
| **D. Wetlands** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| 1. Wetlands remaining wetlands | | | | | |
| 2. Land converted to wetlands | | | | | |
| **E. Settlements** | **108.10** | **0.00** | **0.00** | **0.00** | **108.10** |
| 1. Settlements remaining settlements | | | | | |
| 2. Forestland converted to settlements | 69.30 | | | | 69.30 |
| 3. Cropland converted to settlements | 38.30 | | | | 38.30 |
| 4. Grassland converted to settlements | 0.50 | | | | 0.50 |

*Results reflect calculations of emissions from LULUCF based on 2003 GPG for LULUCF*
*Numbers may reflect rounding.*

The inventory results show that in 2012, forests had the largest contribution to $CO_2$ removals. However, further data (when available) on areas of wetlands (namely hill lakes) and grassland along with their management systems (e.g. status of grazing) can help in providing new insights on their level of contribution in GHG emissions or removals in the future.

The changes in land cover/land-use show that emissions from land conversions, burning of biomass and fuelwood gathering are much higher than the removals caused by the growth of new plantations (afforestation). Although net emissions/removals proved that LULUCF is a major sink, emissions from changes in LULUCF were still high and could not be compensated by the afforestation activities.

### *Biomass losses*

The amounts of biomass loss observed in 2012 are mainly attributed to the change in vegetation cover within forestlands, cropland, and grassland. For instance, areas of lands converted to settlements were estimated at almost 943 hectares in 2012, which can be mainly attributed to the growth of the real estate sector and infrastructural developments such as expansion of the road networks and development of areas of public and private services.

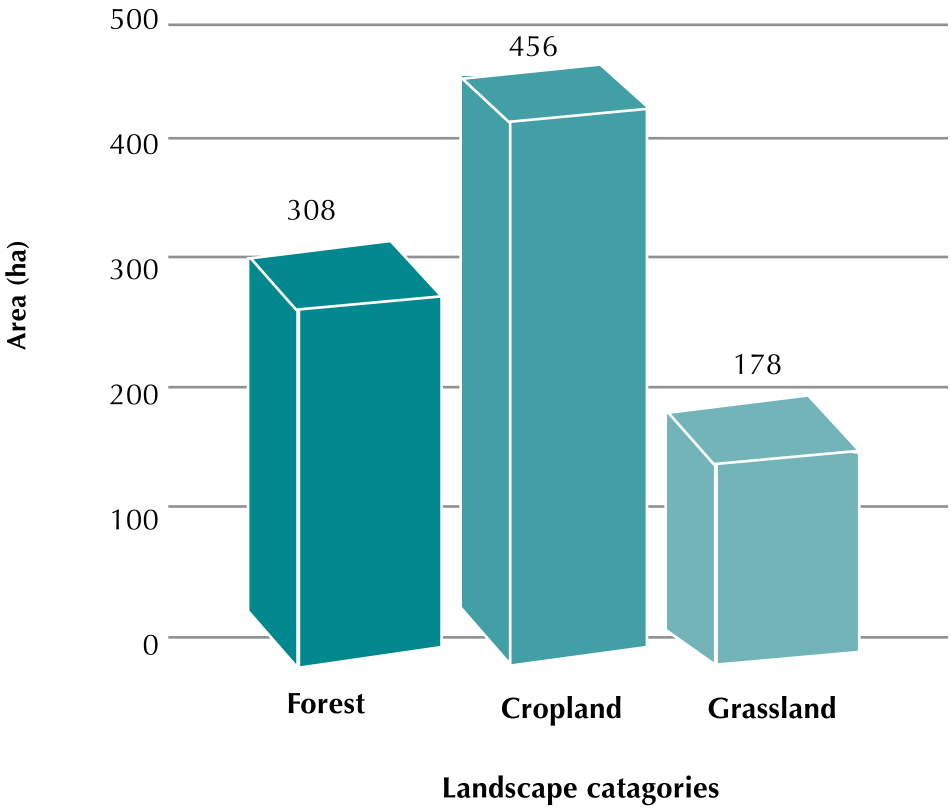



**Figure 20:** Areas of land categories converted to settlements in 2012

As shown in Figure 20, settlements mainly replaced cropland and grassland due to the lack of interest of owners in keeping such type of lands. Indeed, the increased demand for housing resulted in an increase in land prices which was ironically faced by high costs of farming labor and the downsizing of the market for agricultural products.

Forestlands were also lost at the expense of settlements, where broadleaf forests, being the dominant type in Lebanon, were the most affected.

In 2012, 308 ha were lost from forestlands due to urbanization, resulting in a decrease in $CO_2$ removals by 2 Gg and 456 ha were lost from cropland areas covered with perennial woody crops further decreasing decrease $CO_2$ removals by 6 Gg.

Biomass loss is also due to wildfires, which is a main source of the decrease of green areas in Lebanon. In 2012, wildfires affected mainly croplands and grassland, with only 28% of fires hitting forests, especially that 2012 recorded the largest cropland fire in 15 years (1,305 ha). These burning of biomass decreased $CO_2$ removals by 380 Gg through the loss of forest and cropland.

As per the IPCC guidelines, it is assumed that no $CO_2$ is directly emitted from wildfires. Only emissions of $CH_4$ and $N_2O$, in addition to NOx and CO are emitted from fires.

Another source of biomass loss includes the decrease in vegetation from forestlands due fuelwood gathering that is estimated to 18,790 $m^3$ in 2012, causing the decrease in removals by 27 Gg of $CO_2$.

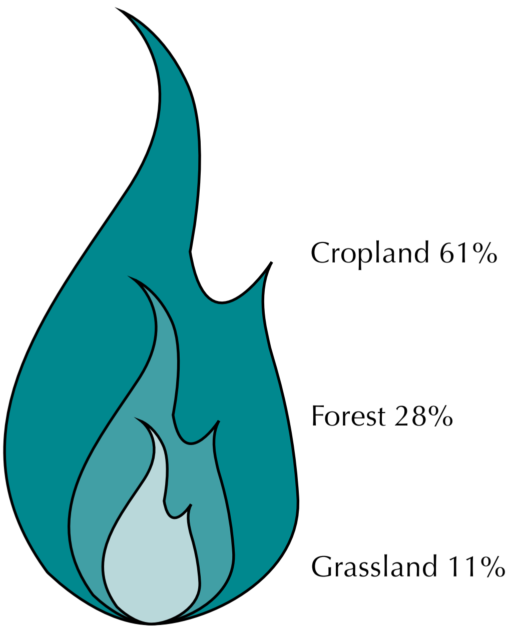



**Figure 21:** Burned areas in 2012 per type of land

### *Biomass increment*

The growth of existing forests and croplands in Lebanon has the largest contribution to $CO_2$ removals in the LULUCF sector, with a total of -3,036 Gg $CO_2$eq. in 2012.

Afforestation activities also contributed in increasing $CO_2$ removal in Lebanon, resulting in -79 Gg $CO_2$ in 2012, where a significant increase of afforested areas was observed comparing to previous years (7 times more afforested areas in 2012 compared to 2011). This was mainly caused by the resuming of the work of the Ministry of Environment on the national reforestation plan through the "safeguarding and restoring Lebanon's woodland resources" project and the implementation of Lebanon Reforestation Initiative with the US Forest Service.

## 4.5 Waste and wastewater

Emissions from this sector emanate from the decomposition of the organic component of waste and wastewater taking into account specificities of solid waste disposal and wastewater handling methods. $CH_4$ emissions are mainly generated from solid waste disposal sites, $N_2O$ emissions mainly from the discharge of wastewater effluents into aquatic environments, while $CO_2$ emissions results from healthcare waste incineration.

**Table 29:** Sources of GHG emissions from waste and wastewater in Lebanon

| Subcategories | Description |
|---|---|
| Solid waste disposal sites (SWDS) | Three "managed" disposal sites are considered (Naameh, Zahle and Tripoli) in terms of quantities disposed and methane recovered.<br>Remaining quantities of solid waste are considered to be disposed of in uncontrolled dumpsites.<br>Activity data on the annual amount of Municipal Solid Waste (MSW) disposed in Solid Waste Disposal Sites (SWDS) uses a population of 5.18 million in 2012 with an average waste generation rate of 1.05 kg/cap/d, a percent recycling/composting of 15% and a percent disposal in controlled dumpsite of 55% and in open dumps of 30%. |
| Wastewater handling | There is no large-size wastewater treatment plant that is currently operational in Lebanon. Therefore, GHG emissions are considered to be generated from the discharge of domestic and industrial wastewater in the sea (63%), in septic tanks (28%) and in rivers (9%). |
| Waste incineration | Waste incineration only accounts for a portion of the Heath Care Waste that is still being incinerated at various medical establishments even without permits or monitoring. No municipal solid waste is currently being incinerated in Lebanon. |

The waste sector is the largest source of $CH_4$ emissions in Lebanon, accounting for 90.5% of the total national $CH_4$ emissions. In 2012, waste and wastewater disposal emitted 2,829.89 Gg $CO_2$eq. or 10.7% of total GHG emissions for the same year.

**Table 30:** Greenhouse gas emissions from solid waste and wastewater per gas in 2012

| | $CO_2$ | $CH_4$ | | $N_2O$ | | Total emissions |
|---|---|---|---|---|---|---|
| | Gg | Gg | Gg $CO_2$eq. | Gg | Gg $CO_2$eq. | Gg $CO_2$eq. |
| Solid waste disposal sites | | 108.24 | 2,273.04 | 0.00 | 0.00 | 2,273.04 |
| Waste incineration | 1.05 | | | | | 1.05 |
| Wastewater | 0.00 | 19.38 | 407.06 | 0.48 | 148.75 | 555.81 |
| Total | 1.05 | 127.62 | 2,680.10 | 0.48 | 148.75 | 2,829.89 |

*Numbers reflect rounding*
*Details on activity data, emission factors and calculation methodology are available in MoE/UNDP/GEF, 2015f*

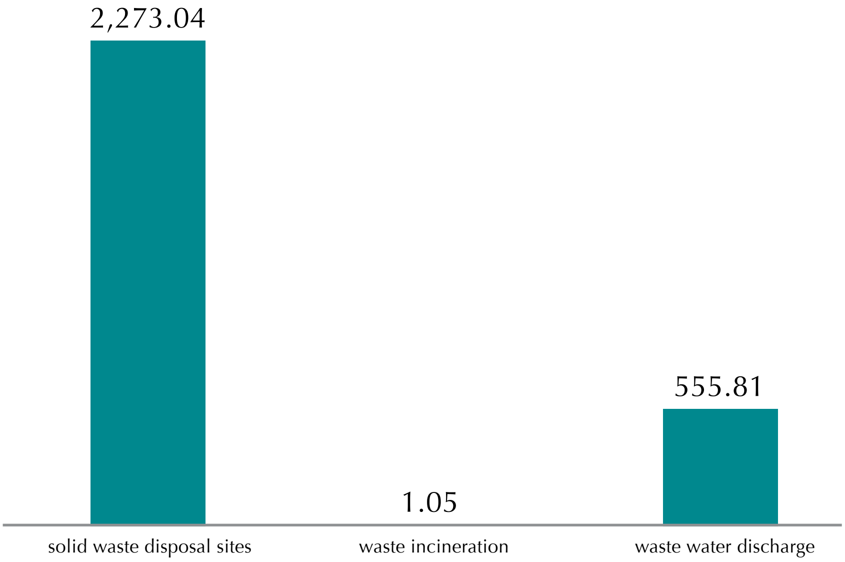



**Figure 22 :** GHG emissions from waste and wastewater (Gg $CO_2$eq.) in 2012

## *Solid waste disposal sites*

The most important greenhouse gas emitted by the waste sector is $CH_4$ mainly generated from solid waste disposal sites, and amounting to 108.24 Gg $CH_4$ or 2,273.04 Gg $CO_2$eq. in 2012 (using a GWP of 21 for $CH_4$). Methane is emitted during the anaerobic decomposition of organic waste disposed in solid waste disposal sites. The amount of methane emitted during the process of decomposition is directly proportional to the fraction of Degradable Organic Carbon (DOC) which is defined as the carbon content in different types of organic biodegradable wastes. The main characteristic of this process is that organic waste decomposes at a diminishing rate over time and takes many years to decompose completely.

In Lebanon, 3 controlled landfills, Naameh Tripoli and Zaahleh, receive around 55% of the total generated waste. The remainder is partially recycled/composted (15%) and disposed in the 670 open dumpsites scattered around the country (30%).

Some of the amounts of $CH_4$ emissions are recovered and flared from the controlled landfills, thus reducing the amounts of methane being emitted into the atmosphere. In 2012, only 11% of the methane emitted from these landfills were recovered and flared, most of which are at the Naameh landfill.

### *Wastewater handling*

Domestic and industrial wastewater discharge produces greenhouse gas emissions from anaerobic decomposition of the organic component of wastewater. In Lebanon, wastewater is discharged without prior treatment either in the Mediterranean Sea in urban coastal areas or in septic tanks in rural areas. A small portion is also discharged directly in river beds.

Emissions from wastewater are estimated at 555.81 $CO_2$eq. in 2012, with 58% of emissions being emitted from discharge in the sea, due to high urbanization of the littoral where 70% of the Lebanese population resides.

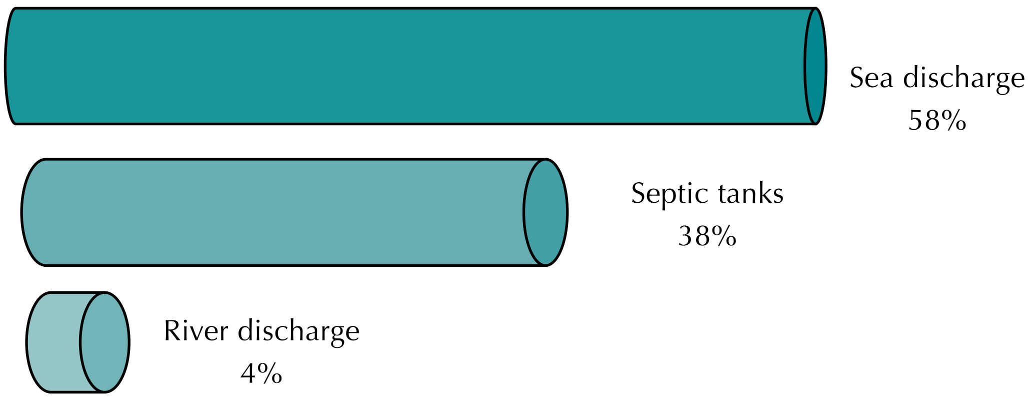



**Figure 23:** $CH_4$ emissions from wastewater discharge in 2012

### *Waste incineration*

GHG emissions from waste incineration, which is the only source of $CO_2$ emissions from this sector, are insignificant in Lebanon since it is restricted to health care waste. Although municipal solid waste incineration is not practiced in Lebanon, a small portion of healthcare waste is still being illegally incinerated in medical facilities. Open air burning of solid waste is not considered in this inventory.

Starting 2002, and after the enactment of decree 8006 (date 11-06-2002) on the proper management of the healthcare waste in Lebanon, several hospitals and organizations started managing their healthcare waste in an environmentally-appropriate manner. Therefore, autoclaving became the main method for treating waste generated by hospitals, handling 55 to 60% of the total healthcare waste stream, which has limited the practice of incineration. The remaining portion of healthcare waste is either being illegally incinerated or dumped with municipal waste in open dumpsites (related emissions accounted under "solid waste disposal sites").

## 5. GHG emissions by gas

Carbon dioxide is the most significant anthropogenic greenhouse gas. As in the majority of countries, the main source of $CO_2$ in Lebanon are the processes of fossil fuel combustion for electricity production and transport (88%) and industrial processes (11.5%).

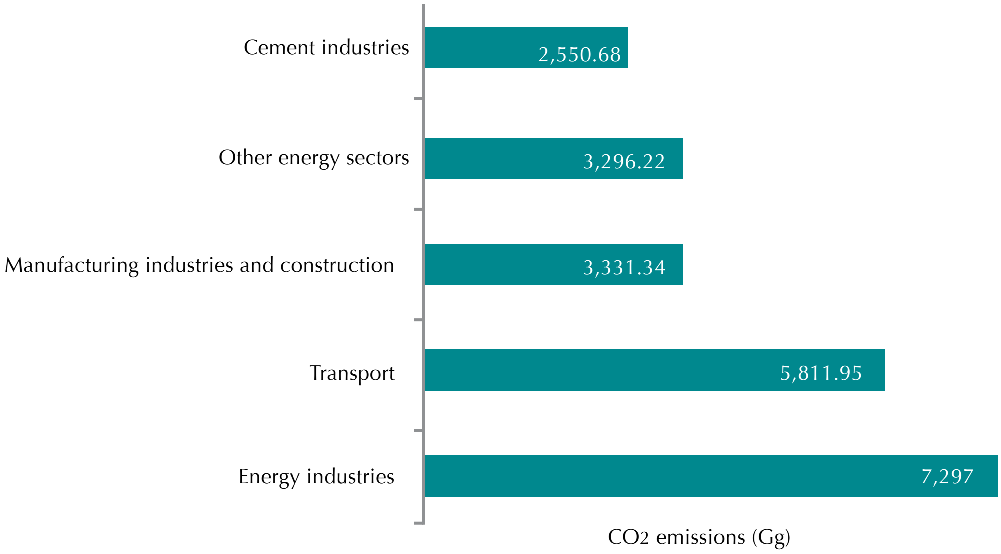



**Figure 24:** $CO_2$ emissions from major sources in Lebanon in 2012

The major source of methane emissions in Lebanon is the waste sector with a share of 90% of total $CH_4$ emissions. Methane emissions from solid waste disposal sites, which is responsible for most emissions, are a result of anaerobic decomposition of organic waste in disposal sites, whether controlled or uncontrolled. In Lebanon, around 2 million tonnes of municipal solid waste are produced annually with a high percent of biodegradable material, most of which are disposed in landfills or open dumpsites.

Methane emissions from the wastewater handling in Lebanon are mainly caused by the disposal of wastewater in septic tanks, particularly in rural areas, where the anaerobic decomposition of the organic component of wastewater results in $CH_4$ emissions.

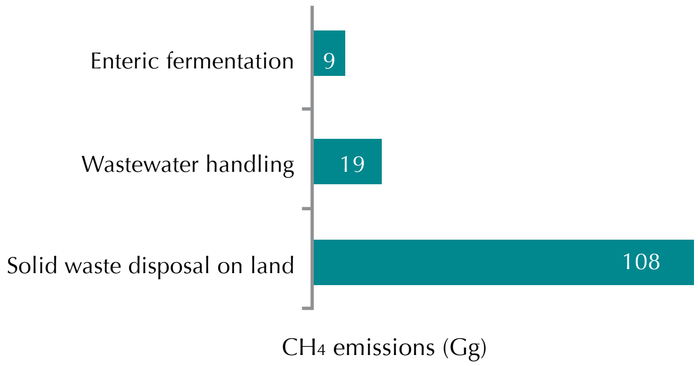



**Figure 25:** $CH_4$ emissions from major sources in Lebanon in 2012

As for $N_2O$, the most important sources in Lebanon are agricultural activities with 66% of total $N_2O$ emissions followed by the energy sector (18%) and waste sector (15%).

In agriculture, direct emissions from agricultural soils are the main source of $N_2O$ followed by direct $N_2O$ emissions from livestock farming and indirect $N_2O$ emissions induced by agricultural activities.

In the energy sector, $N_2O$ emissions are mainly caused by the transport sector and specifically from the increased use of three-way catalytic converters in road transport motor vehicles, which have about 30 times greater $N_2O$ emissions comparing to vehicles without a catalytic converter.

$N_2O$ emissions from the waste sector indirectly occurs from the human sewage, calculated on the basis of the total number of inhabitants and annual protein consumption per inhabitant.

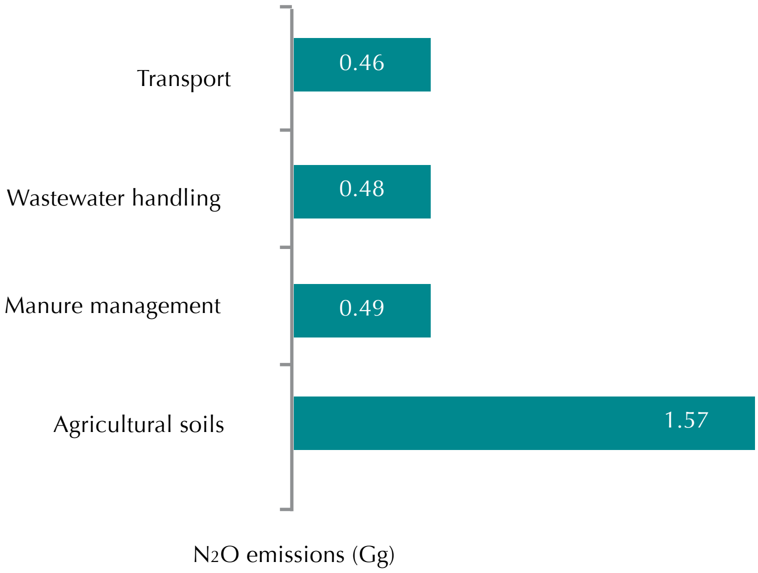



**Figure 26:** $N_2O$ emissions from major sources in Lebanon in 2012

## 6. Trends in GHG emissions: 1994-2012

Lebanon has already prepared national GHG inventories as part of National Communication and Biennial Update Report processes and has produced and updated its numbers since 1994. The current inventory did not only calculate emissions for the year 2012, but recalculated emissions from 1994 to 2012 in the light of new methodologies and new activity data available. In the case of missing information, proxy data, interpolations, extrapolation and estimations were used to ensure consistency in the trend analysis.

The total GHG emissions in 2012, excluding removals by sinks, amounted to 26.3 million tonnes $CO_2eq.$, which represents 89% emissions increase from 1994 and 39% emissions increase from 2000, and averaging to 4.67% annual increase of greenhouse gases in Lebanon.

**Table 31:** Trend of emissions during the period 1994-2012

| | Total GHG emissions (Gg $CO_2$eq.) | Energy (Gg $CO_2$eq.) | Transport (Gg $CO_2$eq.) | Industry (Gg $CO_2$eq.) | Agriculture (Gg $CO_2$eq.) | Land use and forestry (Gg $CO_2$eq.) | Waste (Gg $CO_2$eq.) |
|---|---|---|---|---|---|---|---|
| 1994 | 13,947 | 7,743 | 1,570 | 1,924 | 1,037 | -3,450 | 1,463 |
| 2000 | 18,979 | 11,171 | 2,675 | 1,781 | 1,001 | -3,220 | 2,233 |
| 2012 | 26,333 | 13,980 | 5,980 | 2,557 | 876 | -3,035 | 2,829 |
| % change 1994-2012 | 89% | 81% | 281% | 33% | -16% | -12% | 93% |
| Average % change/year | 4.67% | 4.24% | 14.78% | 1.73% | -0.82% | -0.63% | 4.91% |

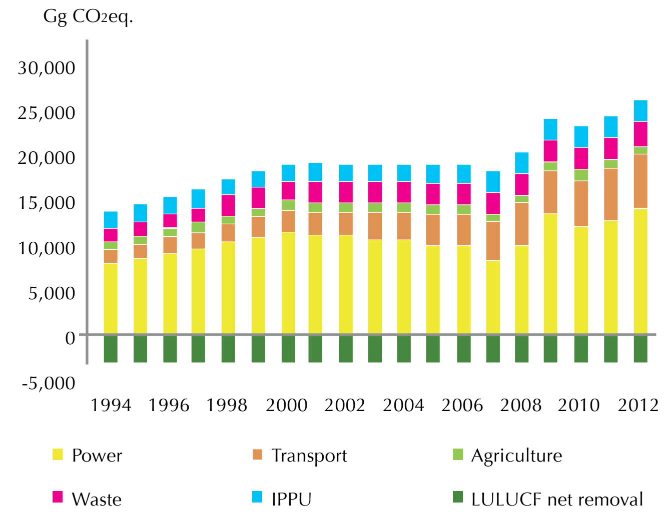



**Figure 27:** Trend in GHG emissions 1994-2012 per sector

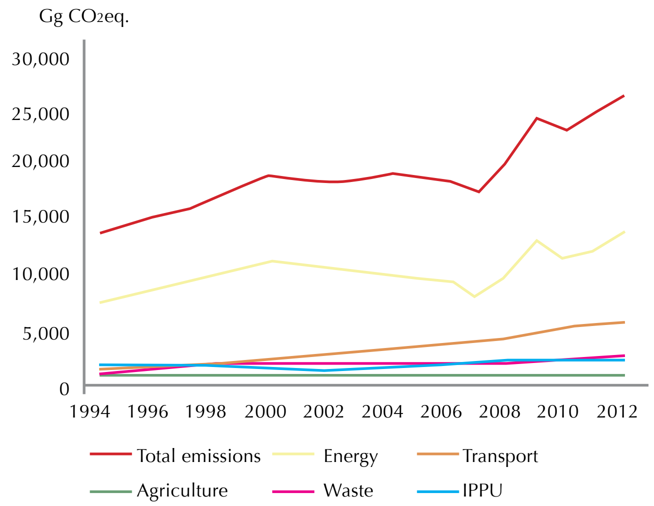



**Figure 28:** Trend of total GHG emissions 1994-2012

As shown in Figure 28, the trend of increase in total GHG emissions closely follows the trend of emissions from the energy sector, which constituted 55 to 59% of total emissions during this period. This significant growth in emissions reflects the growing demand for electricity, due in part to the changing socio-economic conditions and to the expansion of the national grid. In fact, the sharp increase noticed between the 1994 and 2000 emissions is due to the increase in gas/diesel oil consumption that accompanied the installation and operation of the Baalbeck, Tyre, Beddawi and Zahrani diesel power plants during this period.

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

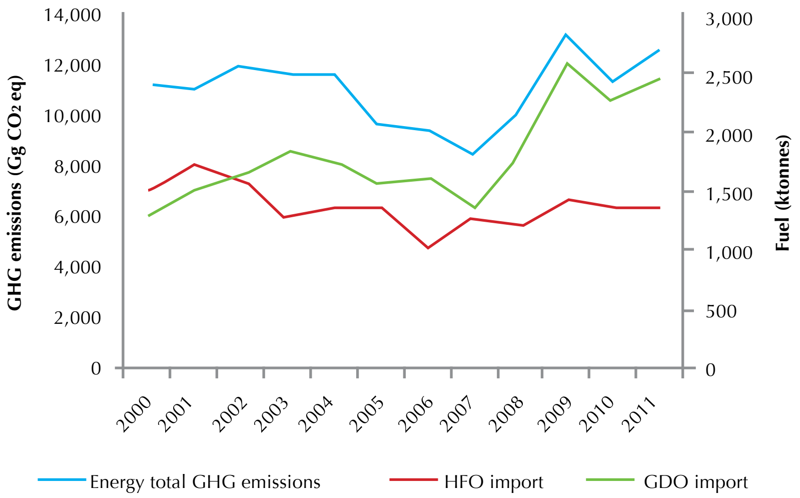



**Figure 29:** Fuel import and GHG emissions trends of the energy sector

The sector with the most significant change in emissions is the transport sector with emissions increasing by a factor of 3.8 reaching 5.8 million tonnes $CO_2$eq. in 2012. This increase is mostly related to the upturn of the number of registered vehicles in Lebanon from 500,000 in 1994 to 1,500,000 in 2012, increasing the rate of vehicle ownership from 175 vehicles per 1,000 persons in 1995 to 330 in 2010 (ESCWA, 2014; MoE, 2014). Among the main reasons for this significant increase is the inefficient and unreliable management of the mass transport sector, preventing the modernization and growth of the system and allowing the market to be controlled by private operators with an ad-hoc evolution strategy; consequently encouraging passengers to rely on their private cars for their daily trips, along with the lack of policy enforcement for encouraging deployment of new fuel efficient vehicle technologies.

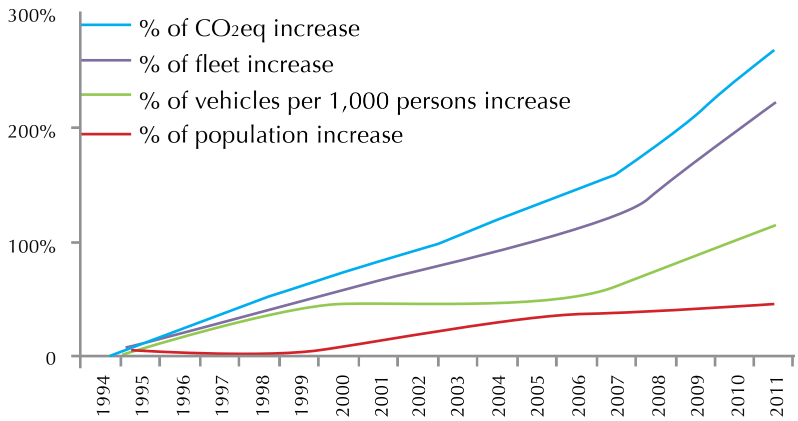



**Figure 30:** Increase of direct GHG in terms of $CO_2$eq., population, fleet and vehicles per 1,000 person for the road transport sector

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

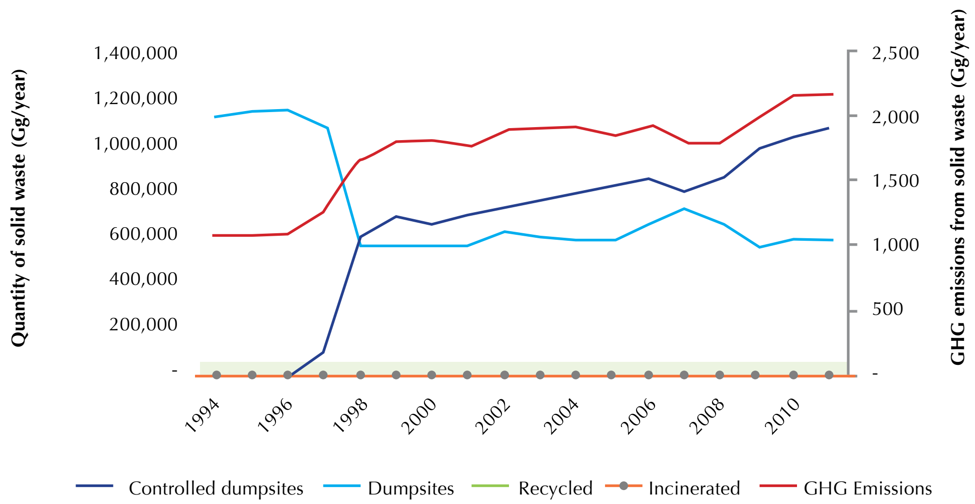



**Figure 31:** Evolution of GHG emissions by solid waste treatment technology

The increasing emission trend is also caused by development of the industrial sector during this period, and namely the increase in cement and lime production from 2006 to 2012. The sector witnessed a decrease of emissions from 1994 to 2002 due to decrease in soda ash use and lime production. Industrial activity picked up starting 2003 with a yearly increase in emissions of 3.9%, except in 2006, where a significant drop of cement production was caused by the July 2006 war. This was compensated by the booming of reconstruction activities after the war, where a noticeable increase in emissions is detected from 2007 to 2009.

The only sector which is showing a decrease in GHG emissions is the agriculture sector. In 2012, emissions decreased by 16% from the 1994 level of 1,037 Gg $CO_2$eq. This is largely a result of decrease in emissions from agricultural soils by 21% and to a lesser extent, a decrease in $CH_4$ emissions from enteric fermentation by 13.4%. These are in turn caused by the decrease in the use of nitrogen fertilizers and in crop residues added to soils during the period 1998-2010 and by the decline in dairy, sheep, and swine populations during the period 1994-2012.

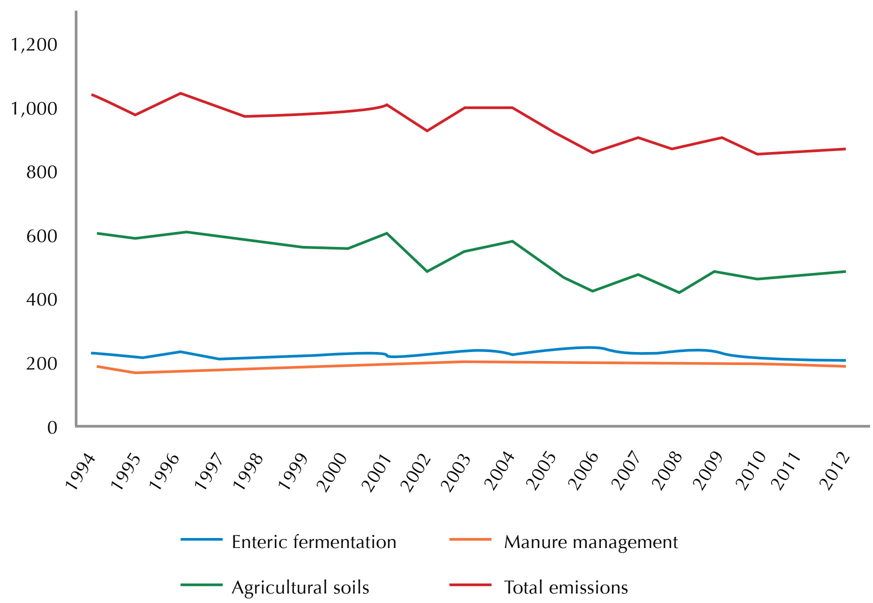



**Figure 32:** Emission trend from agriculture subcategories

As for land use, land use change and forestry, the net $CO_2$ emissions/removals show that forests were important sinks of greenhouse gases in Lebanon with an average of -3,321 Gg/year of $CO_2$eq. sequestrated over the period 1994-2012. However, changes in forest and vegetation covers resulted in about 12% decrease in $CO_2$ removals in 2012 in comparison to 1994. This is mainly attributed to the increase of land conversion to settlements where forests and grasslands are completely lost and to an increase in burned areas and its consequent $CH_4$ and $N_2O$ emissions.

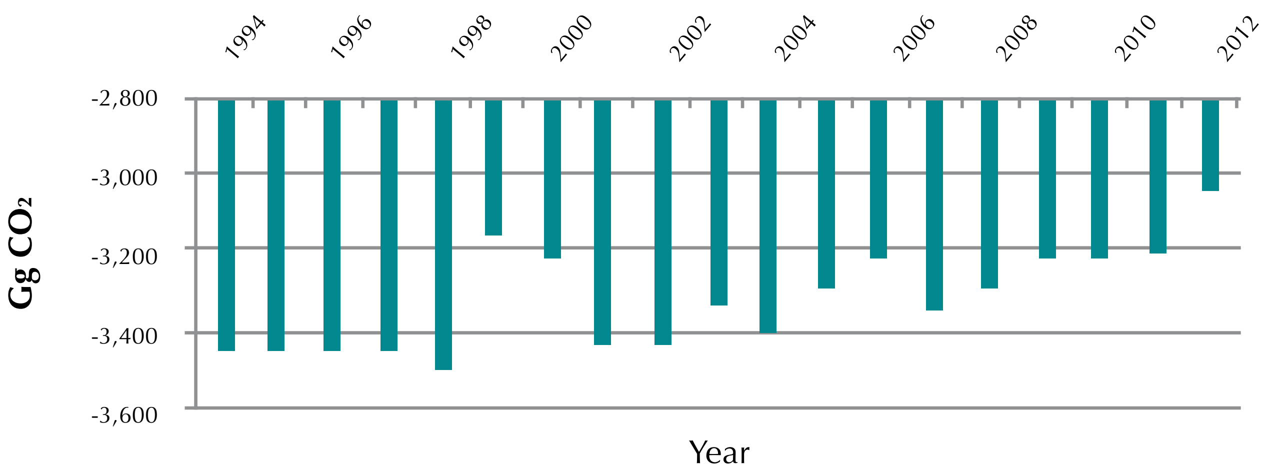



**Figure 33:** Trend in net removals from LULUCF

## 7. Indirect greenhouse gases and sulphur dioxide

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

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

In Lebanon, the transport sector is the major source of indirect greenhouse gases, being responsible for 60% of NOx emissions, 99% of CO emissions and 57% of NMVOCs. Fuel combustion for energy production is the main emitter of $SO_2$ with 94% of emissions, mainly caused by the sulphur content in burnt fuel and some NOx generated through the combustion processes in thermal power plants. As for industrial processes, they mainly emit NMVOCs, being responsible for 42% of these emissions.

**Table 32:** Indirect GHG emissions and $SO_2$ emissions in 2012

| | Emissions (Gg) | | | |
|---|---|---|---|---|
| | $NO_x$ | CO | NMVOCs | $SO_2$ |
| Energy | 32.87 | 2.83 | 0.94 | 104.99 |
| Transport | 51.79 | 358.37 | 72.34 | 5.34 |
| Industrial processes | 0.00 | 0.00 | 53.81 | 1.71 |
| Agriculture | 0.00 | 0.00 | 0.00 | 0.00 |
| LULUCF | 0.008 | 0.77 | 0.00 | 0.00 |
| Waste | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 84.67 | 361.97 | 127.09 | 112.04 |

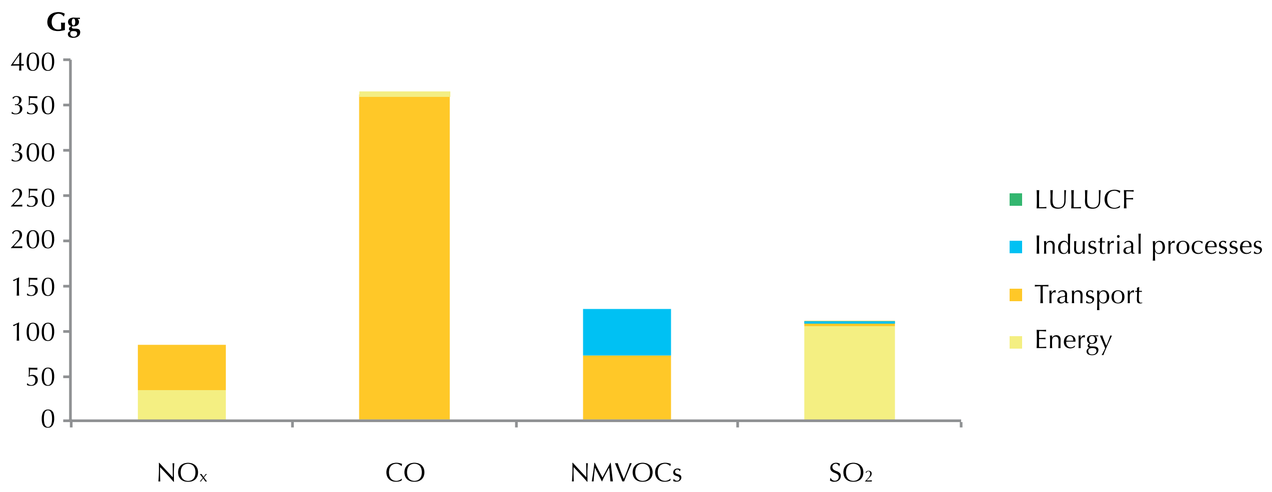



**Figure 34:** Indirect GHG emissions and $SO_2$ emissions in 2012

# 3 MITIGATION ANALYSIS

# 3 MITIGATION ANALYSIS

Lebanon, as a non-Annex I Party to the Convention has no obligation to reduce its greenhouse gas emissions. However, following COP21 and as part of the new Paris Agreement, the Government of Lebanon has declared in its Intended Nationally Determined Contribution (INDC) its intention to reduce greenhouse gas emissions by 15% by 2030 as an unconditional target and by 30% as a conditional one. Emission reduction will emanate from the implementation of various strategies and policies related to the main sources of greenhouse gas emissions in Lebanon.

This chapter presents a series of mitigation options that if implemented have the potential to reduce emissions from the energy, transport, industrial, agricultural, land use and forestry and waste sectors. It is worth noting that not all the proposed activities presented in this section have been incorporated in the INDC. While this chapter presents a range of sectoral activities that have a potential to reduce emissions, the INDC only took into account activities that have been already approved by the Lebanese Government as part of strategies and plans. Hence, the outlined analysis below can serve to update subsequent NDCs.

A Business-As-Usual (BAU) scenario has been developed in each sector to define and project its development for the period of 2017-2040 if no mitigation measure is to be implemented. In addition, the quantification of the emissions reduction potential of each proposed measure has been estimated when possible and compared to the BAU scenario.

Reflecting the results of the GHG inventory, the mitigation analysis presents the energy sector as the sector with the strongest abatement potential. The cumulative mitigation potential at national level for the range of sectors considered, namely, electricity generation, road transportation, agriculture, LULUCF, solid waste and wastewater handling, show that the potential of emission reductions ranges from 18% to 38% in 2030. Table 33 presents a summary of the estimated GHG emission reductions of the sectoral mitigation options proposed here.

**Table 33:** Emission reduction potential by 2030

| Sectors | BAU emissions in 2030 | Emission reduction in 2030 (Gg $CO_2$eq.) | |
|---|---|---|---|
| | | Optimistic scenario | Pessimistic scenario |
| Energy | 21,145 | -7,789 | -3,894 |
| Transport | 5,187.55 | - 2,349.04 | -541.90 |
| IPPU | - | - | - |
| Agriculture | 692.71 | -87.92 | -30.79 |
| LULUCF* | 367.77 | -147.05 | -49.65 |
| Waste | 4,199.01 | -1,480.32 | -1,141.09 |
| Total | 31,592 | -11,853 | -5,658 |
| Emission reduction | | 38% | 18% |

*excluding removals

## 1. Energy sector

Energy production is one of the main sources of greenhouse gas emissions in Lebanon, accounting for more than 53% of national emissions, mainly due to the high reliance on fossil fuel as the main source of energy for electricity production and the poor performance of the existing thermal generation system. The Government of Lebanon has already embarked on a series of projects to increase production capacity and improve the generation conditions.

The mitigation analysis of this sector compares the full implementation of the government's Energy Policy Paper (MoEW, 2010b) to a BAU scenario in order to estimate potential GHG emission reduction for the years 2020 and 2040. The mitigation option targets GHG emissions related to fossil fuel consumption (heavy fuel oil and gas diesel oil) for electricity production, both in thermal power plants and in private generators. In addition to increasing the share of renewable energy and activating the role of Independent Power Producers (IPP). Further detail on the mitigation analysis of this sector is available on MoE/UNDP/GEF, 2015a.

### 1.1 Business-as-usual scenario

The BAU scenario shows no large investments in the power sector from the government. The status of the existing power plants is subject to increased wear and tear, whereas the increase in demand is estimated at 3% per year with private generation increasing as needed while maintaining a supply of 80% of the Energy Not Supplied (ENS) (i.e. assuming that 20% of the ENS remains not served in accordance to the policy paper assumptions) and purchasing from Syria and Egypt decreasing as a result of the Syrian conflict. Emissions related to purchased energy are attributed to the country of origin and thus not accounted in Lebanon's total emissions. The BAU scenario assumes that natural gas will not be available before 2019.

Table 34 summarizes the data simulation for the BAU scenario. The years 2009 until 2011 are filled in with actual recorded data, whereas the data for the years 2012 until 2030 is simulated based on the assumptions that are specific to each technology and each particular plant.

**Table 34:** $CO_2$ emissions under BAU scenario

| | 2009 | 2010 | 2011 | 2012 | 2015 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|---|---|---|
| Demand (MWh/Year) | 15,000 | 15,956 | 16,564 | 18,433 | 20,637 | 23,924 | 27,735 | 32,152 |
| Production + Purchase (MWh/Year) | 11,522 | 12,460 | 12,406 | 10,969 | 11,013 | 10,815 | 9,352 | 9,535 |
| Private generation (MWh/Year) | 2,782 | 2,797 | 3,326 | 5,971 | 7,699 | 10,487 | 14,706 | 18,093 |
| Share of renewable energy | 4.95% | 6.35% | 5.73% | 7.63% | 4.67% | 4.72% | 1.14% | 1.65% |
| $CO_2$eq. (Tonnes $CO_2$eq.) * | 9,093,019 | 8,745,369 | 10,086,667 | 11,231,083 | 12,948,453 | 15,128,302 | 18,242,128 | 21,415,102 |
| Average $CO_2$eq./MWh (tonnes $CO_2$eq./MWh) | 0.689 | 0.624 | 0.678 | 0.676 | 0.715 | 0.745 | 0.791 | 0.804 |

* Emissions from energy industries and private generation, in terms of $CO_2$eq.

## 1.2 Mitigation option 1: Implementing the Energy Policy Paper

The Energy Policy Paper (PP2010) includes a series of initiatives to remedy most of the problems of the electric energy sector. Planned activities relate to the addition of generating capacity through conventional and renewable energy sources (up to 5,000 MW additional capacity, from which 2,500 MW from Independent Power Producers (IPP)), upgrade of the transmission and distribution infrastructure including one for natural gas, establishment of a smart grid, development of demand side management and energy efficiency as well as tariff restructuring. However, since the implementation of the policy paper still did not happen, an updated time schedule has been considered in this mitigation scenario (as of January 2015).

**Table 35:** Updated schedule of Energy Policy Paper 2010

| Initiative | Planned production date | Rescheduled production date | Remarks |
|---|---|---|---|
| Power wheeling | 2010 | 2010 | Done |
| Barges | 2010 | 2013 | Done |
| Zouk 194 MW ICE Plant | End 2014 | End 2015 | In Progress |
| Jiyeh 78.2 MW ICE Plant | Mid 2014 | Mid 2015 | In Progress |
| Deir Aamar II CCPP 539 MW | End 2016 | End 2017 | In Suspension |
| Rehabilitation of Zouk and Jiyeh thermal power plants | End 2015 | End 2018 | Under Procurement |
| Upgrade of Zahrani and Deir Aamar CCPP | 2013 | 2014 | Done |
| CC add on of Tyre and Baalbeck power plants | 2012 | 2018 | Under Study |
| IPP 1,500 MW | 2015 | 2018 | Under Study |
| IPP 1,000 MW | 2018 | 2021 | Under Study |
| Hydro 40 MW | 2015 | 2018 | Under Study |
| Wind 60 MW | 2013 | 2017 | Under Procurement |
| Waste to energy | 2014 | 2017 | In Progress |

**Box 1:** Assumptions for BAU scenario

**CONVENTIONAL STEAM THERMAL POWER PLANTS**

The actual decay in the plants of Zouk, Jiyeh and Hrayche is currently slightly worse than the norm for the same type of plants as EDL is often unable to perform the overhauls and maintenance activities in a timely manner, thereby leaving room for further loss of performances. The degradation of these plants is reflected by a Net Power Output (NPO) decrease of 1.06% per year, a specific consumption increase between 2% to 4% per year and a capacity factor decrease by 1% to 2% per year.

**COMBINED CYCLE GAS TURBINES POWER PLANTS RUNNING ON DIESEL OIL**

The wear and tear behavior of diesel oil fired Combined Cycle Power Plants (CCPP) similar to the ones of Zahrani and Deir Aamar (combined cycle I) is not well documented as most CCPP usually run on natural gas. It is assumed that the specific consumption of these plants increases by 1.75% per year, while the capacity factor follows identical 4 years cycles and the NPO decreases 0.04% per year. As for the Deir Aamar combined cycle II, the BAU scenario assumes that natural gas will become available in 2019.

**SIMPLE CYCLE GAS TURBINE PLANTS RUNNING ON DIESEL OIL**

The power plants of Tyre and Baalbeck are usually running in simple cycle and have fuel costs that are higher than the other plants as these are being supplied by truck tankers only. They are thereby being used only as peak units when needed. It is assumed that the specific consumption of these plants increases by 0.5% per year, while the capacity factor and NPO decrease by 1% and 0.04% per year respectively.

**HYDROPOWER PLANTS**

The hydro production has been simulated based on historical data from the last 4 years assuming that a similar rainfall pattern every 4 years will repeat itself. Lebanon had during these years one very dry year and one abundant year, the others being in between, which reflects the full range of changes in rainfall quantities. The loss of production caused by the implementation of the Conveyor 800 project on the Litani River is reflected starting from year 2018.

**PRIVATE GENERATION**

The private generation is calculated to be 80% of the Energy Not Supplied in line with the policy paper assumptions. The PG is assumed 100% from diesel oil generation and the specific consumption used in the calculations corresponds to a medium size new generator unit.

**SHARE OF RENEWABLE ENERGY**

The share of renewable energy in the BAU scenario is limited to the power generated by hydropower.

## 1.3 Emission reduction potential in the energy sector

The implementation of the MoEW Energy Policy Paper (2010) including recent updates can inflict a cumulative decrease of 82,600 Gg $CO_2$eq. from 2017 to 2030, with an average annual decrease of 5,900 Gg $CO_2$eq. per year as compared to the business-as-usual scenario (Figure 35). Implementing the policy paper will reduce emissions by 36% by 2030 compared to the BAU scenario.

**Box 2:** Assumptions for mitigation scenario PP2010

**THERMAL GENERATION**

The existing plants are rehabilitated and upgraded, and large investments are made to increase the generation capacity to meet demand within 2018. When production becomes close to the demand level, the highest costs plants of Jiyeh and Hrayche are decommissioned, and the load of the barges and the peak plants of Tyre and Baalbeck are being managed by order of merit to meet the demand.

Starting from 2019, the barges are decommissioned and Zouk plant is being used at partial load as needed to meet the demand. Starting from 2028, the plant of Baalbeck is decommissioned or kept in stand-by. Natural gas is available by end of 2018.

ZOUK THERMAL POWER PLANT

HFO conditioning improvements starting 2013.
HFO conditioning decreases consumption around 0.7% on the average.
Plant rehabilitation starting 2018.
One unit is in shutdown during the rehabilitation.
Plant rehabilitation restores efficiency to 39.05% and availability to 82%.
SC increases by 2% per year before rehabilitation.
SC increases by 0.53% per year after rehabilitation.
Capacity factor drops around 1% per year.
NPO decreases 1.06% per year after year 2026.

JIYEH, HRAYCHE THERMAL POWER PLANTS

Jiyeh and Hrayche thermal power plants start to be decommissioned in 2018.

ZOUK AND JIYEH ICE PLANTS

Both plants enter in operation on HFO in 2015.
Both plants switch to NG operation in 2019.
Specific consumption increases by 0.258% per year.
NPO decreases by 0.258% per year.
Capacity factor drops around 0.001% per year.

BAALBECK AND TYRE

Both plants will benefit from the combined cycle add on in 2018.
Both plants will be converted to natural gas in 2019.
NPO becomes respectively 115.07 MW and 103.36 MW with add on.
SFOC becomes respectively 222 g/kWh and 211 g/kWh with add on.
Capacity increases +2.5% on natural gas.
Efficiency increases +1.2% on natural gas.
Capacity factor drops 0.1% after 2019.
SC increases by 0.5% per year and 1.75% for combined cycle.

ZAHRANI AND DEIR AAMAR I COMBINED CYCLE

The plants of Deir Aamar I and Zahrani have been upgraded in 2013 and start operating on natural gas in 2019.
Gas turbines upgrades increase plant capacity to 464.5 MW in Deir Aamar and 468.5 MW in Zahrani and reduce specific consumption by 5%.
Capacity increases +2.5% on natural gas.
Efficiency increases +1.2% on natural gas.

DEIR AAMAR II COMBINED CYCLE

Deir Aamar II enters into service in 2018 on HFO.
Plant switches to NG operation in 2019.
NPO decreases 0.04% per year.
SC increases 1.75% per year.
Capacity factor follows identical 4 years cycles.

**HYDROPOWER PLANTS**

Production follows the same pattern as the historical data of the previous years (i.e.: similarly to the BAU scenario).
Additional energy produced by Kadesha following the completion of its hydro fleet rehabilitation in 2016 (+37% energy).
Addition of the Janneh hydro plant in 2019.

**PRIVATE GENERATION**

The private generation and purchasing gradually decrease when production reaches the demand level in 2018. Private generation is estimated to be 80% of the Energy Not Supplied in accordance with the policy paper assumptions (i.e.: 20% of the ENS remains not served).

**SHARE OF RENEWABLE ENERGY**

The PV generation is based on a continuous growth of 725 MWh/year of the small PV installations (i.e. similar to the historical data during the past years).

Addition of the five stages of the Beirut River Snake project respectively in 2015, 2018, 2021, 2025 and 2029 is taken into account.
The energy produced from renewable sources is replacing energy that would have been produced from fossil-fired sources.

**PURCHASING**

Purchasing is assumed to come back gradually to the 2009 level starting from 2015 after having dropped significantly during the last 3 years.

**BARGES**

The barges started operation in 2013 and are gradually decommissioned starting 2019 following the rehabilitation completion and the reach of a balance between demand and supply. The barges are a policy paper initiative and would never have been brought under BAU conditions.

**INDEPENDENT POWER PRODUCERS (IPP)**

The IPP power plants are gradually introduced as needed to cope with the increasing demand starting from 2019:
IPP1, 545 MW GE gas turbines combined cycle, on the grid in 2019
IPP2, 474.8 MW Alstom gas turbines combined cycle, on the grid in 2021
IPP3, 486.6 MW Ansaldo gas turbines combined cycle, on the grid in 2024
IPP4, 474.4 MW Siemens gas turbines combined cycle, on the grid in 2027
IPP5, 497.5 MW MAN reciprocating engines plant, on the grid in 2029

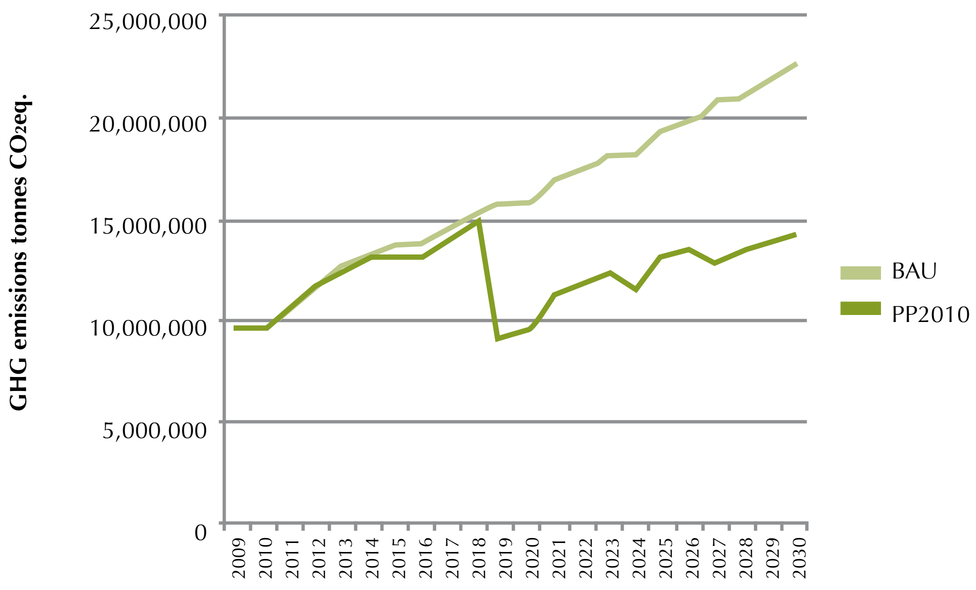



**Figure 35:** Emission reduction potential from implementing scenario PP2010

Figure 36 clearly illustrates the changes that would result from the implementation of the PP2010 scenario. Compared to the business-as-usual conditions, power production under PP2010 meets demand in the year 2020 while completely eradicating private generation. This is made possible mainly by the switch of most power plants to natural gas by 2019 and by improving the efficiency of power plants, in addition to the increase in the share of hydropower and other renewable energies.

These significant technical changes between both scenarios are reflected in terms of the $CO_2$ emissions generated by this sector, as presented in Figure 36. Starting 2019, a noticeable drop of 38% in emissions is observed compared to the BAU, also mainly due to the switch of most power plants from heavy fuel oil and diesel oil use to natural gas. The introduction of additional production capacity by IPPs contributes to reducing even further $CO_2$ emissions in 2024, 2027 and 2029.

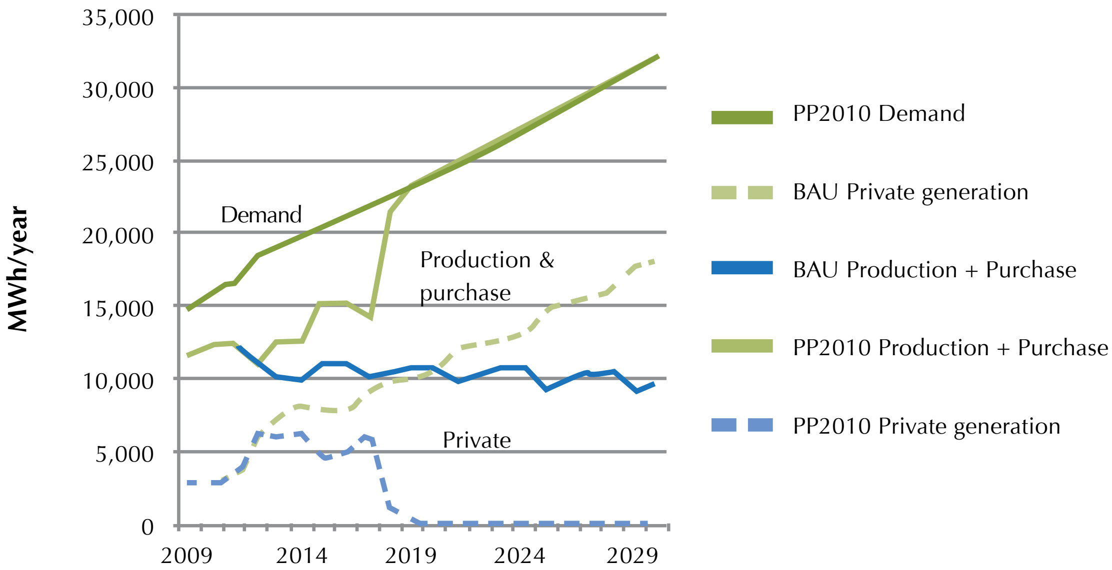



**Figure 36:** Variations between BAU and PP2010 scenarios

It is worth highlighting that in most optimistic scenarios, the contribution of the renewable energies to the improvement of the emission factor in tonnes $CO_2$eq. /MWh remains very modest as shown in Figure 37. This underlines the fact that the main contributor to emission reduction in the energy sector relies primarily on switching from fossil fuel to natural gas and the improvement of the efficiency of the large-scale production technologies.

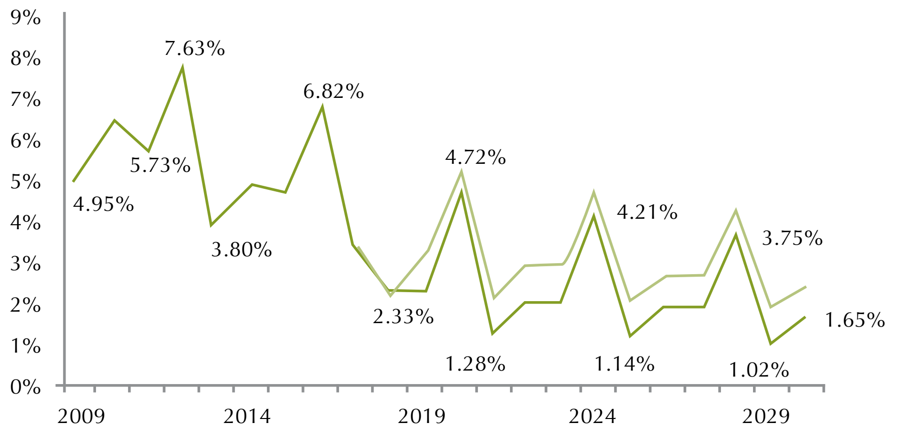



**Figure 37:** Renewable energy percentage of avoided emissions between BAU and PP2010 scenarios

## 1.4 Enabling environment for energy mitigation

The implementation of the Energy Policy Paper to mitigate GHG emissions from the power sector faces various challenges that should be urgently tackled. Some of the barriers and recommendations are presented below:

**Fuel sourcing:** Fuel sourcing for the new generation capacity needs to be taken into consideration. Notwithstanding the fact that Lebanon is expected to have its own domestic sources of NG available for the next decades. Until the domestic NG will become readily available, the government should ensure the supply of NG in sufficient quantities at a competitive price. The GoL would suffer from huge financial problems with the policy paper planned IPPs should the fuel quantities or quality be at risk.

**Fuel distribution:** Even though the policy paper has foreseen the construction of a domestic NG pipeline along the Lebanese seashore for the NG distribution to all the facilities, the project implementation is being delayed and might be even reconsidered. In case of replacement by FSRUs for each plant located along the seashore, the advantage of supplying NG to the cities and other facilities will be lost. Also the loss of the possibility to extend the network by supplying NG to the internal parts of the country such as the Bekaa puts a limitation on the number of potential sites for future power plants developments.

**Availability of technology:** Not all power plants can be converted to natural gas, such as the Zouk, Jieh and Hrayche plants. Therefore, the mitigation scenarios must be adapted accordingly. An alternative to NG, would be to select the most appropriate abatement technology for these plants and use combustion improvement technologies such as the HFO conditioning.

**Legal and regulatory framework for IPP:** The present lack of clarity of the regulatory and legal standing of the private sector participation and the lack of experience of authorities to manage

IPPs might hinder the progress of IPP development which is relied on for future developments. This represents a major risk as the future 2,500 MW addition is all planned to be under the IPP scheme.

**Legal barriers:** There are many old concessions in the hydropower sector that have rights on the energy produced from the water. These concessions have old power purchase agreements with EDL at reduced tariffs and are expected to expire mostly within the next 15 years. This situation constitutes a major barrier for the development of the hydropower sector as neither the concessions owners are able to invest (due to the low tariffs and the short remaining duration), nor the GoL is able to do the same unless it decides to buy back the concessions.

**Political risk:** This is a major aspect to consider, especially with the surrounding conflicts, uncertainties and the fragility of the Lebanese regime. In addition, the current negative financial standing of the country and the power sector makes it as non-creditworthy for reliable investors and lenders to think of mobilizing funds and invest in such a capital intensive infrastructure.

**EDL fragility:** The national utility is being exposed by the lack of coherence of the decisions of the GoL. EDL is not being allowed to raise the tariffs in a way to cover its costs, nor to freely recruit as needed, and is unable as a result to invest adequately in its fleet maintenance and development. The prevailing situation might lead to a total collapse of the national utility thereby hindering most of the plans in the energy sector.

## 2. Transport sector

The transport sector accounts for more than 40% of national oil consumption and emits 23% of GHG emissions, while being the main source of urban air pollution. As the country urbanizes and population grows, the negative externalities from air pollution, on-road congestion, and traffic accidents demonstrate the flaws in the conventional approach to transport planning. Efficient and modern transport systems are critical not only for emission reduction but also for development and economic growth. Therefore, tackling the transport problem as part of climate change mitigation carries a series of co-benefits that meet immediate development needs while addressing longer-term climate change concerns.

The mitigation options presented here build on the transport technologies prioritized in Lebanon's Technology Needs Assessment (TNA) which include 1) the replacement of old and inefficient vehicles gradually with fuel-efficient vehicles, 2) the introduction of hybrid electric vehicles in the market, and (3) the restructuring and modernization of the bus transport system in GBA.

This section synthesizes the emission reduction potential of these options for the years 2020 and 2040 compared to BAU scenario, using the For Future Inland Transport Systems model (ForFITS) (UNECE, 2013). The analysis covers passenger and freight mobility services on inland transport modes, taking into consideration the different vehicle classes, powertrains and fuel blends consistent with the technology requirements. Non-motorized transport (walking and cycling), aviation and maritime transport and freight transport were excluded from the mitigation scenario projections as the scope of this study considers only mitigation measures for passenger transport. Therefore, emission projections used here

under BAU for 2020 and 2040 are lower than what they should be. Further details on the mitigation analysis of the transport sector are available in MoE/UNDP/GEF, 2015b.

## 2.1 Business-as-usual scenario

The Business-as-usual scenario uses 2010 as a base year for projecting transport data for the 2013-2030 period and maintains all identified transport characteristics. This includes:

- A passenger transport system index of 0.1 for the passenger activity data of 2010. This relates to the share of passenger-kilometer on mass transport, reflecting a totally dependent system on personal vehicles.
- An environmental culture index of 0.2, which reflects the poor behavioral changes associated with environmental consciousness.
- A powertrain technology share of 11.8% for small vehicles, 54.9% for midsize vehicles and 33.3% for large vehicles (same as 2010), taking into account the improvement of the fuel consumption characteristics of each vehicle technology.
- Constant $CO_2$ emission factors as of 2010, reflecting no changes in fuel blends and therefore excluding switches towards lower energy-and carbon-intensive fuel options.
- A growth in gasoline and diesel fuel price by 50% in 2040.
- A population increase by 22% and a GDP growth by a factor of 4 by 2040.

Under the BAU scenario, both the passenger and freight activity increase substantially compared to the base year, which is a direct consequence of the economic growth which leads to an increase in transport activity and in fuel consumption. This is reflected by an increase in the number of personal passenger cars and their annual distance travel especially for Light Duty Vehicles (LDV) where vehicle-kilometer (vkm) activity increases by 31% in 2020 and 103% in 2040 compared to the base year. Thus, any fuel saving measures adopted to improve the vehicle performance and efficiency will only partly offset the increasing trend of emissions.

The expected increase in $CO_2$ emissions is directly related to the increase in energy demand and is largely dominated by midsize and large passenger cars (Figure 38 and Figure 39), mainly due to the absence of environmental considerations during vehicle purchase, resulting in 88% share of midsize and large vehicles of the total passenger vehicle fleet.

**Table 36:** Business-as-usual scenario for passenger transport

| | Base year (2010) | BAU 2020 | BAU 2040 | Ratio 2020/2010 | Ratio 2040/2010 |
|---|---|---|---|---|---|
| Total passenger vehicle stock | 1,292,433 | 1,693,136 | 2,663,349 | 1.31 | 2.06 |
| 2-3 wheelers | 60,587 | 79,632 | 124,268 | 1.31 | 2.05 |
| Passenger LDV | 1,219,460 | 1,599,130 | 2,523,080 | 1.31 | 2.07 |
| Buses | 12,387 | 14,375 | 16,001 | 1.16 | 1.29 |
| Total vehicle-km (billion vkm/year) | 13.68 | 17.98 | 27.74 | 1.31 | 2.03 |
| Total energy use (toe/year) | 1,497,765 | 1,633,910 | 1,898,235 | 1.09 | 1.27 |
| Total $CO_2$ emissions (Gg $CO_2$/year) | 4,350 | 4,747 | 5,514 | 1.09 | 1.27 |

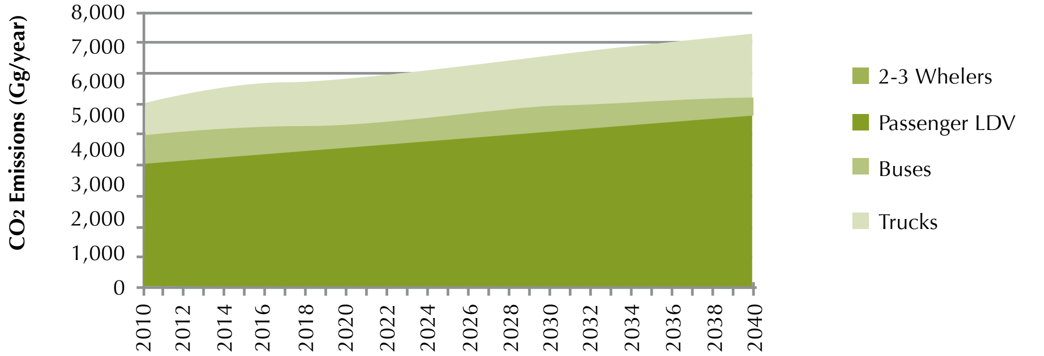



**Figure 38:** Baseline projection of passenger CO2 emissions

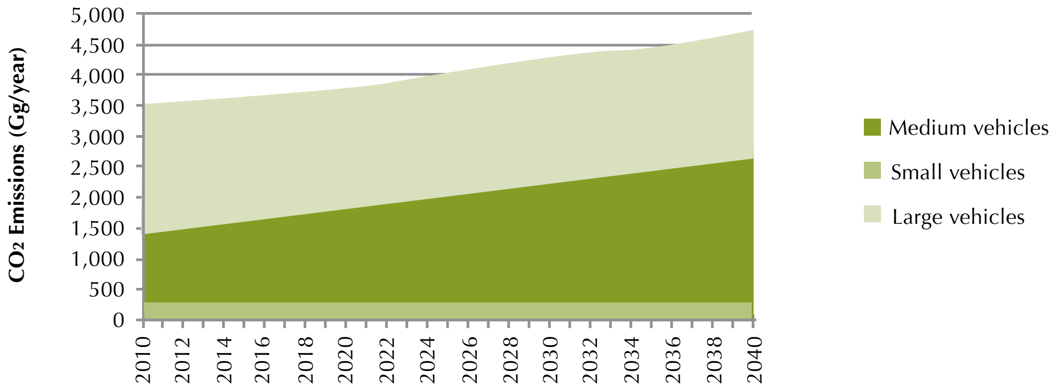



**Figure 39:** Baseline projection of passenger vehicles $CO_2$ emissions

## 2.2 Mitigation option 1: Increase share of fuel-efficient vehicles

Fuel-Efficient Vehicles (FEV) are commonly known in Lebanon by conventional gasoline powered vehicles with reduced fuel consumption, equipped with advanced technologies like downsized turbocharged engines. In general, fuel-efficient vehicles fall mainly under the small vehicles category; however, continuous developments are held to reduce consumption of conventional midsize and large vehicles, which therefore might be more efficient than small vehicles if these cars are used regularly by more than one occupant. Consequently, fuel-efficient vehicles are defined as vehicles presenting reduced consumption per vehicle occupant.

This scenario considers a higher market penetration of fuel-efficient vehicles technologies and a reduction of share of large vehicles. This scenario targets an increase of the share of small passenger vehicles to 35%, maintaining the share of midsize vehicles to 55% and decreasing the share of large vehicles to 10%. The market for these fuel efficient vehicles will develop gradually with new vehicles registrations and will rely on the implementation of policies and awareness campaigns to improve the environmental culture of drivers and direct their purchases to environmental friendly vehicles.

### 2.3 Mitigation option 2: Increase share of fuel-efficient vehicles and hybrid electric vehicles

Hybrid Electric Vehicles (HEV) combine an electric motor and battery pack to the internal combustion engine found in conventional vehicles. They are classified as micro-hybrid, mild-hybrid, full-hybrid, plug-in hybrid and range-extender electric vehicles; and differentiate by the fraction of electric power added onboard; consequently, the ability to achieve more hybrid functions. Note that the more electric energy is available onboard, the more fuel reduction will result, at the expense of additional purchase cost.

This scenario adopts the same assumptions as mitigation option 1, i.e. an increase of share of small vehicles with fuel-efficient powertrains and decrease in large vehicles. In addition, this scenario considers the introduction of HEV to the market, assuming their share of sales of new registered vehicles will increase over time to reach 10% by 2040.

### 2.4 Mitigation option 3: Increase the share of mass transport

The shift to mass transport in this scenario takes into account a change of the passenger transport characteristic index from 0.1 to 0.15, representing a mass transport passenger-kilometers share increase from 36% in 2010 to 53% by 2040. The rationale is to reduce the gap between the passenger transport system indexes of Lebanon (0.1) and mass-transport-oriented sustainable European cities (0.45) by 15% in 2040.

In practice, this assumption is represented by the deployment of a well-designed mass transit system covering the Greater Beirut Area, part of which is the public transport plan prepared by the Ministry of Public Works and Transport (MoPWT), in addition to a wide number of policies favoring mass transport over personal vehicles, such as parking and access restrictions for personal vehicles, land use policies that encourage lane dedication for buses, and support for the provision of appealing, widely available and high-quality public transport services (MoE/URC/GEF, 2012).

### 2.5 Emission reduction potential in the transport sector

The analysis of the potential $CO_2$ emissions of the 3 mitigation measures show that renewing the fleet with efficient vehicles can reduce emissions by 19% by 2040 compared to the BAU scenario, with an additional 8% from deploying hybrid vehicles. On the other hand, increasing the share of mass transport activities can lead to a reduction of 40% in emissions by 2040. This will eventually reflect a net improvement in traffic congestion in addition to resolving other major environmental, economic and social problems associated with increased transport activity in Lebanon. The implementation of all mitigation combinations concurrently can reduce up to 67% of GHG emissions from the sector. Further details on methodology and data used are available in MoE/UNDP/GEF,2015b.

**Table 37:** Summary of the BAU and mitigation scenarios for transport
*(Shaded cells highlight the key changes from a scenario to another)*

<table>
<tr><th rowspan="2"></th><th rowspan="2">Gasoline and diesel price</th><th rowspan="2">Passenger transport system index[1]</th><th colspan="2">Passenger LDV powertrain shares</th></tr>
<tr><th>Conventional</th><th>Hybrid</th></tr>
<tr><td>BAU scenario:<br>Baseline year 2010</td><td rowspan="4">50% up by 2040</td><td rowspan="3">Constant over time</td><td>Constant over time[2]</td><td>0%</td></tr>
<tr><td>Mitigation option 1:<br>Increase share of Fuel Efficient Vehicles (FEV)</td><td>Share increase of small and midsize vehicles[3]</td><td></td></tr>
<tr><td>Mitigation option 2:<br>Increase share of FEVs and hybrid vehicles</td><td>Share increase of small and midsize vehicles[3]</td><td>10% of new registered vehicles[4]</td></tr>
<tr><td>Mitigation option 3:<br>Increase share of mass transport</td><td>Passenger Kilometer (PKM) share growth on collective passenger vehicles[5]</td><td>Constant over time[2]</td><td>0%</td></tr>
</table>

1 The “passenger transport system index” aims to allow the understanding of the modal shift in passenger transport (changes associated with shifts to/from private vehicles from/to mass transport). It is related with the shares of PKM on personal and mass passenger transport. An index of 1 reflects a full reliant transport system on collective passenger vehicles, and an index of 0 reflects a totally dependent system on personal vehicles. According to the transport activity data, the passenger transport index is barely 0.1 for Lebanon in 2010.
2 Same powertrain shares as 2010 (base year): 11.8% for small vehicles, 54.9% for midsize vehicles and 33.3% for large vehicles.
3 Target powertrain shares by 2040: 35% for small vehicles, 55% for midsize vehicles and 10% for large vehicles.
4 10% of new registered vehicles are assumed to be hybrids.
5 Increase the passenger transport system index to 0.15 in order to reduce the gap by 15% with high-populated European city (where passenger transport index is 0.45).

**Table 38:** Emission reduction potentials of transport mitigation scenarios

| | 2020 (Gg $CO_2$eq.) | 2040 (Gg $CO_2$eq.) | % reduction in 2040 compared to BAU |
|---|---|---|---|
| **Business-as-usual scenario (BAU)** | 4,747 | 5,514 | |
| **Mitigation option 1:** Increase share of Fuel Efficient Vehicles (FEV) | 4,502 | 4,486 | 19% |
| **Mitigation option 2:** Increase share of FEVs and hybrid vehicles | 4,431 | 4,007 | 27% |
| **Mitigation option 3:** Increase share of mass transport | 3,912 | 3,308 | 40% |

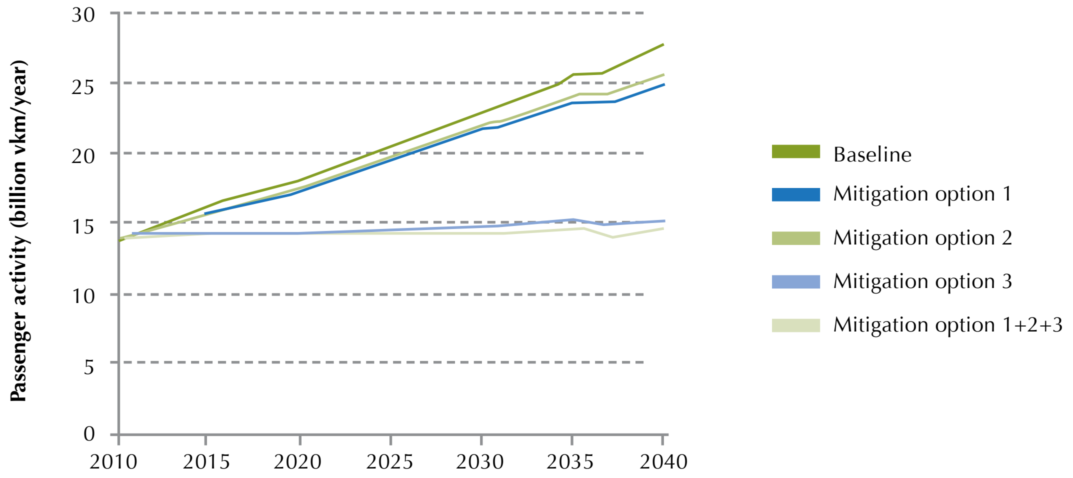



**Figure 40:** Change in transport activity

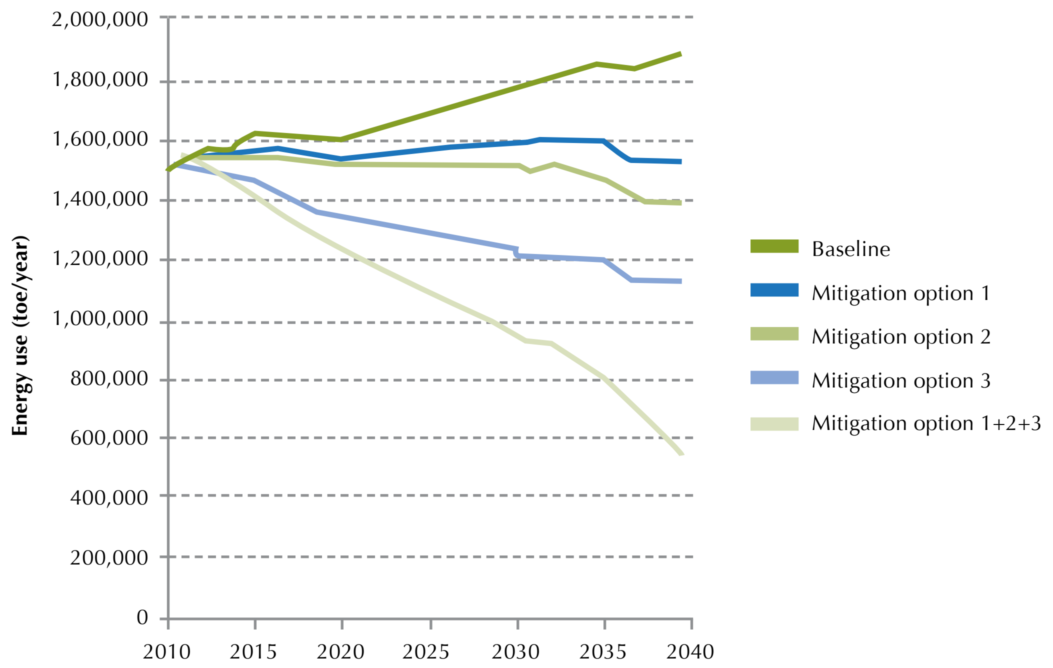



**Figure 41:** Change in energy use

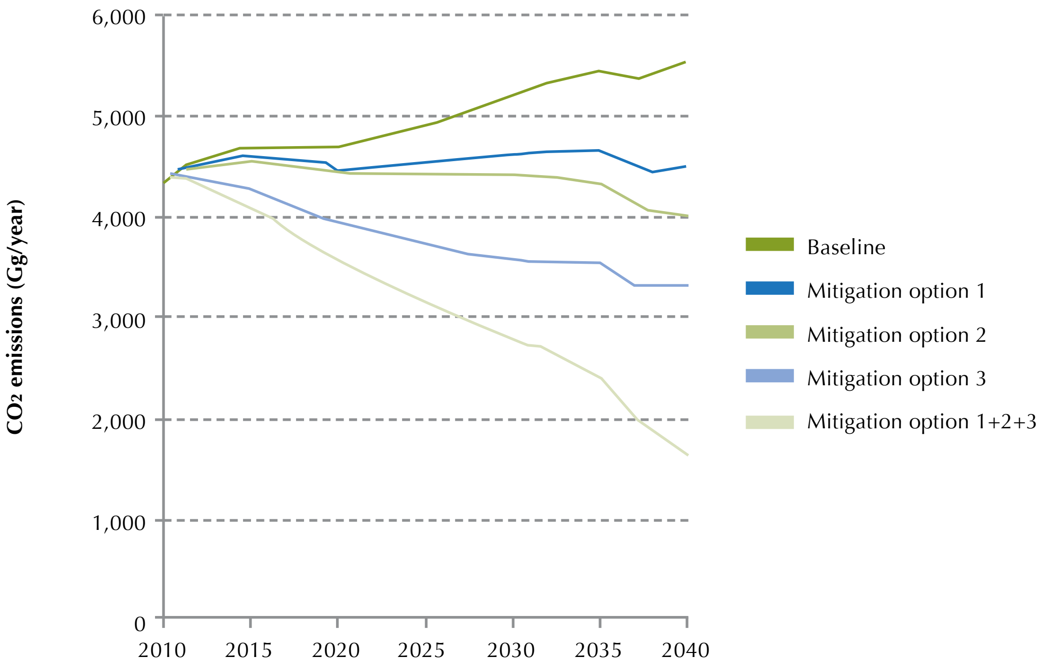



**Figure 42:** Change in $CO_2$ emissions

### *2.5.1. Emission reduction from mitigation option 1: Increase share of fuel efficient vehicles*

Despite the fact that this scenario reduces the passenger transport energy use and $CO_2$ emissions in 2040 by 19% compared to BAU scenario (Figure 41 and Figure 42), the transport system remains characterized by being highly personal vehicle oriented, as use of mass transport still represents less than 10% of the total passenger-kilometer transport activity.

The reduction in energy use and $CO_2$ emissions is not only the consequence of change in the share of fuel efficient vehicles (from 11.8% in 2010 to 35% in 2040), and large low efficiency vehicles (from 33.3% to 10% in 2040) but also the result in the fuel price increase by 50% in 2040. A no-growth fuel price scenario in 2040 would result in an increase in the transport vehicle-kilometer activity; consequently $CO_2$ emission savings will be counterweighed. Therefore, the fuel price (or from a wider perspective, the mobility cost per mode) is a key parameter to ensure the successful implementation of this scenario.

It is worth noting that the energy use and $CO_2$ emissions are somehow stabilized during the period 2010-2040 due to the balanced effect of increased passenger-kilometer activity and reduced fuel consumption of the fleet, since new fuel-efficient vehicles are replacing large and non-efficient vehicles.

**Table 39:** Passenger transport projections of the mitigation option 1 scenario

| | BAU | 2020 | 2040 |
|---|---|---|---|
| Total passenger vehicle stock | 1,292,433 | 1,652,426 | 2,425,655 |
| *2-3 wheelers* | 60,587 | 77,797 | 113,503 |
| *Passenger LDV* | 1,219,460 | 1,560,650 | 2,297,710 |
| *Buses* | 12,387 | 13,978 | 14,442 |
| Total vehicle-km (billion vkm/year) | 13.68 | 17.50 | 25.10 |
| Total energy use (toe/year) | 1,497,765 | 1,549,395 | 1,543,931 |
| Total $CO_2$ emissions (Gg $CO_2$/year) | 4,350 | 4,502 | 4,486 |

### 2.5.2. *Emission reduction from mitigation option 2: Increase share of fuel efficient vehicles and hybrid electric vehicles*

The increase in the share of hybrid cars to the Lebanese fleet induces an additional decrease of 8% in energy use and $CO_2$ emissions, bringing the total emission reductions of the mitigation option 2 to 27% compared to the BAU. This is due to the shift from high consuming large vehicles to high efficient ones (Figure 43) in addition to the deployment of hybrid technologies.

**Table 40:** Passenger transport projections of the scenario shift powertrain technology to FEV and HEV

| | BAU | 2020 | 2040 |
|---|---|---|---|
| Total passenger vehicle stock | 1,292,433 | 1,653,549 | 2,437,284 |
| *2-3 wheelers* | 60,587 | 77,838 | 113,950 |
| *Passenger LDV* | 1,219,460 | 1,561,750 | 2,308,995 |
| *Buses* | 12,387 | 13,961 | 14,339 |
| Total vehicle-km (billion vkm/year) | 13.68 | 17.57 | 25.70 |
| Total energy use (toe/year) | 1,497,765 | 1,525,047 | 1,378,665 |
| Total $CO_2$ emissions (Gg $CO_2$/year) | 4,350 | 4,431 | 4,007 |

### 2.5.3. *Emission reduction from mitigation option 3: Increase share of mass transport*

The shift to mass transport in this scenario results in 45% reduction of vehicle-kilometer activity by 2040 compared to the BAU scenario, which obviously reflects a net improvement in traffic congestion. As a result, the energy use and $CO_2$ emissions are reduced by 18% in 2020 and 40% in 2040 compared to the BAU.

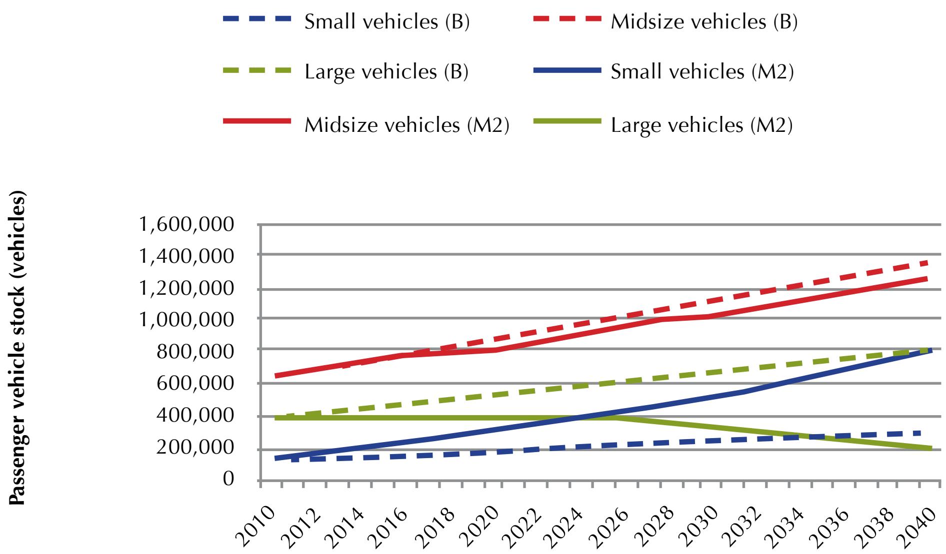



**Figure 43:** Passenger LDV activity under BAU and mitigation option 2 scenario

**Table 41:** Passenger transport projections of the scenario shift to mass transport

| | BAU | 2020 | 2040 |
|---|---|---|---|
| Total passenger vehicle stock | 1,292,433 | 1,515,801 | 2,163,453 |
| *2-3 wheelers* | 60,587 | 71,099 | 99,530 |
| *Passenger LDV* | 1,219,460 | 1,429,350 | 2,040,880 |
| *Buses* | 12,387 | 15,352 | 23,043 |
| Total vehicle-km (billion vkm/year) | 13.68 | 14.40 | 15.24 |
| Total energy use (toe/year) | 1,497,765 | 1,345,957 | 1,135,994 |
| Total $CO_2$ emissions (Gg $CO_2$/year) | 4,350 | 3,912 | 3,308 |

## 2.6 Enabling environment for the transport mitigation

Although the 3 mitigation options proposed here clearly indicate a significant emission reduction, a number of legal, institutional and technical barriers still hinder the proper implementation of a fleet renewal and mass transport programme. The root cause lies in the absence of an adequate national policy providing a coherent transport demand management strategy, mainly due to the government clash of interests and therefore its limited willingness to invest.

Measures for overcoming the barriers are specific to each mitigation option; however, a common enabling framework serving all mitigation options consists mainly of creating a financial

mechanism incentivizing the use of mass transit systems and environmentally friendly vehicles and discouraging the use and purchase of inefficient vehicles. A Nationally Appropriate Mitigation Action (NAMA) was developed in 2015 by the Ministry of Environment and UNDP to implement a car scrappage and replacement program for old vehicles, set up an institutional, legal and regulatory framework for managing and operating the NAMA and ensure the promotion of and awareness for fuel efficient vehicles. Other measures are certainly needed to efficiently plan and implement a national transport strategy, as presented in Table 42 and Table 43.

**Table 42:** Action plan for the implementation of scenario shift to fuel-efficient and hybrid electric vehicles

| Measures | Objective | Activities | Priority | Responsible party | Time scale | Monitoring and evaluation indicators |
|---|---|---|---|---|---|---|
| Create appropriate financial incentives for hybrid and fuel efficient cars purchase. | Reduce car purchase and ownership costs. | Exemption from customs and excise fees, exemption from registration fees, exemption from road-usage fee at registration. | 1 | MoF | Short term | Law on tax exemption by government |
| | | Payments of minimum salvage value (ex. USD 2,500) as down payment for car loan, extension of loan period to 8 years, reduce loan interest. | 1 | MoF<br>BDL<br>Commercial Banks | Short term | Car loan package and facilities for hybrid and fuel efficient cars |
| Create disincentives for import of non-efficient pre-owned cars. | Limit the import of pre-owned non fuel-efficient vehicles. | Reduce gradually maximum age of imported pre-owned vehicles to 3 years instead of 8 years with a mileage lower than 100,000 km. | 1 | Ministry of Interior and Municipalities (MoIM) | Short/ medium term | Law on import of pre-owned cars |
| Set up new coherent tax policies. | Cope with the high demand for high fuel consuming pre-owned vehicles. | Adopt a Bonus-Malus tax policy where polluters pay more annual road-usage fees, and where taxes such as the road usage fees are reconsidered according to fuel efficiency and/or emissions rather than engine displacement. | 2 | MoF | Short term | Bonus-Malus tax scheme |
| Renew the passenger car fleet. | Enhance the efficiency of the passenger car fleet. | Create a car scrappage program based on swapping current passenger cars with hybrid and fuel-efficient cars. | 2 | MoF<br>New cars dealers | Short term | Car scrappage program |
| Implement a vehicle retirement program. | Remove old cars from the fleet. | Create a car termination plant that deals with the car termination process after the swap in the scrappage program. | 3 | MoPWT<br>MoIM<br>MoE | Short/ medium term | Car termination plant |
| Implement legislation governing vehicle emissions. | Improve air quality, as transport sector is the main air polluter. | Update decree 6603/1995 relating to standards on permissible levels of exhaust fumes and exhaust quality to cover all types of vehicles. | 4 | MoE | Short/ medium term | Updated law 6603/1995 |
| | | Update the vehicle inspection program requirements taking into consideration special requirements for hybrid cars' inspection, in addition to mandating the presence of catalytic converters on conventional gasoline vehicles. | 4 | MoE<br>MoIM | Short/ medium term | Updated vehicle inspection program |

| Measures | Objective | Activities | Priority | Responsible party | Time scale | Monitoring and evaluation indicators |
|---|---|---|---|---|---|---|
| Create institutions to support technical standards for transportation. | Limit the import of deficient and crashed pre-owned cars. | Set up a mechanical inspection unit at the port of Beirut in charge of checking up the emissions and safety standards of imported pre-owned cars before entering the country. | 5 | MoPWT MoE | Short/ medium term | Mechanical inspection unit at the port of Beirut |
| Establish awareness campaign. | Promote hybrid and fuel-efficient cars. | Enforce all marketing campaign (billboards, TV, etc.) and new car dealers to post up factsheets on all vehicles, clearly displaying information on vehicle average fuel consumption and annual fuel costs, in addition to average $CO_2$ emissions. | 6 | MoPWT MoE | Short/ medium term | Awareness campaign |
| Create Mobility Monitoring Indicators (MMI) framework. | Develop sustainable transportation strategies. | Delegate the CAS with additional experimented personnel and authority to provide on yearly basis the complete MMI set. | 7 | MoPWT MoE | Short/ medium term | Mobility monitoring indicator framework delegated to CAS |

Source| adapted from MoE/URC/GEF, 2012

**Table 43:** Action plan for implementation of scenario shift to mass transport

| Measures | Objective | Activities | Priority | Responsible party | Time scale | Monitoring and evaluation indicators |
|---|---|---|---|---|---|---|
| Deploy effective infrastructure measures. | Shift travel demand to efficient transport means: bus transit system. | Design a complete bus network covering all boroughs within the Greater Beirut Area (GBA) and reserve lanes for bus operation. | 1 | Municipalities; Office des Chemins de Fer et des Transports en Commun (OCFTC) ; Directorate General of Roads and Buildings; Council for Development and Recon-struction (CDR) | Short term | Bus network on reserved lanes in GBA |
| Develop the supply channels of bus mass transit system. | Cover the designed network with sufficient number of buses and avoid irregularities in operation. | Ensure sufficient number of transit buses with the proper powertrain technology. | 1 | MoPWT | Short term | Purchase of the required buses |
| Give appropriate financial incentives for mass transit buses. | Decrease the cost incurred for the government on the import of the mass transit buses. | Exempt mass transit buses (and their spare parts) from custom and excise fees, and from registration fees. | 1 | MoF | Short term | Law on fee exemption enacted by the government |

**Table 43:** Action plan for implementation of scenario shift to mass transport

| Measures | Objective | Activities | Priority | Responsible party | Time scale | Monitoring and evaluation indicators |
|---|---|---|---|---|---|---|
| Encourage taxi and shared taxi owners to work in the bus mass transit system. | Limit the number of illegal taxis (17,000 taxis) and reduce the number of taxis (33,000 taxis). | Create an employee package for taxi drivers including social benefits, insurance, retirement plans, etc. | 1 | MoPWT<br>OCFTC<br>MoF | Short/ medium term | Package for bus drivers |
| Stimulate passengers demand to use mass transit buses. | Shift travel demand to efficient transport means: bus transit system. | Establish smart card ticketing schemes with appropriate reduced tariffs. | 2 | OCFTC | Medium term | Smart card ticketing schemes |
| Deploy effective operation measures. | Provide a quality of service that approximates that which car drivers have been used to with passenger cars. | Optimize the operation management of the bus mass transit system: conserve a clear and regular bus operation, implement a real-time information system, deploy personalized travel planning tools, implement transit signal priority, set up stringent maintenance and cleanliness program, construct relevant maintenance and repair workshops. | 2 | MoPWT<br>Directorate General of Civil Aviation and Maritime Affairs<br>OCFTC | Short/ medium term | Operation management strategy |
| Set up a regulatory framework for mass transit sector. | Manage the transport demand rather than being controlled by incumbents (private and public operators and the taxi owners). | Set clear regulations specifying the operation maneuvers of private bus operations and taxi owners. | 3 | MoPWT | Short term | Legislation on specifying the operation maneuvers between the various mass transit operators |
| Induce/initiate legislative reforms in urban planning laws, expropriation laws, and traffic laws. | | Draft new amended laws for increasing parking space and reserving lanes for buses. | 4 | MoPWT | Short/ Medium term | Parking spots and reserved lanes for mass transit buses in congested urban areas |
| Enhance the role of the Traffic Management Organization (TMO). | Carry out the traffic management mandates it was conceived for. | Develop technical expertise among TMO staff and high-level management. | 5 | MoPWT | Medium term | Well-trained TMO staff |
| Increase awareness of travelers on ecological and economic benefits of transit bus systems. | Shift travel demand to efficient transport means: bus transit system. | Provide information on $CO_2$, fuel and cost savings comparing to passenger cars. | 6 | MoPWT | Short/ medium term | info display tools on $CO_2$ and fuel savings: mobile applications, dedicated website, media campaigns, etc. |

Source| adapted from MoE/URC/GEF, 2012

## 3. Industrial processes and products use

No new mitigation analysis was performed to reduce emissions from Lebanon's industrial processes and products use, which represent 9.7% of the country's GHG emissions. Given that cement industries are the main source of these emissions, mitigation measures targeting this sector have already been presented in the Second National Communication, as summarized in Table 44. The efficient implementation of these mitigation options requires creating and sustaining a dialogue platform between the government and the cement factories where voluntary targets can be established for GHG emissions reduction.

**Table 44:** Mitigation measures for cement industries

| **Mitigation measure 1:** Increasing the additive blend in cement production | |
|---|---|
| Description | In blended cement, a portion of the clinker is replaced with industrial by-products, resulting in reduction of $CO_2$ associated with calcination of limestone in kilns. |
| $CO_2$ emission reduction | Emission reduction depends on the application level, the availability of blending materials, and on standards and legislative requirements. An increase of the share of additive such as fly from 27.66% to 35% would reduce the emissions by an estimated average of 1.32% of $CO_2$ emissions. |
| Other mitigation measures | |
| - Substitution of conventional pre-calcination method by a pre-calcination method aimed at $CO_2$ production in a highly concentrated form<br>- Replacement of parts of the plant (motors, raw mill vent fan, preheater fan, kiln drives, etc.) by efficient ones<br>- Application of energy management and process control in grinding<br>- Modification of clinker cooler (use of mechanical flow regulator)<br>- Optimization of heat recovery/upgrade clinker cooler<br>- Using efficient transport system (mechanical transport instead of pneumatic transport)<br>- Establishment of annual targets for GHG emissions reduction in cement factories | |

Source| UNFCCC, 2005; Hasanbeigi et al., 2010; Rodriguez N. et al., 2009; Huntzinger D. and Eatmon T., 2009

## 4. Agriculture sector

Agriculture is not a major source of GHG emissions, contributing only to 3.3% of national emissions. Therefore, it is not expected to reach significant emission reductions through implementing mitigation measures. However, planning adequate activities for the agriculture sector offers the opportunity to efficiently manage resources (water, fertilizers, seeds, fuel), increase rural income, sustain the livelihoods of 170,000 farm holdings and increase resilience to better adapt to the impacts of climate change. Therefore GHG mitigation measures in the agriculture sector have a greater impact and probability of success when concurrently addressing the concerns of farmers namely water scarcity, resource scarcity, drought and climate change variability.

Mitigation analysis of the agriculture sector concentrates on two mitigation options: conservation agriculture and fertigation, that have the potential of conserving water, fuel, and labor and increasing income while at the same time contributing to reducing GHG emissions. Further details on mitigation analysis of the agriculture sector are available in MoE/UNDP/GEF, 2015d.

## 4.1 Business-as-usual scenario

Due to resource limitations and lack of adequate information that allows the modelling of future agricultural activities in Lebanon, the BAU scenario estimates that future trends in GHG emissions in the sector follow a simple trend line of GHG emissions of the period 1994-2012. Therefore, and since past emissions from the agricultural sector show a decreasing trend, GHG emissions are estimated to reach 788 Gg $CO_2$eq. in 2020 and 595 Gg $CO_2$eq. in 2040, corresponding to a 32% decrease compared to 2012.

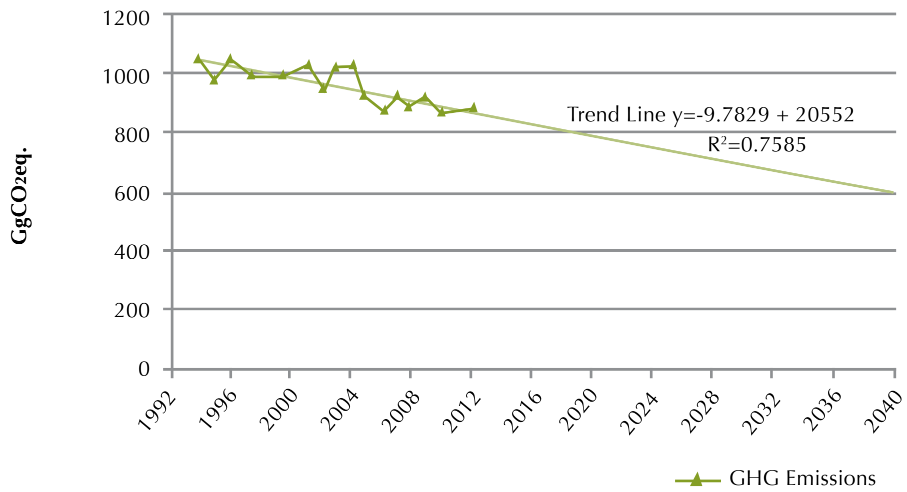



**Figure 44:** Emission trend for the agriculture sector under BAU scenario

## 4.2 Mitigation option 1: Conservation agriculture

The first mitigation scenario considers the conversion of 10% of land planted with cereals, olive and fruit trees to conservation agriculture by 2020 and 20% by 2040. Assuming that Lebanon has an average total area of 205,670 ha planted with cereals, olives and fruit trees (average of 2006-2010), the target would be to convert 20,567 ha in 2020, and 41,134 ha in 2040.

Conservation agriculture, which consists of no-tillage, permanent soil cover through crop residues or cover crops and crop rotation, contributes to climate change mitigation in many ways. By using 60-70% less fuel from reducing or eliminating tractor movement for ploughing and seedbed preparation, 20-50% less fertilizer and pesticides, and 50% less dependence on machinery and labor, conservation agriculture can reduce GHG emissions. In addition, it sequestrates 0.2-0.7 tonnes C/ha/year by reducing soil disturbance and decomposition of organic matter and reduces nitrous oxide emissions from less leaching and volatilization (Basch et al, 2012).

## 4.3 Mitigation option 2: Fertilizer best management practices-fertigation

The two major field practices responsible for increased $N_2O$ emissions from agricultural land are surface irrigation (flood or furrow), and application of solid N-fertilizers in high dosages. Therefore

fertigation, which is the practice where N fertilizers are administered in small repeated doses with drip irrigation, is proposed as the second mitigation measure for this sector.

The mitigation measure considers targeting potato plantations, which is a major cash crop in Lebanon, occupying 17% of the irrigated area. Potato plantations heavily rely on irrigation water (through sprinkler and microsprinklers) and their fertilization mostly consists of adding Nitrogen, Phosphorus and Potassium fertilizers in a pre-plant application, either with plowing or when making the furrows. It is also common to find farmers making a second split-application, 4 to 6 weeks after germination. Despite the high prices of chemical fertilizers, Lebanese farmers tend to exceed the amount that is required, using around 590 kg N/ha while the recommended agronomic rate is 220 kg N/ha (FAO, 2006).

The target of this mitigation measure is to introduce fertigation in 50% of the current irrigated potato land areas by 2020 and 100% by 2040. Assuming that the present land area is 11,533 ha (as an average of 2010-2012), this is translated to 5,767 ha and 11,533 ha by 2020 and 2040 respectively. This is a reasonable target when considering that potato cropped areas might increase by 2020 and 2040.

$N_2O$ emissions are reduced from evading the formation of water-logged zones, maintaining properly aerated soil conditions, providing crop fertilizer-N requirement in small applications at the time it is needed, and minimizing the leaching of nitrate-N to zones inducing denitrification. Other benefits of fertigation over traditional fertilization include low energy requirements, 85-90% efficiency in water use and improved plant nutrition management.

## 4.4 Emission reduction potential in the agricultural sector

The use of simple agricultural practices such as conservation agriculture and fertigation to a limited crop type and harvest area have shown the ability to reduce GHG emissions by 10% in 2020 and 27% in 2040, compared to the BAU scenario. Although this is not significant on the national basis, but its importance lies in the significant adaptation, economic and social co-benefits the implementation of these measures can provide.

**Table 45:** Total GHG emission reduction for 2020 and 2040 without mitigation (BAU) and with conservation agriculture and fertigation

| Year | BAU GHG emissions (Gg $CO_2$eq.) | Conservation Agriculture GHG emissions (Gg $CO_2$eq.) | % reduction | Fertigation GHG emissions (Gg $CO_2$eq.) | % reduction |
|---|---|---|---|---|---|
| 2020 | 788 | 729 | 7% | 767 | 3% |
| 2040 | 595 | 478 | 20% | 554 | 7% |

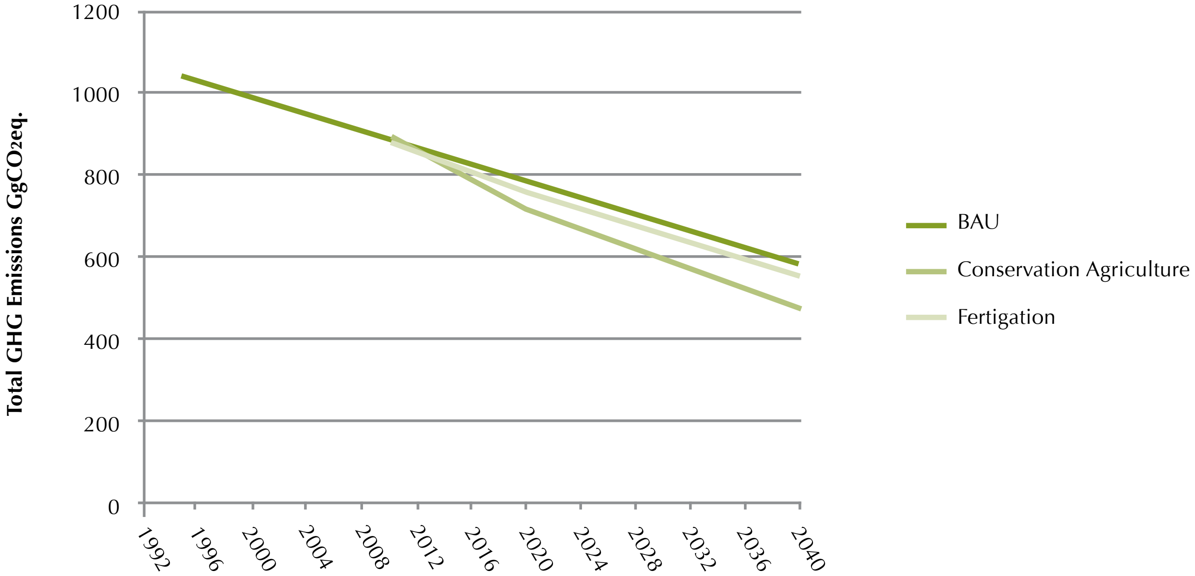



**Figure 45:** Emission reduction under conservation agriculture and fertigation compared to BAU

### *4.4.1. Emission reduction from mitigation option 1: Conservation agriculture*

GHG emission reduction in conservation agriculture is largely due to carbon sequestration resulting from the combination of no till, cover crops, and long crop rotation. This can reduce around 2.85 tonnes of $CO_2$ per hectare per year, amounting to a total of 117.2 million tonnes of $CO_2$ reduced in 2040 from converting 20% of land planted with cereals, olive and fruit trees to conservation agriculture. Further details on data and methodology used are available in MoE/UNDP/GEF, 2015d.

The potential GHG emission reductions from fuel savings, from the direct and indirect emissions of N fertilizers saved when leguminous cover crops are used and from the improvement of soil organic matter and less leaching of applied nitrogen have not been factored in this calculation due to lack of relevant data. Thus the mitigation potential presented here is the minimum that can be achieved through practicing conservation agriculture.

The abatement cost of converting land to conservation agriculture can be significant. Based on Lebanon's Technology Needs Assessment (MoE/UNDP/GEF, 2012), shifting 4,000 ha of fruit trees and 15,000 ha of cereals and legumes to conservation agriculture over a 10 year period costs around USD 3.47 million (including cost for research and development, training programmes, and subsidies to farmers), which roughly translates to a cost of USD 183/ha. Therefore, converting 20,567 ha can cost approximately USD 3.7 million, at an abatement cost of USD 0.06 per kg $CO_2$.

### *4.4.2. Emission reduction from mitigation option 2: Fertigation*

Emission reduction from fertigation is mainly due to direct or indirect mechanisms associated with N fertilizer application, which can save up to 370 kg N/ha through improving the application of fertilizers.

Fertigation reduces GHG emissions through the following mechanisms:

- Precision in administering N fertilizer at low doses at the time it is needed, with repeated dosing to provide crop fertilizer requirement. This results in lower direct $N_2O$ emissions from soils.
- Efficiency in applying irrigation water and its controlled application to maintain properly aerated soil conditions and minimize leaching losses. This results in lower direct and indirect $N_2O$ emissions from soils.
- Solid fertilizers containing ammonium-N applied on soil surface are subject to the volatilization of $NH_3$ to the air, especially with Lebanese calcareous soils. Using fertigation allows fertilizers to be applied in smaller quantities at the root zone, thus dramatically reducing $NH_3$ volatilization losses to the air. This results in lower indirect $N_2O$ emissions from soils.

Applying fertigation to 11,533 ha of potatoes plantation by 2040 can save up to 41.06 Gg $CO_2$eq. per year. Since fertigation can be applied to almost all crops that could be irrigated through drip irrigation, the example on potato can be replicated to other crops.

**Table 46:** GHG reduction potential of fertigation on potatoes for 2020 and 2040

| | 2020 | 2040 |
|---|---|---|
| Percent conversion of potato plantation to fertigation | 50% | 100% |
| Hectares converted to fertigation | 5,767 | 11,533 |
| Direct emission reduction Gg $CO_2$eq/year ** | 11.69 | 23.38 |
| Indirect emission reduction from volatilization Gg $CO_2$eq/year | 1.04 | 2.08 |
| Indirect emission reduction from leaching Gg $CO_2$eq/year | 7.80 | 15.6 |
| $CO_2$ emissions reduction (Gg $CO_2$/year ) | 20.53 | 41.06 |

**The calculation is based on the difference between the currently applied amounts of fertilizer (590 kg N/ha) with the recommended rate (220 kg N/ha).
Calculation details available on MoE/UNDP/GEF, 2015d

### 4.5 Adaptation co-benefits of mitigating agriculture

Conservation agriculture has strong mitigation and adaptation synergies. Conservation tillage has been shown to enhance soil structure and thus water holding capacity, making agriculture more resilient to extreme weather events such as heavy rains and drought. In addition, the increase in soil water content in dry climates can limit soil erosion, decrease desertification and make agricultural lands more resilient to climate change. Furthermore, the buildup of soil organic matter improves soil fertility and plant health and thus enhances the capacity of crops for climate change adaptation. Conservation agriculture also contributes to sustainable rural development by increasing yield and farm income, sustaining or increasing agricultural land, reducing surface and groundwater pollution, and maintaining the diversity of rural landscape through enhanced crop diversity and cover crops.

Fertigation can also contribute to adapting the climate change impacts though reducing water pollution caused by excessive use and leaching and runoff of N fertilizer, and more efficient water use. It also contributes to improve input use efficiency, increasing yield and farm income, increasing irrigated agricultural land, and reducing irrigation water demand.

### 4.6 Economic co-benefits of mitigating agriculture

Converting agricultural lands to conservation agriculture does not only rely on a change of behavior and practice, but also imposes costs that should be borne by the farmers. The major costs are associated with equipment, seeds, herbicides, and labor. However, costs are often met with increased profitability of conservation agriculture due to lower expenditures on energy, reduced cost of mechanization, reduced cost of fertilizer, more efficient use of water, and higher yield. Small demonstration projects conducted by LARI, AUB, GIZ, ICARDA, ACSAD and others in Lebanon compared the cost of production with increased income generation and results showed higher net revenues under conservation agriculture of USD 400/ha for barley and USD 560/ha for barley-vetch mixture in the Bekaa region. Other results show a net revenue of USD 980/ha for using conservation agriculture and drop irrigation on maize.

There are other economic benefits associated with environmental protection (mainly surface and groundwater quality) and ecosystem services that conservation agriculture provides as summarized in Table 47.

**Table 47:** Potential economic benefits and costs associated with conservation agriculture

| Benefits | Cost |
|---|---|
| Reduction of GHG emissions, resulting from carbon sequestration and reduced use of N fertilizers | Purchase of specialized planting equipment |
| Reduction in on-farm costs: savings in time, labor and mechanized machinery | Short-term pest problems due to the change in crop management |
| Increase in soil fertility and retention of soil moisture, resulting in long-term yield increase, decreasing yield variations and greater food security | Cost of additional herbicides |
| Stabilization of soil and protection from erosion leading to reduced downstream sedimentation | Development of appropriate technical packages and training programs |
| Reduction in nitrate contamination of surface water and groundwater | Opportunity cost of crop residues (crop residues are used as livestock fodder) |
| Reduction in flooding and the re-emergence of dried wells | Cost of cover crops |
| Recharge of aquifers as a result of better infiltration | Possible cost of additional labor |
| Reduction in air pollution resulting from soil tillage machinery | |

Source| Adapted from FAO, 2001

Fertigation has also significant economic benefits from changing both the type and amount of fertilizers. Using Urea, Diammonium Phosphate (DAP) and Potassium sulphate ($K_2SO_4$) in fertigation, can reduce the cost by about 67% while reducing 1,700 kg of fertilizer use. Comparison of cost of fertigation versus conventional irrigation is presented in Table 48.

**Table 48:** Comparison of amount of fertilizer, price per tonne and total price of applied fertilizer in fertigation with sprinkler irrigation on potatoes

| Conventional (Sprinkler) | | | | Fertigation (Drip) | | | |
|---|---|---|---|---|---|---|---|
| **Fertilizer** | **Amount kg/ha (kg N /ha)** | **Price USD/tonne** | **Total price USD** | **Fertilizer** | **Amount kg/ha (kg N /ha)** | **Price USD/tonne** | **Total price USD** |
| **N-P-K 15-15-15** | 1,500 (225) | 700 | 1,050 | **Urea** | 376 (173) | 500 | 188 |
| **Ammonium nitrate** | 1,000 (330) | 500 | 500 | **Diammonium Phosphate** | 260 (47) | 700 | 182 |
| **N-P-K 20-20-20** | 100 (20) | 2,000 | 200 | **Potassium Sulphate** | 330 | 700 | 221 |
| **Potassium Nitrate** | 100 (13) | 800 | 80 | | | | |
| **Total** | 2,700 (590) | | 1,830 | **Total** | 966 (220) | | 591 |

Source| adapted from FAO, 2006

Demonstration projects across Lebanon also showed that other economic benefits can be also realized in fertigation through decreased water use, increased yield and revenue, (5 tonnes of potatoes by hectare), saving in labor cost (USD 70/ha) and fuel cost (USD 1,100/ha) in addition to saving in water estimated at 1,656 $m^3$/ha (Bashour and Nimah, 2004 and USAID, 2011). Thus the net profit each year from fertigation is estimated at USD 3,096 per hectare.

**Table 49:** Cost/Benefit analysis of fertigation and drip irrigation on potatoes in Lebanon

| | |
|---|---|
| **Cost of drip irrigation (USD/ha)** | 3,500 |
| Life time of the project 10 years<br>Cost per year (USD/ha/year) | 350 |
| Annual interest on investment + maintenance = 6% (USD/ha) | 213 |
| Total annual cost per year (USD/ha) | 563 |
| Value of saved labor (USD/ha) | - 70 |
| Value of saved fuel (USD/ha) | -1,100 |
| Value of saved fertilizer (USD/ha) | -1,239 |
| Value of increased yield (USD/ha) | -1,250 |
| **Net profit per year (USD/ha)** | **3,096** |

Source| adapted from Bashour and Nimah (2004) and USAID (2011)

## 4.7 Enabling environment for the agriculture mitigation

Table 50 presents the main barriers for the proper implementation of the proposed mitigation measures for the agricultural sector.

**Table 50:** General constraints to adoption of conservation agriculture and fertigation

| Gaps and constraints | Measures |
|---|---|
| Farmer perception that cultivation (ploughing) is essential for crop production<br><br>Limited knowledge and know-how to adopt the practices of conservation agriculture and fertigation | Awareness campaigns and field farmer schools , including demonstration classes on conservation agriculture and fertigation and training of landowners, farmers and extension personnel on the practices and benefits of these practices in dryland and irrigated farming |
| Limited availability of affordable seeding machinery appropriate for conservation agriculture | Leverage international financial support for capacity building and assist farmers in financing the high initial cost associated with conservation agriculture |
| Perceptions of worsening of weeds, pests, and disease infestation | Conduct trials with farmer participatory approach to reduce or eliminate pests and weeds. |
| Unwelcoming policy and extension environments<br><br>Lack of research to fully explore the potential of conservation agriculture and fertigation for GHG mitigation | Increase research to fully explore the potential of conservation agriculture and fertigation for increased carbon sequestration and reduced $N_2O$ emissions |
| Inappropriate land tenure system in Lebanon. The majority of growers are either small-land owners with less than 5 hectares or growers that lease land on a yearly basis from large-land owners and thus do not have the incentive to pursue conservation agriculture, the benefits of which requires several years to reap. | Involve landowners early on in the decision-making of adopting the technology and in participatory research. Improve research on small mechanization (small no-till planters) adapted to small farms. |
| Competing demands for crop residues and lack of interest in cover crops. Cereal growers usually rent their land for grazing after harvest. Resource poor farmers are hesitant to invest in cover crops they do not consume. | Set up pilot projects on different cropping patterns that address the competing demands for crop residues and the reluctance to use cover crops. |
| Misconception on the suitability of fertigation for potato growing | Organize field demonstrations to prove that this can be applicable to all crops that could be irrigated via drip (vegetables, fruit trees, banana plantations, etc.) in addition to tubers. |
| High initial capital cost of drip irrigation | Set up pilot projects to demonstrate that additional revenue from the saved fertilizer use and fuel cost will recuperate the initial investment after just one year. |
| Clogging of drip irrigation system | Encourage research and development to increase efficiency of drip irrigation. |

## 5. Land use, land use change and forestry

Land Use, Land-Use Change and Forestry (LULUCF) proved to be a major sink for greenhouse gases with an average of -3,321 Gg/year of $CO_2$eq. sequestrated over the inventory period of 1994 to 2012. However, a net decrease of 12% in $CO_2$ removals was recorded between 1994 and 2012, mainly due to the conversion of vegetated lands into settlements. In addition, forest fires appeared to have largely contributed to the increase in GHG emissions and thus decreasing the net sequestration effect of the LULUCF sector.

LULUCF climate mitigation measures can have significant environmental and socio-economic impacts depending on the measures and the means by which they are implemented. LULUCF-based interventions that have the potential to significantly contribute to climate change mitigation options include 1) protecting existing carbon reservoirs from losses associated with deforestation, forest and land degradation and urbanization, 2) enhancing carbon sequestration and expanding carbon stocks through reforestation, afforestation, and forest management and 3) reducing emissions of other greenhouse gases, primarily $CH_4$ and $N_2O$ from land use interventions, mainly from fire management.

Therefore, the measures presented here tackle the 3 components of effective mitigation while offering direct and indirect economic impact, consistency with national development goals, and economic feasibility. Further details on the mitigation analysis of the LULUCF are available in MoE/UNDP/GEF, 2015e.

### 5.1 Business-as-usual scenario

The baseline scenario targets forest lands since they have one of the largest contributions to the changes in emissions and removals from LULUCF. The main changes taken into account were land conversions to settlements, burned areas, and afforestation activities (MoA, MoE, AFDC, LRI). In the absence of a clear trend for these changes, the cumulative averages (1999-2012) were used as baseline values. It is to be noted that areas of lands converted to forestlands by afforestation between 1999 and 2012 were added to the forestland area after 20 years of their conversion.

Based on trend data of 1999-2012, the cumulative removals from existing forests and wooded land until 2030 are estimated to 55,5547.14 Gg $CO_2$eq. , with an average of -3,086 Gg $CO_2$eq. per year and the net cumulative emissions from forest fires and afforestation activities are estimated to 6,760.5 Gg $CO_2$eq. with an average of 376 Gg $CO_2$eq. per year (Table 52).

### 5.2 Mitigation option 1: Maintaining the current extent of Lebanon's forest and other wooded land cover

The first mitigation scenario includes maintaining the current extent of Lebanon's forest and other wooded land cover through the following activities:

- Reducing the extent of new losses in the cover due to urbanization and compensating the annual loss to urbanization through afforestation/reforestation activities. This will preserve the removal potential of existing forests (cumulative -55,547.14 Gg $CO_2$eq. for the period 2013-2030) and add -1,907.66 Gg $CO_2$eq. cumulative removal from afforestation activities.

- Modifying fire risk through fire vulnerability reduction and prevention of harmful fires (second component of Lebanon's national strategy for forest fire management decision no. 52/2009).
- Preventing large and intense wildfires by adopting the strategic objective from the fourth component (response) of Lebanon's national strategy for forest fire management (AFDC/MoE, 2009). This will keep annual emissions from forest fires to 434.08 Gg $CO_2$eq. for the 2013-2030 period.

## 5.3 Mitigation option 2: Increasing Lebanon's forest and other wooded land cover by 7% by 2030

The second scenario involves increasing the current extent of Lebanon's forest and other wooded land cover by 7% by 2030 through afforestation/reforestation activities in line with the national programs, initiatives, and principles to restore forested lands (refer to MoE/UNDP/2015e). Estimating that the current cover of forests and other wooded land is 24.3%, this scenario suggests:

- Increasing the current extent of Lebanon's forest and other wooded land cover up to 31.3% through afforestation.
- Facilitating the natural post-fire recovery of vegetation (fifth component of the national fire management strategy decision no. 52/2009).
- Preventing large and intense wildfires by adopting the strategic objective from the fourth component (response) of Lebanon's national strategy for forest fire management (AFDC/MoE, 2009).

To increase the forest cover by 7% (73,164 hectares) during the period of 2013-2030, there is a need to plant about 4,064 hectares per year over 18 years. In addition, the increase in forest and other wooded land cover accounts for the annual average losses to urbanization estimated to 244.78 ha/year. Therefore, the total area for afforestation will be around 4,309 ha/year, thus inducing an average yearly removal of -208 Gg $CO_2$eq. between 2013 and 2030.

**Table 51:** Emission reduction potential from implementing scenario 1 and 2

| Mitigation scenario 1 | Mitigation scenario 2 |
|---|---|
| Reducing and compensating losses due to urbanization through the implementation of appropriate economic instruments: the cumulative reduction potential from 2013 to 2030 is equal to 39 Gg $CO_2$eq. (Approx. 0.57%). | Increasing the current extent by 7% through the implementation of appropriate economic instruments. The cumulative reduction potential from 2013 to 2030 is equal to 1,792 Gg $CO_2$eq. (Approx.26.5%). |
| Preventing large and intense wildfires: the cumulative reduction potential from 2013 to 2030 (including $CH_4$ and $N_2O$) is equal to 813 Gg $CO_2$eq. (Approx. 12%). | Preventing large and intense wildfires: the cumulative reduction potential from 2013 to 2030 is equal to 813 Gg $CO_2$eq. (Approx.12%). |
| Total cumulative reduction potential of mitigation scenario 1 is equal to 852 Gg $CO_2$eq. (Approx. 12.57%). | Total cumulative reduction potential of mitigation scenario 2 is equal to 2,605 Gg $CO_2$eq. (Approx. 38.5%). |
| It should be noted that the prevention of large and intense wildfires contributes to 95.42% of the emission reduction of the mitigation scenario. | It should be noted that the prevention of large and intense wildfires contributes to 31.2% of the emissions reduction of the mitigation scenario. |

## 5.4 Emission reduction potential in LULUCF

The results of the implementation of both mitigation scenarios indicate a 12.57% reduction potential for scenario 1 and 38.5% reduction potential for scenario 2 in comparison to the baseline scenario.

In scenario 1, 854.8 Gg $CO_2$eq. will be reduced during 2013-2030, with prevention of intense and large wildfires being the main source of reduction. Whereas, in scenario 2,147 Gg $CO_2$eq. will be reduced mainly from increasing the forest cover by afforestation (Table 52). Generally, fire prevention would involve short to medium-term activities, while afforestation would involve medium-to long-term activities.

**Table 52:** Details on emissions and removals from LULUCF

| Scenario | Description | 2013 | 2020 | 2030 | Cumulative |
|---|---|---|---|---|---|
| BAU | Removal from existing forests and wooded lands Gg $CO_2$eq. | -3,077.19 | -3,090.91 | -3,086.69 | -55,547.14 |
| | Emissions from forest fire Gg $CO_2$eq. | 479.28 | 479.28 | 479.28 | 8,627.10 |
| | Removals from afforestation Gg $CO_2$eq. | -84.60 | -109.46 | -111.52 | -1,866.54 |
| | Net emissions Gg $CO_2$eq. | 394.69 | 369.83 | 367.77 | 6,760.57 |
| | Total removal Gg $CO_2$eq. | -2,682.50 | -2,721.08 | -2,718.93 | -48,786.57 |
| M1 | Removal from existing forests and wooded lands Gg $CO_2$eq. | -3,077.19 | -3,090.91 | -3,086.69 | -55,547.14 |
| | Emissions from forest fire Gg $CO_2$eq. | 434.08 | 434.08 | 434.08 | 7,813.37 |
| | Removals from afforestation Gg $CO_2$eq. | -84.82 | -111.26 | -115.96 | -1,905.66 |
| | Net emissions Gg $CO_2$eq. | 349.25 | 322.81 | 318.11 | 5,905.71 |
| | Total removal Gg $CO_2$eq. | -2,727.94 | -2,768.10 | -2,768.58 | -49,641.43 |
| | Reduction from baseline Gg $CO_2$eq. | 45.43 | 47.02 | 49.65 | 854.86 |
| M2 | Removal from existing forests and wooded lands Gg $CO_2$eq. | -3,077.19 | -3,090.91 | -3,086.69 | -55,547.14 |
| | Emissions from forest fire Gg $CO_2$eq. | 434.08 | 434.08 | 434.08 | 7,813.37 |
| | Removals from afforestation Gg $CO_2$eq. | -182.22 | -208.67 | -213.36 | -3,659.11 |
| | Net emissions Gg $CO_2$eq. | 251.85 | 225.41 | 220.71 | 4,152.48 |
| | Total removal Gg $CO_2$eq. | -2,825.34 | -2,865.50 | -2,865.98 | -51,394.66 |
| | Reduction from baseline Gg $CO_2$eq. | 142.84 | 144.42 | 147.05 | 2,608.09 |

The trends of the scenarios are greatly influenced by the previously conducted afforestation activities. For instance, the decrease in emissions between 2013 and 2018 is closely associated with the afforestation activities resulting in the increase of $CO_2$ removals. Starting 2019, the $CO_2$ removals capacity of forested areas planted between 1999 and 2012 (followed in conversion for 20 years) slightly decreases. The growth rate of the mature forests becomes quite constant in comparison with their growth as new plantations. Consequently, their $CO_2$ removal capacity decreases resulting in a slight increase in the net emissions from the changes.

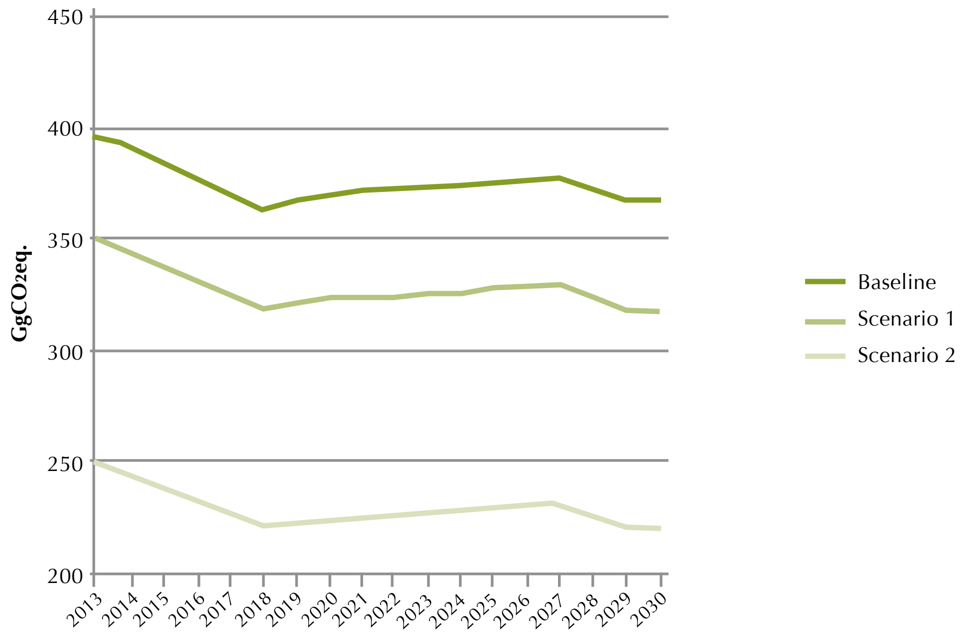



**Figure 46:** Net removals from the changes in the LULUCF sector: baseline versus mitigation scenarios

## 5.5 Enabling environment for the LULUCF mitigation

The implementation of the proposed mitigation actions would require an integrated approach involving improved legislation and law enforcement, land use planning, education and awareness, economic valuation of forests, and funding. In this context, the "reforestation fund" stipulated by the forest law of 1949 (article 98) represents a promising source for funding.

The provision of appropriate economic instruments can also ensure an efficient implementation of the mitigation measures, such as payment for ecosystem services (preferably for scenario 1), subsidy for reforestation (preferably for scenario 2) as well as land conversion and community forestry, as explained in Table 53.

**Table 53:** Proposed economic instruments to support implementation of LULUCF mitigation scenarios

| Instrument name | Instrument definition | Instrument applicability in Lebanon |
|---|---|---|
| Payment for Environmental Services (PES) | A voluntary transaction where a well-defined environmental service is being bought by a "buyer" (private individual or institution) from a "provider" (forestland owner). | - PES requires a detailed environmental valuation of the services provided by forests.<br>- Fragmentation of land ownership and the increase in the value of built estate can be a major obstacle.<br>- Income from environmental services of the forests cannot compensate that of real estate project.<br>- PES is more efficient with large landowners such as religious endowments. |
| Subsidy for reforestation | A benefit given by the government to groups or individuals usually in the form of a cash payment or tax reduction for the plantation of new areas. | - Requires good economic valuation of the forests as a good basis for the calculation of the subsidy.<br>- Better applied on large privately owned lands. |
| Conservation payment programs for land conversion | Establishment of a payments system for farmers to convert agricultural land to other uses, including forests or agroforestry. | - Instrument is usually acceptable by farmers since it does not require the conversion of the whole area to forest but rather creating corridors around the fields.<br>- Conversion of croplands to agroforestry still provides the economic opportunities of agricultural products.<br>- The long-term investment of 20 years for a forest to become fully productive can be an issue of concern |
| Establishment of community forests | Establishment of community-based organizations through which forest users are given collective management responsibility (but not ownership) of local forests. | - It provides a source of income for communities through bidding for grazing and pruning for charcoal production.<br>- Income is used for developmental projects within the community.<br>- The absence of a detailed plan and monitoring system may result in the overexploitation of the forest resources in addition to possible managerial conflicts within the committees in charge of the land. |

**Table 54:** Implementation frameworks for LULUCF mitigation scenarios

| **Mitigation Scenario 1: Maintaining the current extent of Lebanon's forest and other wooded land cover.** | | |
|---|---|---|
| **Economic instruments** | **Activities** | **Target Group** |
| Payment for Environmental Services (PES)<br><br>Conservation payment programs for land conversion<br><br>Establishment of community forests | Reducing the extent of new losses in the cover due to urbanization. | Land owners, municipalities, local communities |
| | Compensating the annual loss to urbanization through afforestation/reforestation* activities. | Compensating the annual loss to urbanization through afforestation/reforestation* activities. |
| | Modifying fire risk through fire vulnerability reduction and prevention of harmful fires (second component of the national strategy for forest fire management). | Land owners, municipalities, local communities<br>NGO, farmers, regional development offices (agriculture forestry), local authorities<br>Land managers (agriculture agents, rangers)<br>Research institutions<br>Land users, private enterprises, residents and tourists in areas of risk |
| | Preventing large and intense wildfires (fourth component of the national strategy for forest fire management). | Forestry and natural resources department<br>Municipalities, local communities<br>Fire department, fire brigade at the civil defense,<br>Forest guards<br>NGOs |
| **Mitigation Scenario 2: Increasing the current extent of Lebanon's forest and other wooded land cover 7% by 2030.** | | |
| **Economic instruments** | **Activities** | **Target Group** |
| Subsidy for reforestation*<br><br>Conservation payment programs for land conversion<br><br>Establishment of community forests | Increasing the current extent of Lebanon's forest and other wooded land cover up to 31.3% through afforestation*. | Land owners, municipalities, local communities<br>NGOs, farmers, tree nursery owners |
| | Facilitating the natural post-fire recovery of vegetation (fifth component of the national fire management strategy). | Land owners, municipalities, local communities<br>Forest guards, land managers and users<br>NGOs, research institutions |
| | Preventing large and intense wildfires (fourth component of the national strategy for forest fire management). | Forestry and natural resources department<br>Municipalities, local communities,<br>Fire department, fire brigade at the civil defense,<br>Forest guards<br>NGOs |
| ***Afforestation's potential funding sources and estimated costs** | | |
| **Funding agencies** | • **National: GoL (Reforestation Fund, National Environmental Fund, MoF-BDL), municipalities (revenues from forest investments), private sector.**<br>• **International: EU, FAO, IUCN, UNDP (GEF), USAID (USFS)** | |
| **Estimated build-up costs** | • **15 USD per tree**<br>• **7,700 USD per hectare (for a total 4,309 ha/year)**<br>• **Approximate cost: 33,180,000 USD per year (over 20 years)** | |

## 6. Waste and wastewater sector

The mismanagement of waste and wastewater in Lebanon is responsible for emitting 10.7% of national greenhouse gas emissions, and 90.5% of national methane emissions. Finding efficient and sustainable management solutions for waste and wastewater has become a priority at the country level, especially following the waste crisis of 2015. Despite the disagreement on a national waste strategy, various management options, which can also be considered as mitigation measures, can be implemented to dually tackle sustainable development and climate change.

This section explores the potential of emission reduction from introducing and progressively increasing the rate of use of waste-to-energy technologies in waste management in addition to increasing the rate of wastewater collection and treatment and consequently, decreasing discharges in septic tanks and in surface waters. Further details on the analysis of mitigation measures are available in MoE/UNDP/GEF, 2015f.

### 6.1 Business-as-usual scenario

The BAU scenario is based on the current waste management practices and assumes that new sanitary landfills with gas recovery will be built and open dumpsites will be closed simultaneously. It is estimated that this scenario should achieve 80% of disposal in Solid Waste Disposal Sites (SWDS) by 2020 and 70% by 2040, while the remaining proportion of waste is reused/composted/recycled. This scenario also assumes that methane from landfilling activities is recovered through flaring or electricity generation and only part of the healthcare waste is being incinerated. The BAU scenario is the most pessimistic among the three considered scenarios whereby no mitigation action is taking place and the government is not being able to agree on and implement a waste management strategy.

Under the BAU scenario, GHG emissions will reach around 3,332 Gg in 2040, despite the increase in recycling rates. With only a conservative forecast of healthcare waste incinerated, $CO_2$ emissions are negligible compared to $CH_4$ emissions.

**Table 55:** Assumptions under the BAU scenario

| Year | Population | Percentage of waste into SWDS | Percent recycling | Methane recovery (Gg) | Incineration of healthcare waste (Gg) | GHG emissions ($CO_2$eq.) |
|---|---|---|---|---|---|---|
| 2020 | 5,912,587 | 80% | 20% | 18 | 1.5 | 2,697.08 |
| 2040 | 8,202,103 | 70% | 30% | 15 | 1.9 | 4,039.52 |

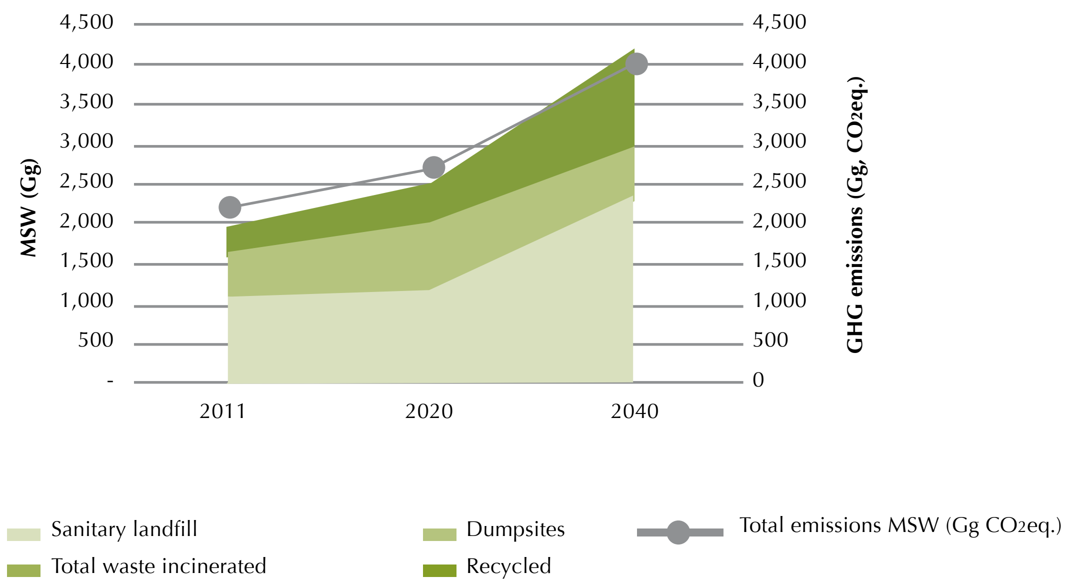



**Figure 47:** GHG emissions from solid waste management under BAU

The BAU scenario also assumes the continuation of the current wastewater management practices through 2040. Despite the population increase, no treatment of wastewater will be implemented, thus discharge fractions in surface water and in septic tanks remain unchanged, i.e. 72% and 28%.

Although GHG emissions from wastewater are by far less important than those from solid waste, emissions (mainly $CH_4$) increase between 2012 and 2040 are mainly due to population growth, reaching 70% increase in 2040.

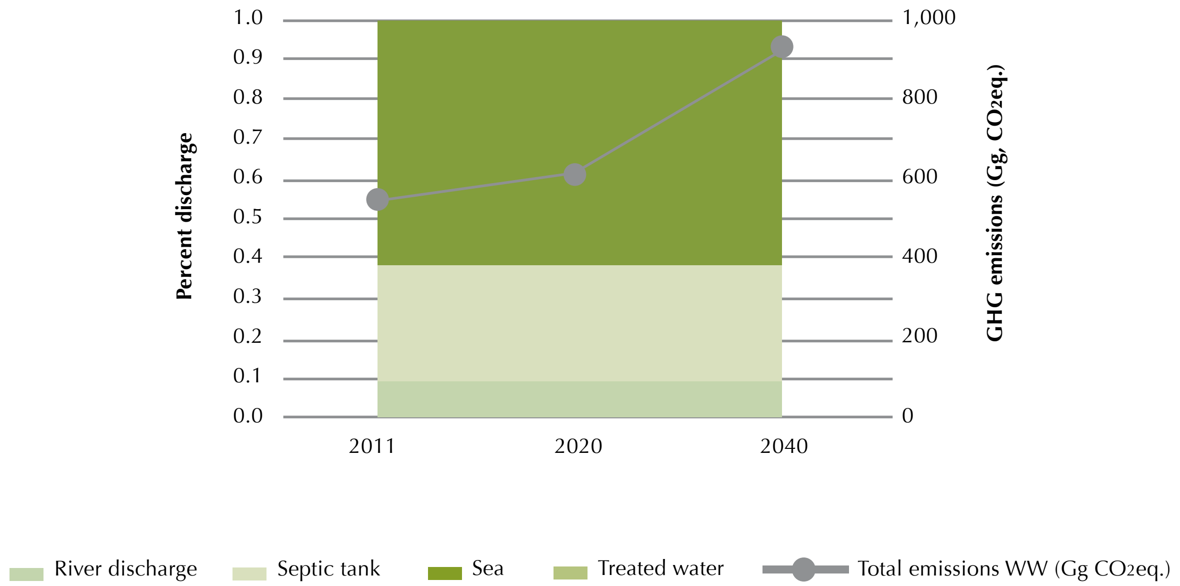



**Figure 48:** GHG emissions from wastewater under BAU

**Table 56:** Summary results of GHG emissions under the BAU scenario

| Year | Solid waste related emissions (Gg $CO_2$eq.) | Wastewater related emissions (Gg $CO_2$eq.) | Total GHG emissions (Gg $CO_2$eq.) |
|---|---|---|---|
| 2020 | 2,697.08 | 635.44 | 3,332.52 |
| 2040 | 4,039.52 | 927.53 | 4,967.05 |

## 6.2 Mitigation option 1: Waste-to-energy in 2 governorates and up to 50% wastewater treatment

Based on the proposed solid waste management strategy approved by the CoM and taking into consideration the feasibility study prepared by Ramboll (CDR, Ramboll, 2012) on adopting waste to energy alternatives as a treatment of solid waste, this first mitigation scenario considers that the Waste-to-Energy (WtE) technology will be used in Lebanon by 2020 only in Beirut and Mount Lebanon. Outside these 2 governorates, landfilling and uncontrolled dumping will still be practiced as in the business-as-usual scenario. Recycling rates will also follow the BAU scenario. Methane recovery is anticipated in smaller amounts since part of the waste is expected to be incinerated.

**Table 57:** Assumptions under scenario 1

| Year | Population | Percentage of waste into SWDS | Percentage of waste treated through WTE | Percent recycling | Methane recovery (Gg) |
|---|---|---|---|---|---|
| 2020 | 5,912,587 | 50% | 30% | 20% | 14 |
| 2040 | 8,202,103 | 30% | 40% | 30% | 11 |

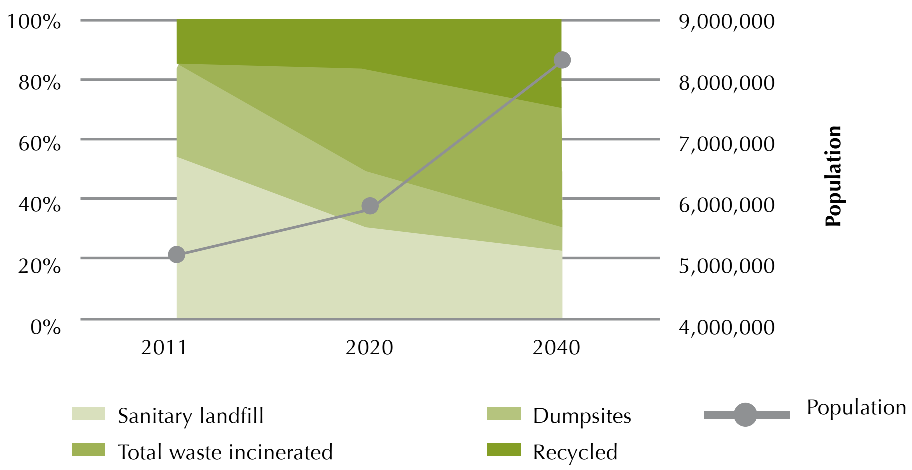



**Figure 49:** Scenario 1 - solid waste management options through 2040

With respect to developments in wastewater management, this scenario is based on the recent national water sector strategy developed by the Ministry of Energy and Water (MoEW, 2010a), which lays out the plans of the GoL in the management of wastewater and consequently quantities of wastewater treated and/or discharged without treatment in the various bodies. Scenario 1 assumes improved wastewater treatment services reaching 35% in 2020 and 51% in 2040. This implicitly reduces discharges in surface waters and in the sea, without any implication on household connections and use of septic tanks.

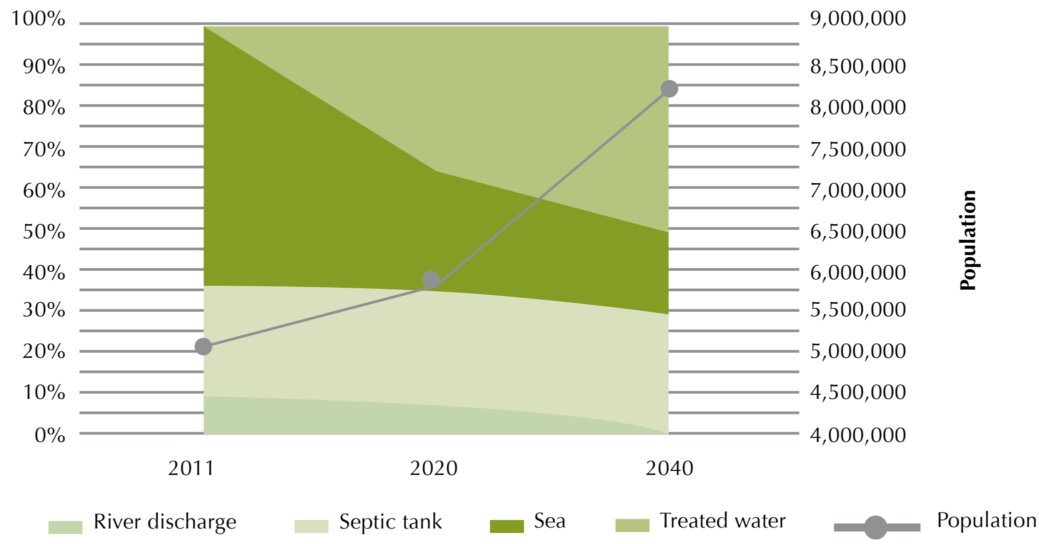



**Figure 50:** Scenario 1 - wastewater management options through 2040

## 6.3 Mitigation option 2: Waste-to-energy in 4 governorates and up to 74% wastewater treatment

This second scenario considers that the waste-to-energy technology will be used in Lebanon by 2020 in 4 locations, Beirut, Mount Lebanon, Saida and Tripoli. In the rest of the country, landfilling and uncontrolled dumping will still be practiced. Similarly to scenario 1, methane recovery is anticipated in smaller amounts since a bigger portion of the waste is expected to be incinerated.

**Table 58:** Assumptions under scenario 2

| Year | Population | Percentage of waste into SWDS | Percentage of waste treated through WTE | Percent recycling | Methane recovery (Gg) |
|---|---|---|---|---|---|
| 2020 | 5,912,587 | 40% | 40% | 20% | 11 |
| 2040 | 8,202,103 | 20% | 50% | 30% | 7 |

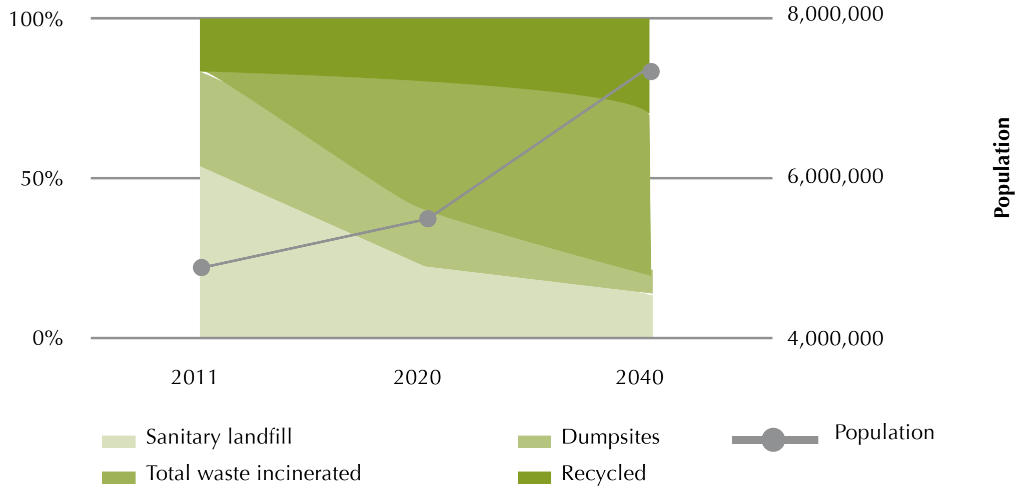



**Figure 51:** Scenario 2 - solid waste management options through 2040

For wastewater management, scenario 2 assumes significant improvements in wastewater treatment services reaching 51% in 2020 and 74% in 2040. This scenario also includes gradually improving wastewater collection and therefore decreasing discharges not only in surface waters but also in septic tanks.

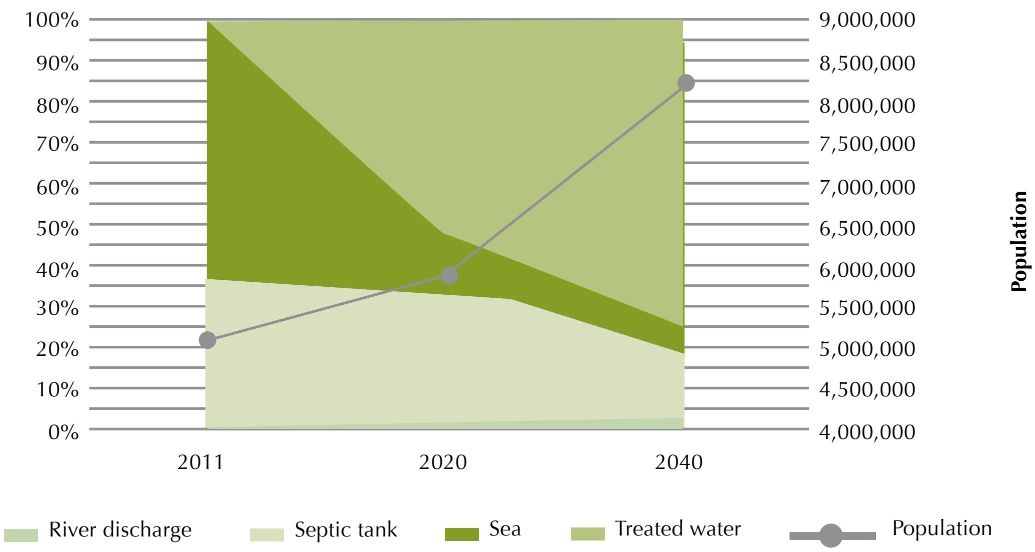



**Figure 52:** Scenario 2 - wastewater management options through 2040

## 6.4 Emission reduction potential in waste and wastewater

The implementation of the proposed mitigation options have the potential to reduce the sector's emission by 32% by 2040 with mitigation scenario 1 and up to 38% with scenario 2.

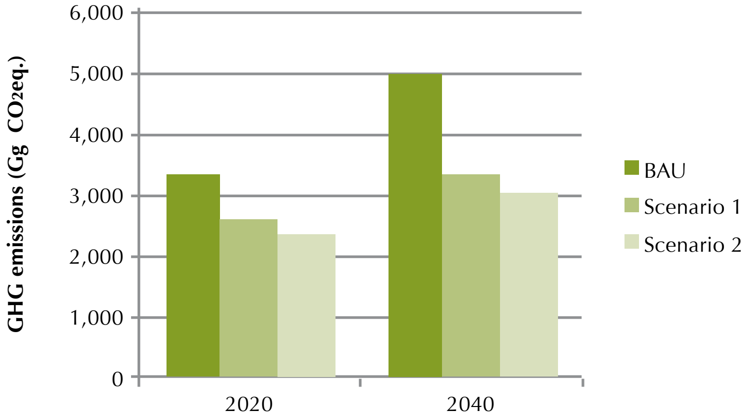



**Figure 53:** GHG emissions comparison of scenario 1 and scenario 2 with the BAU

Most of the emission reductions are the result of treating solid waste, and more specifically using waste to energy to replace landfilling and open dumping. Indeed, with the introduction of this technology, $CO_2$ is generated while $CH_4$ is decreased as compared to the BAU scenario. Therefore, the reduction of $CH_4$ emissions, which have a GWP of 21, is the main reason behind the drop of overall GHG emissions, although $CO_2$ emissions have increased for the same years. Mitigation scenario 1 can reduce up to 1,261 Gg $CO_2$eq. by 2040 or 31% of the BAU emissions from solid waste. Mitigation scenario 2 can further increase it to 34%.

**Table 59:** Summary of mitigation measures for solid waste

| Year | Total waste generated (Gg/year) | % deposited in SWDS | % deposited in sanitary landfills | % going to dumpsites | % recycled reused composted | % of MSW incinerated | GHG emissions (Gg $CO_2$eq.) |
|---|---|---|---|---|---|---|---|
| BAU 2020 | 2,589.71 | 80% | 48% | 32% | 20% | - | 2,697.08 |
| BAU 2040 | 4,191.27 | 70% | 56% | 14% | 30% | - | 4,039.52 |
| Sc1 2020 | 2,589.71 | 50% | 30% | 20% | 20% | 30% | 2,157.74 |
| Sc1 2040 | 4,191.27 | 30% | 24% | 6% | 30% | 40% | 2,778.39 |
| Sc2 2020 | 2,589.71 | 40% | 24% | 16% | 20% | 40% | 2,012.95 |
| Sc2 2040 | 4,191.27 | 20% | 16% | 4% | 30% | 50% | 2,672.36 |

Although in absolute amounts, wastewater treatment can only reduce up to 529 Gg $CO_2$eq. by 2040, it can relatively be considered significant since this means reducing 57% of emissions from wastewater, in addition to solving one of the most prominent environmental problems of the country. Indeed the reduction of $N_2O$ is the result of increasing the proportion of wastewater that is treated as compared to the BAU scenario where all wastewater is discharged in nature without treatment.

**Table 60:** Summary of mitigation measures for wastewater

| Year | Discharge in septic tank | Discharge in rivers | Discharge in sea | Percent of treatment | GHG emissions (Gg $CO_2$eq.) |
|---|---|---|---|---|---|
| BAU 2020 | 28% | 9% | 63% | - | 635.44 |
| BAU 2040 | 28% | 9% | 63% | - | 927.53 |
| Sc1 2020 | 28% | 7% | 30% | 35% | 450.42 |
| Sc1 2040 | 28% | 1% | 20% | 51% | 596.97 |
| Sc2 2020 | 28% | 1% | 20% | 51% | 363.56 |
| Sc2 2040 | 15% | 1% | 10% | 74% | 398.19 |

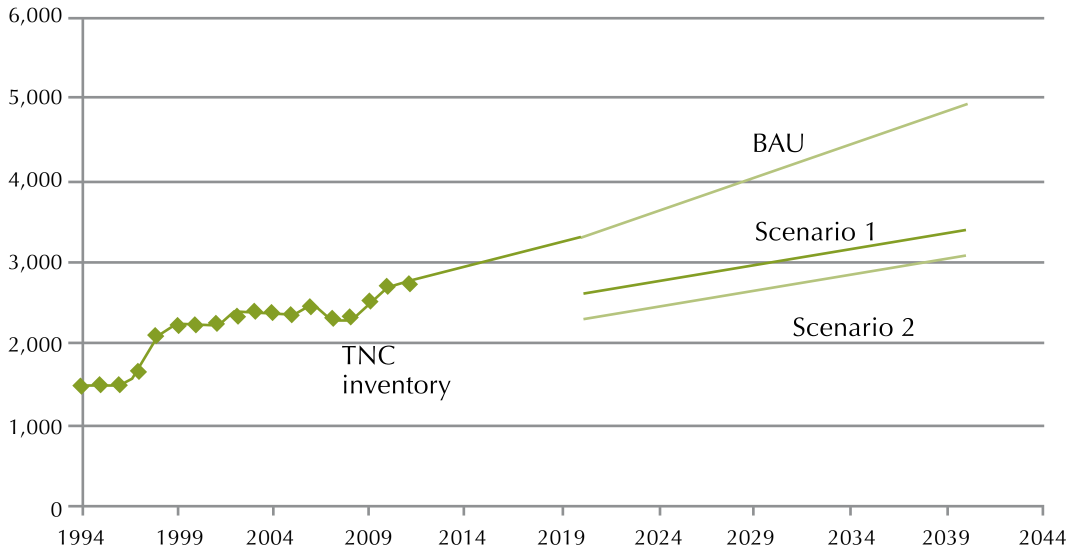



**Figure 54:** Summary of the GHG emissions inventory and mitigation scenarios

## 6.5 Enabling environment for the waste and wastewater emissions mitigation

The assessment of GHG reduction potential was based on policies and plans set by the government for the next decades. The actual implementation of these policies remains a function of a number of local factors, technical, political, financial and institutional that could hinder or delay the implementation of the approved strategy and consequently introduce changes in the GHG reduction potential of the mitigation measures. Indeed, the implementation of the strategy, although approved by the CoM, remains in a deadlock due to the following:

- At the political level: no commitment from the CoM on the allocation of funds needed for the implementation of the adopted national strategy for solid waste management in Lebanon.
- At the financial level: financing for the phased implementation of the strategy is not readily available.
- At the implementation level: the complex and lengthy administrative procedures for the

tendering process are delaying actual implementation of both the waste and wastewater strategies (approval of the strategy, design, tendering and award of the project, implementation of the works, commissioning, passing through the complex institutional set-up at the central and local levels simultaneously).

Therefore, recommended specific actions and options for improvement of waste and wastewater management are summarized here below (adapted from SWEEP-Net, 2010):

- Issue the policy/ legal/ institutional framework to enable the implementation of waste and wastewater strategies.
- Finalize the applicable decrees necessary for the implementation of the solid waste and wastewater management legislations following their approval, in the aim to ensure a sustainability of the system (cost recovery, institutional, etc.).
- Ensure the institutional viability of any project in terms of commitment and support at both the national (CoM and Parliament) and local (municipalities) levels.
- Ensure political commitment (CoM and Parliament) in support to locally developed waste and wastewater strategies.
- Ensure the building up of a global consensus at all levels: communities, municipalities and government, through public awareness campaigns.
- Avoid confinement in standard political visions aiming at balanced regional development. Focus should rather be targeted at those areas with local consensus on an agreed upon plan.
- Follow a "progressive coverage" for waste management schemes by proceeding first with tendering of waste disposal operations where there is agreement over specific final disposal locations.
- Ensure that old dumpsites closure is an integral part of local development vision or strategy. International donors should be encouraged to fund closure of dumps as part of an integrated plan that includes the pre-condition of having an alternative treatment facility. Funding would cover site assessment, detailed design of remediation activities, implementation of remedial project.
- Create a priority list for closure of all dumps, establishing the 10 most important ones to close.
- Set the open, transparent and competitive procedures in contracting the private sector in waste and wastewater management.
- Organize capacity building campaigns and workshops for capacity development at both the national and the municipal level in the various technical and administrative sectors.
- Support specific campaigns for promoting sorting of wastes at the source in the household (priority in a pilot village which already disposes of a composting treatment plant, hence clearly illustrating the correlation between sorting at the source and the improvement of the waste management in general and compost quality in particular).
- Set a mechanism for data management and sharing between the various stakeholders.
- Monitor, in the medium and long term, the future implementation of the strategies, in order to identify the eventual gaps and needed adjustments and improvements.

# 4 CLIMATE RISKS, VULNERABILITY AND ADAPTATION ASSESSMENT

# 4 CLIMATE RISKS, VULNERABILITY AND ADAPTATION ASSESSMENT

## 1. Future climatic changes in Lebanon

Analysis of historical climatic records of Lebanon from the early 20th century with future emissions trajectories indicates that the expected warming in Lebanon has no precedent.

Projected climatic changes in the Arab region and their impacts on natural resources were recently assessed through the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources in the Arab Region (RICCAR) which was led by the United Nations Economic and Social commission for Western Asia (ESCWA). RICCAR used an integrated assessment methodology that combined climate change impact assessment with socio-economic and environmental vulnerability assessment, based on the generation of dynamically downscaled regional climate modeling projection covering the Arab/Middle East North Africa (MENA) domain and a series of associated ensemble outputs.

The Arab domain was established for framing the application of Regional Climate Models (RCMs) in accordance with the Coordinated Regional Climate Downscaling Experiment (CORDEX) of the World Climate Research Programme. The projections are based on two of the Representative Concentration Pathways (RCPs) developed by the Intergovernmental Panel on Climate Change (IPCC), RCP4.5 (moderate case scenario) and RCP8.5 (current scenario with the highest levels of potential GHG emissions or worst-case scenario). The projections were then linked to two regional hydrological models to specifically analyze the impact of climate change on the region's freshwater resources. These outputs were in turn used as inputs into a regional vulnerability assessment to identify hotspots across the Arab region.

RICCAR results show a consistent warming trend with a general increase in the frequency of warm days and longer summer periods in the Arab region. The rise in temperature becomes increasingly evident across the region by the end of the century.

In Lebanon, the results of an ensemble of projections show an increase of 1.2°C and 1.7°C (RCP4.5 and RCP8.5, respectively) by mid-century (2046-2065) and up to 3.2°C by 2100 compared to the baseline period of 1986-2005 (Figure 55). A decrease in precipitation of 4 to 11% is projected (RCP4.5 and RCP8.5, respectively), with drier conditions by the end of the century (up to 5.8 mm decrease in average monthly precipitation) (Figure 56).

Temperature and precipitation extremes will also intensify by the end of the century, causing the seasonal prolongation and geographical expansion of drought periods. RICCAR results show increasing trends of warming, reaching up to 43 additional days with maximum daily temperature higher than 35°C. The projections also trends towards drier conditions with an increase in number of consecutive dry days (maximum annual number of consecutive dry days when precipitation $< 1.0$ mm) by the end of the century. This indicated that the dry summer season will extend in length, projected by an additional maximum number of 6 consecutive drought days. This combination of significantly less wet and substantially warmer conditions will result in hotter and drier climate.

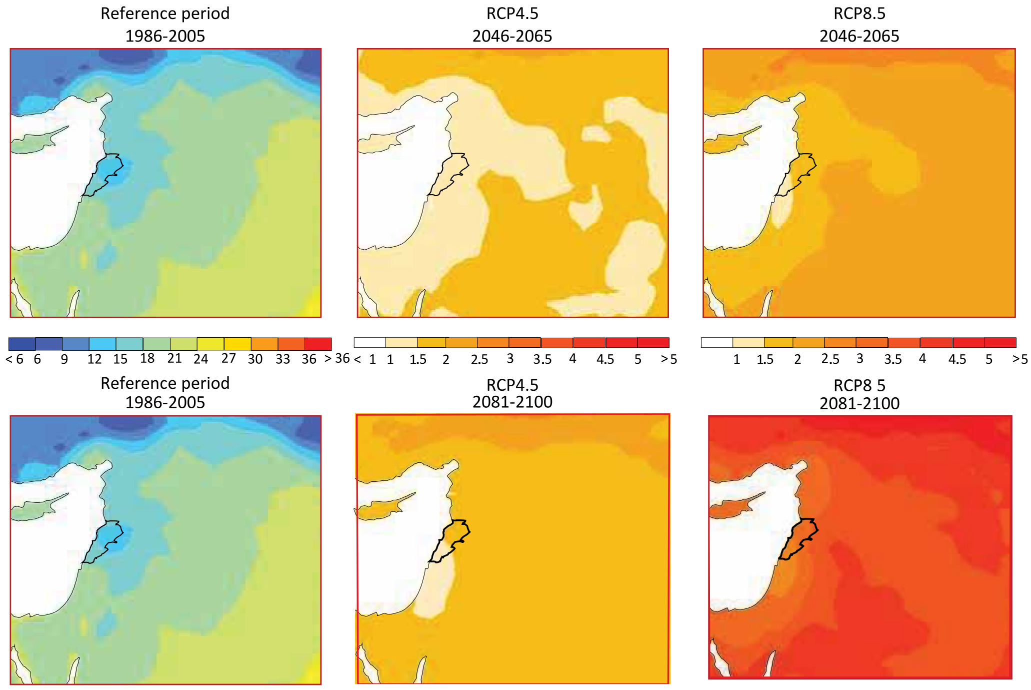



**Figure 55:** Projected changes in temperatures in Lebanon
Source | Adapted from ESCWA, 2015

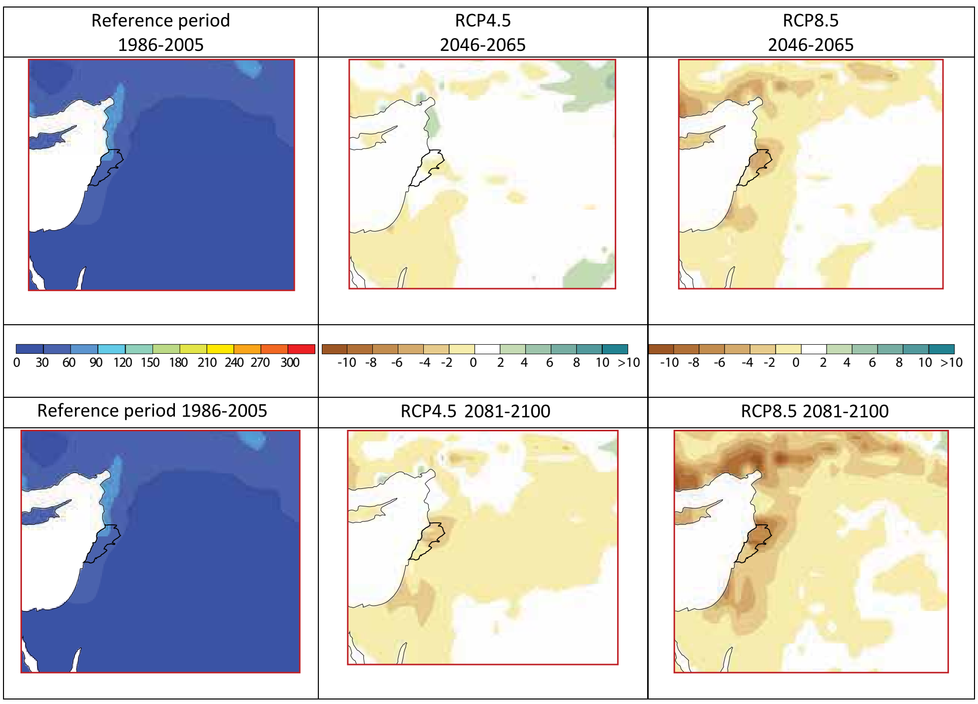



**Figure 56:** Projected changes in precipitations in Lebanon
Source | Adapted from ESCWA, 2015

**Table 61:** Climate change indices by 2080-2100

| Indices | Code | Definition | Projected changes in Lebanon | |
|---|---|---|---|---|
| | | | **Under moderate scenario (RCP4.5)** | **Under worst case scenario (RCP8.5)** |
| Changes in temperature index | | | | |
| Summer days Tmax> 35°C | SU35 | Annual number of days when Tmax> 35°C | + 15 days | + 43 days |
| Changes in precipitation index | | | | |
| Maximum length of dry spell | CDD | Maximum annual number of consecutives dry days (precipitation <1mm) | + 1 day | +6 days |

Source | Adapted from ESCWA, 2015

## 2. Impacts of climate change in Lebanon

Climatic changes are expected to have diverse implications for Lebanon's environment, economy, and social structure. Extreme weather events can have adverse impacts on public heath, human settlements, transport infrastructure, agriculture production, power supply and the economy at large. The fragile biodiversity, ecosystems, and natural habitats will be threatened by increased forest fires, pest outbreaks and sea level rise. The country's vulnerability assessment does not single out one specific vulnerable sector, but identifies the agriculture, forestry, water resources, human health, coastal zone, and tourism sectors as most vulnerable with distinctive social, economic and environmental implications (MoE/ UNDP/GEF, 2011).

Table 62 presents a summary of the impacts that climate change will have on several sectors in Lebanon, as identified in the Second National Communication. Since recent climate models such as RICCAR's confirmed the changes that were identified in the Second National Communication, it is assumed that the sectoral impacts are still the same.

**Table 62:** Summary of sectoral climate change impacts in Lebanon

| | |
|---|---|
| **Less snow** | - Loss of ski season as a reduction of 40% of the snow cover of Lebanon with an increase of 2°C in temperature is projected, reaching 70% decrease in snow cover with an increase of 4°C.<br>- Less precipitation will fall as snow, with snow that currently falls at 1,500 m shifting to 1,700 m by 2050, and to 1,900 m by 2090.<br>- Decrease in snow residence time from 110 days to 45 days. |
| **Less water availability** | - Snow will melt earlier in the spring. These changes will affect the recharge of most springs, reduce the supply of water available for irrigation during the summer, and increase winter floods by up to 30%. The declines in precipitation will also exacerbate existing challenges to water availability for agriculture, commercial and residential uses.<br>- This will have adverse impacts on rivers and groundwater recharge, and will affect water availability during the summer season and in drought periods. |
| **Increase drought period** | Droughts will occur 15 days to 1 month earlier, and countrywide drought periods will extend 9 days longer by 2040 and 18 days longer by 2090. The already dry regions, such as the Bekaa, Hermel, and the South, will experience the sharpest effects. In addition, cost impacts will be added to irrigation needs, as more pumping hours will be required, therefore consuming more energy. |
| **Less agriculture productivity** | - Soil moisture will decline in response to higher temperatures, reduced precipitation, and higher evapotranspiration.<br>- Changes in temperature and rainfall will decrease productivity of lands currently used to produce most crops and fruit trees, especially wheat, cherries, tomatoes, apples, and olives, and may affect the quality of grapes, despite some transient benefits from the expansion of the coastal plantations such as banana and tomatoes.<br>- Most crops also will face increased infestation of fungi and bacterial diseases. |
| **Higher energy demand** | Higher temperatures in summer will increase demand for cooling, with related consumption of electricity increasing 1.8% for a 1°C increase in temperature, and 5.8% for a 3°C increase in temperature. |
| **Weakened tourism** | Winter outdoor tourism will diminish as warmer temperatures and reduced precipitation shorten the skiing season. Other impacts on tourism will occur in response to changes in ecosystems, loss of natural attractions, such as sandy public beaches, and structural damage to the nation's archaeological heritage. |
| **Sea level rise** | Sea levels will rise up to 30-60 cm in 30 years, if the recent rate of rise, approximately 20 mm/year, continues. The higher sea levels will lead to seawater intrusion into aquifers, increase the risk of coastal flooding and inundation, increase coastal erosion, cover sand beaches, and alter coastal ecosystems in natural reserves and elsewhere. |
| **Forests at risk** | Forests will be adversely affected by climate change, especially that forest stands suffer from fragmentation, pest outbreaks, forest fires and unsuitable practices that already challenge their capacity to survive and develop. |
| **Increased mortality and morbidity** | Lebanon will experience increases in the incidence of infectious diseases, morbidity, and mortality resulting from higher temperatures, more frequent extreme weather events, increased malnutrition from droughts and floods that affect agriculture, and reduced availability of clean water. Increases in temperatures will cause 2,483 to 5,254 additional deaths per year between 2010 and 2030.<br>The effects of climate change on public health include the outbreak of infectious diseases from changing temperatures, increased morbidity and mortality from heat and other extreme weather events, malnutrition from droughts and floods and other water-borne, rodent-borne diseases and vector-borne diseases. |
| **Damaged infrastructure** | Buildings and public infrastructure will suffer damage from changing patterns in precipitation, sea level rise, and increased frequency and intensity of storms. This damage will materialize from inundation of coastal settlements and buildings, floods, mudslides, and rockslides. |

## 3. Economic costs to Lebanon's households, businesses and communities from climate change

Extensive evidence shows that changes in climate stemming from emissions of carbon dioxide ($CO_2$) and other Greenhouse Gases (GHG) already impose economic costs on Lebanon's households, businesses, communities, and government (DARA and Climate Vulnerable Forum, 2012). For example, higher temperatures erode the health of children and the elderly, reduce the productivity of workers exposed to the heat, and reduce the productivity of crops. Reductions in water supplies diminish the wellbeing of water users and changes in ecosystems impair their ability to provide valuable goods and services.

This section quantifies many of these potential costs. To do so, it knits together information from the best available sources of data and most recent research. The results offer general calculations of the costs Lebanon's households, businesses, communities, and government might expect in 2020, 2040, and 2080. The 2020 estimates generally represent near-term costs that cannot be avoided, insofar as the climate impacts of past GHG emissions are still unfolding, and inertia in economic systems and behaviors suggest that the current trends in climate and its effects likely would continue with little change. The 2040 estimates generally represent costs that likely would materialize within the lifetimes of most Lebanese citizens alive today. The 2080 estimates generally represent costs that likely would materialize within the lifetimes of today's children.

### 3.1. Analytical assumptions and approach

The calculation of climate-related costs in monetary terms is a straightforward, three-part process:

- First, obtain a credible, quantitative estimate of the per-year change in some factor—public health, agricultural production, energy costs, etc.—expected to result from climate change that will worsen the future economic wellbeing of households, businesses, or communities in Lebanon.
- Second, obtain a credible estimate, in monetary terms (2015 US dollars), of the per-unit value of the factor.
- Third, multiply the two estimates to yield an estimate of the potential economic harm per year.

For those costs where other studies have developed a credible estimate of the quantitative change, the per-unit value, or both, the present analysis employs that information. Where this information does not exist, the present analysis estimates these variables directly. In every case, the results are sensitive to the reliability of the assumptions and data employed. The costs shown in this report are estimates of the costs that global GHG emissions might impose on Lebanon. Each cost estimate embodies uncertainty about multiple factors: how the emissions will affect the climate, how the changing climate will affect ecosystems and socio-economic systems, how these effects will reduce the value of goods and services available to Lebanon's households, businesses, and government. Because of this uncertainty, it is impossible to estimate each cost with absolute precision. Instead, costs are approximated through the use of rounding rules. The comprehensive methodological details are available in the full report which the present section is based on (MoE/UNDP/GEF, 2015g).

Whenever possible, the monetary calculations reflect the IPCC's scenario RCP8.5, which is characterized by the highest levels of potential GHG emissions. The top line of Figure 57 shows this scenario. In many cases, however, estimates of climate-related impacts on Lebanon come from research that employed other scenarios of future GHG emissions. Some research reports identify the underlying scenario only in general terms. Whenever possible, the analysis identifies the scenario being employed.

The bottom line in Figure 57 illustrates expected emissions under the IPCC's current lowest-emissions scenario, known as RCP2.6. It includes the most extreme, yet plausible, assumptions about changes in economic development, behaviors, etc., beginning in 2010, that would yield reductions in GHG emissions. Insofar as such changes have not fully materialized, RCP2.6 likely overstates the potential reductions, at least for the near future. This bias notwithstanding, the analysis sometimes uses data from RCP2.6 to describe the potential costs Lebanon would avoid if global society took the steps necessary to move emissions from the path represented by RCP8.5 to the path represented by RCP2.6.

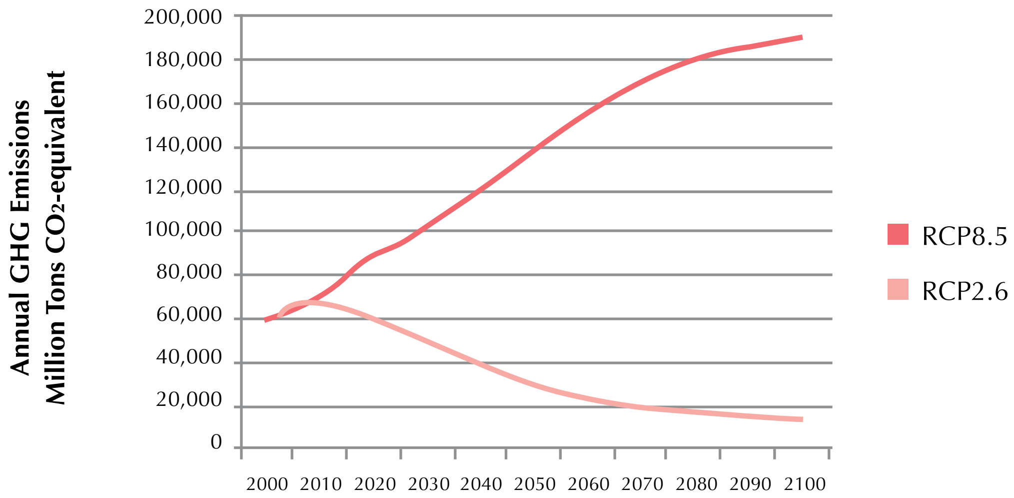



**Figure 57:** Actual GHG emissions, 2000 and 2010, and projected emissions under RCP8.5 and RCP2.6, 2020-2100. Source | RCP Database (2015) and Myrhe et al. (2013).

Other important assumptions embedded in this analysis include:

- The percentage changes in economic and social characteristics of Lebanon presented throughout this analysis are relative to a Business-As-Usual (BAU) scenario of population and Gross Domestic Product (GDP) growth. The BAU scenario does not take into account the effect that political instability, social unrest or regional turmoil might inflict on predicted population and GDP growth. The BAU scenario also does not take into account the elaboration and implementation of any new development plan that might change the performance of the main sectors of the economy in Lebanon.

- It is estimated that Lebanon's population will total 5.5 million in 2020, 6.0 million in 2040, and 5.9 million in 2080. It also will have 1.3 million households in 2020, 1.4 million in 2040, and 1.4 million in 2080. Annex II explains the derivation of these numbers.
- Without the effects of global GHG emissions, Lebanon's GDP would grow from about USD 47.3 billion in 2015 to USD 55.4 billion in 2020, USD 104.1 billion in 2040, and USD 366.9 billion in 2080.
- Past GHG emissions have not yet produced their full impact on climate. Hence, some climate-related costs will materialize regardless of efforts to rein-in future GHG emissions.
- Lebanon's households, businesses, communities, and government will continue to engage in behaviors and adopt technologies similar to those of today. This assumption acknowledges the inertia that exists insofar as these behaviors—as well as the existing residential, commercial-industrial, and public capital—generally reflect climate conditions of the past rather than those of the future.
- In 2010 global GHG emissions over the preceding decades had raised annual average temperatures in Lebanon by 0.85°C, relative to the 1880-1919 reference period. If current trends in global GHG emissions continue, average annual temperatures in Lebanon will be higher. Relative to the reference period of 1880-1919, the increase will be: 1°C in 2020, 2°C in 2040, and 5°C in 2080. Relative to 2010, the increase will be: 0.15°C in 2020, 1.15°C in 2040, and 4.15°C in 2080. Annex II also explains the derivation of these numbers.

Both market costs and non-market costs are important. Market costs would quickly materialize as lower disposable incomes for households, higher costs and lower net revenues for businesses, and higher costs or lower financial resources for government. Higher temperatures, for example, could reduce workers' productivity, reducing their incomes and the output of business and government. Non-market costs might yield such outcomes more slowly. If future climate-related droughts were to displace farm families from their homes, or sea-level rise was to displace coastal families, for example, the resulting disruption might lower the ability of children to secure a good education and lower their earnings as adults. By their nature, non-market costs are not measured by market prices. Instead, measuring them requires targeted studies that look at how people express their desire for non-market goods and services or at how they respond to differences in these items. In general, such studies are lacking for non-market goods and services potentially susceptible to the impacts of climate change in Lebanon. Hence, this report does not measure the value of the non-market costs resulting from climate change. This omission likely causes it to substantially understate the full costs climate change would impose on Lebanon if current trends in global GHG emissions continue.

Available information suggests the results reported herein generally understate the true, potential economic costs that climate change would impose on Lebanon if current trends in GHG emissions continue. Moreover, as global GHG emissions endure, the likelihood that they will accelerate changes in climate and initiate irreversible changes in ecosystems and social systems will increase. Hence, the degree of understatement will likely grow larger as GHG emissions continue over time.

## 3.2. The overall economic costs that future global GHG emissions might impose on Lebanon

The estimation and calculation of the economic cost that climate change might impose on Lebanon is based on 4 different perspectives:

1. The total costs that Lebanon might experience from the cumulative effects of global GHG emissions between 2015 and each of those years.
2. The costs from single-year emissions in 2020, 2040, and 2080.
3. The extent to which costs could be avoided if nations around the world acted soon to rein-in global GHG emissions. It compares costs expected under the IPCC's lowest-emissions scenario, RCP2.6, against the highest-emissions scenario, RCP8.5.
4. The potential distribution of costs among different groups within Lebanon. It distinguishes among the costs to urban, rural farm, and rural nonfarm households. Within each group, it distinguishes among the costs to households with different levels of income.

The full methodological details of the analysis are found in MoE/UNDP/GEF, 2015g.

### *3.2.1. Potential costs from cumulative global GHG emissions*

This analysis recognizes that the changes in climate—and accompanying costs—from each year's emissions will build atop the effects of emissions from previous years, including years prior to 2015.

The analysis considers two major categories of potential costs. One is the reduction in GDP that would occur as changes in climate reduce the rate of Lebanon's economic growth. The other is the economic damage that would materialize each year through climate-related changes in net agricultural productivity, human health, the impacts of floods and storms on property, the value of services derived from Lebanon's ecosystems, etc.

#### *Results*

Emissions between 2015 and 2020 would impose direct damage costs from climate-related changes in net agricultural productivity, human health, the impacts of floods and storms on property, the value of services derived from Lebanon's ecosystems, drought, etc. of about USD 320 million and cause Lebanon's GDP to be about USD 1.6 billion, or 3%, smaller in 2020 than it otherwise would be. The forgone GDP would be about USD 14,100 million (14%) in 2040, and USD 115,700 million (32%) in 2080 (Table 63).

The total cost, USD 1,900 million, in 2020 would be equivalent to about USD 1,500 per household, on average. These numbers suggest that the average cost per household would likely exceed average household annual earnings soon, which currently are about USD 12,000[3], with many households becoming impoverished. If the government were to maintain its current general role in the economy, its share of the overall costs would total about USD 610 million in 2020, USD 5,400 million in 2040,

[3] Average earnings per household calculated by dividing workers' total earnings by the number of households. Details of calculations available in MoE/UNDP/GEF, 2015g.

and USD 44,300 million in 2080. These costs could represent sizeable portions of government's budgets, insofar as its 2012 expenditures were about USD 72,000 million (MoF, 2013). The actual budgetary impact of climate change on government could be higher, especially if it accepts new responsibilities for addressing needs associated with the anticipated increases in household poverty. The overall cost resulting from global GHG emissions between 2015 and 2040 would total USD 16,900 million in 2040, and between 2015 and 2080, USD 138,900 million in 2080.

**Table 63:** Potential costs for Lebanon from the cumulative effects of global GHG emissions (2015 USD)

| | 2020 | 2040 | 2080 |
|---|---|---|---|
| Direct annual damage from drought, etc. in Lebanon (millions) | USD 320 | USD 2,800 | USD 23,200 |
| Forgone GDP in Lebanon (millions) | USD 1,600 | USD 14,100 | USD 115,700 |
| Percentage reduction in GDP | 3% | 14% | 32% |
| Total cost to Lebanon (millions) | USD 1,900 | USD 16,900 | USD 138,900 |
| Average cost per household in Lebanon | USD 1,500 | USD 13,100 | USD 107,200 |
| Government's share (millions) | USD 610 | USD 5,400 | USD 44,300 |

Numbers reflect rounding.
Calculation details available in MoE/UNDP/GEF, 2015g

### *Discussion*

The actual costs might be higher or lower than those shown in Table 63. It seems reasonable, however, to conclude that the actual costs likely would be higher. The two economic studies that form the foundation for this analysis, Interagency Working Group, (2015) and Moore and Diaz (2015), capture only a portion of the impacts of hotter temperatures and changes in precipitation on economic output. More recent research (Burke, Hsiang, and Miguel 2015) concludes that anticipated increases in climate warming will yield costs perhaps 100 times larger than indicated by prior estimates, with the largest costs occurring in regions, such as the Middle East, that already experience high temperatures. Researchers have not yet reconciled these different studies. The findings reported by Burke, Hsiang, and Miguel 2015 suggest, however, that the actual reduction in GDP might be substantially larger than those derived from Interagency Working Group, (2015) and Moore and Diaz (2015).

Moreover, this analysis does not capture the persistent effects of global GHG emissions before 2015. It also does not capture the costs that economists have not yet reliably modeled. These include, but are not limited to, the costs associated with the effects of $CO_2$ emissions on ocean acidification (Secretariat of the Convention on Biological Diversity, 2014), or the costs that might materialize if global GHG emissions trigger catastrophic local, regional, or global outcomes (King et al., 2015).

### *3.2.2. Potential costs and savings from annual global GHG emissions under highest and lowest emission scenarios*

Consistent with the analysis in the preceding section, this analysis considers two types of costs. One is the direct economic damage that would materialize as these emissions contribute to future extreme weather events and other changes in climate that would destroy crops, impose heat stress on workers, etc. The other is the forgone GDP that would materialize as the economic damage reduces growth in the economy's ability to produce goods and services for consumers and income for workers and property owners. The indicated cost for each year is a single number equivalent in value to the stream of costs that would materialize in subsequent years as a result of that year's GHG emissions. Called the present value, this number is calculated using a process called discounting, through which the value of a cost some years in the future is reduced for each of those years by an annual discount rate. This analysis uses a discount rate of 3% per year, reflecting the core analysis of Interagency Working Group on Social Cost of Carbon (2015).

#### *Results*

The analysis suggests that, if current trends continue under the RCP8.5 scenario, annual GHG emissions in 2020 would impose costs on Lebanon totaling USD 21,200 million. Of this total, about USD 17,600 million, would materialize as the climate change slows growth in GDP. The direct, annual economic damage from droughts, storms, heat waves, diseases, etc. would be smaller, about USD 3,600 million. Costs resulting from annual global emissions in 2040 and 2080 would total USD 80,700 million, and USD 1,009,700 million, respectively, with forgone GDP accelerating faster than direct damage costs. Costs would be borne by both households (68%) and the government (32%). However, if meaningful actions were taken on the global level to reduce GHG emissions to those of the IPCC lowest emission scenario (RCP2.6), the economic costs would be USD 15,200 million in 2020, USD 30,800 million in 2040 and USD 91,300 in 2080. This would yield savings to Lebanon of up to 918,400 million in 2080, which reduces 91% of the cost that would have been imposed of emissions were to be generated at the same level of today (RCP8.5).

**Table 64:** Present value of economic costs that annual global GHG emissions would impose on Lebanon under the highest-emissions and lowest scenario (2015 USD)

| | **2020** | **2040** | **2080** |
|---|---|---|---|
| A. Potential costs if global emissions follow the IPCC's highest-emissions scenario (current trends) | | | |
| Total cost (millions) | USD 21,200 | USD 80,700 | USD 1,009,700 |
| Average per household | USD 16,400 | USD 57,300 | USD 721,900 |
| Government's share (millions) | USD 6,800 | USD 25,800 | USD 322,000 |
| B. Potential costs if global emissions follow the IPCC's lowest-emissions scenario | | | |
| Total cost (millions) | USD 15,200 | USD 30,800 | USD 91,300 |
| Average per household | USD 11,700 | USD 21,900 | USD 65,200 |
| Government's share (millions) | USD 4,800 | USD 9,800 | USD 29,100 |
| C. Potential savings from reducing global emissions to the lowest-emissions scenario | | | |
| Potential savings (millions) | USD 6,000 | USD 49,900 | USD 918,400 |
| Potential savings (percentage) | 28 | 62 | 91 |

Numbers reflect rounding.

## *Discussion*

The actual costs and savings might be higher or lower than those shown in Table 64. It seems reasonable to conclude that this analysis likely understates the overall costs future global GHG emissions would impose on Lebanon under the IPCC's highest-emissions scenario. Recently published research concludes that anticipated increases in climate warming will yield costs at least 2.5 times larger—and perhaps 100 times larger—than indicated by prior estimates, with the largest costs occurring in regions, such as the Middle East, that already experience high temperatures (Burke, Hsiang, and Miguel 2015).

Moreover, this analysis does not capture the costs that economists have not yet reliably modeled. These include, but are not limited to, the costs associated with the effects of $CO_2$ emissions on ocean acidification (Secretariat of the Convention on Biological Diversity, 2014), or the costs that might materialize if global GHG emissions trigger catastrophic local, regional, or global outcomes (King et al., 2015).

All else equal, however, it seems reasonable to conclude that the savings would be greater, insofar as the two scenarios do not capture all the potential costs global GHG emissions would impose on Lebanon.

Note that the values shown represent the present value, in 2020, 2040, and 2080, of the sum of all costs that would materialize in subsequent years from GHG emissions in each of those years. As such, they are not directly comparable to results presented in Table 63 that show the cumulative cost of previous years' emissions that would materialize only in 2020, 2040, or 2080.

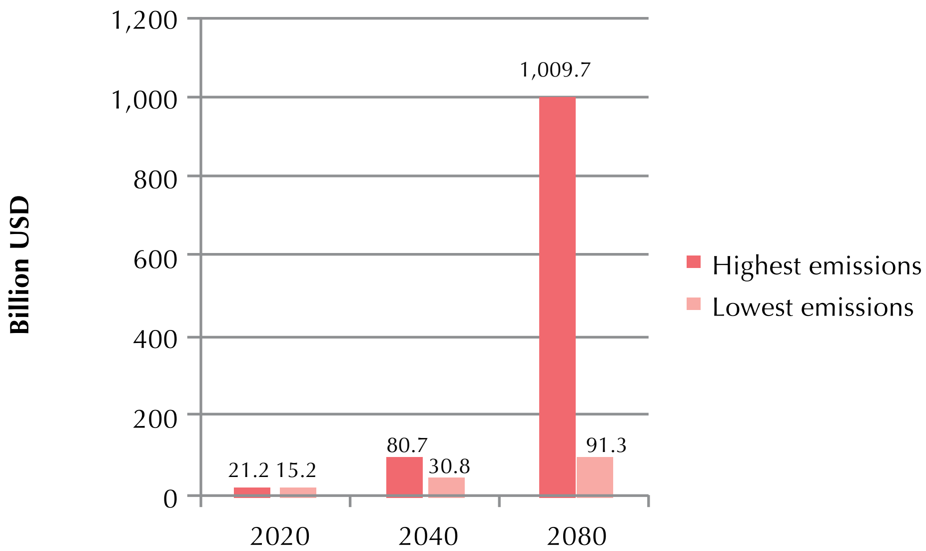



**Figure 58:** Comparison of potential costs to Lebanon from global GHG emissions in 2020, 2040, and 2080 under the IPCC's highest- and lowest-emissions scenarios

### *3.2.3. Potential costs borne by rural and urban households with different levels of income*

Climate related costs would affect the incomes of different groups within Lebanon as Table 65 shows the potential percentage reduction, relative to 2010, in average income per household for urban, rural nonfarm and rural farm households. It also describes, for each group, the percentage reduction in income for households with different levels of income, represented by income quintile.

#### *Results*

If current trends in global GHG emissions continue, the resulting changes in climate would reduce the average income in 2020 of the highest quintile of urban households by about 12%. The average income of the lowest quintile of rural nonfarm households will be reduced by about 24% by 2020, 56% by 2040, and 86% by 2080. Other households fall between the two extremes.

As a total, changes in climate would reduce the average income in 2020 of the highest quintile of all households by about USD 14,400, relative to 2010 and by USD 3,900 for the lowest income quintile.

#### *Discussion*

The potential costs reflect one of the medium-emissions scenarios, A1B, developed by the IPCC before it developed the RCP scenarios which assumes that if human-caused GHG emissions follow the path underlying IPCC's highest-emission scenario, RCP8.5, households likely would experience larger reductions in income than those shown in Table 65.

The numbers in Table 65 illustrate some general patterns. Urban households generally would experience smaller percentage reductions in income, followed by rural farm households and rural nonfarm households. For each group, households with the lowest incomes would experience the largest percentage reductions, and those with higher incomes would experience smaller reductions. These patterns reflect expectations that urban households and high-income households generally will have greater resiliency to the effects of climate change. That is, they likely would have more opportunities to find replacement jobs and sources of income if they suffer a climate-related disruption of existing jobs. Similarly, rural farm households likely would have greater resiliency than rural nonfarm households insofar as higher crop prices resulting from climate change would boost their incomes and somewhat offset other impacts of climate change.

**Table 65:** Percentage reductions, relative to 2010, in average Lebanese household income for urban, rural farm, and rural nonfarm households, by income quintile

| Year of emissions | 2020 | 2040 | 2080 |
|---|---|---|---|
| Urban households, percentage reductions by income quintile | | | |
| 5 (highest income) | 12% | 32% | 60% |
| 4 | 16% | 40% | 69% |
| 3 | 17% | 43% | 73% |
| 2 | 18% | 45% | 75% |
| 1 (lowest income) | 20% | 49% | 80% |
| Rural farm households, percentage reductions by income quintile | | | |
| 5 (highest income) | 16% | 41% | 71% |
| 4 | 19% | 46% | 77% |
| 3 | 18% | 45% | 75% |
| 2 | 18% | 45% | 75% |
| 1 (lowest income) | 20% | 49% | 80% |
| Rural nonfarm households, percentage reductions by income quintile | | | |
| 5 (highest income) | 16% | 40% | 69% |
| 4 | 20% | 49% | 80% |
| 3 | 20% | 49% | 80% |
| 2 | 21% | 51% | 81% |
| 1 (lowest income) | 24% | 56% | 86% |
| All households, monetary reductions by income quintile | | | |
| 5 (highest income) | USD 14,400 | USD 37,200 | USD 65,700 |
| 4 | USD 9,800 | USD 24,300 | USD 40,400 |
| 3 | USD 6,600 | USD 16,400 | USD 27,200 |
| 2 | USD 5,500 | USD 13,600 | USD 22,400 |
| 1 (lowest income) | USD 3,900 | USD 9,300 | USD 14,600 |

Numbers reflect rounding.

## 3.3. Costs that climate change might impose on segments of Lebanon's economy and society

This section presents illustrative calculations of several types of economic costs that climate change might impose on different segments of Lebanon's economy and society in 2020, 2040, and 2080. Comprehensive details on data considerations, assumptions and methodologies are found in the full study (MoE/UNDP/GEF, 2015g).

Priority sectors were identified by stakeholders during a consultation workshop on 19 march 2015 in Beirut. Beginning with this set of priorities, a subsequent review of the readily available, relevant information determined there is sufficient information to describe the potential costs to Lebanon from the potential impacts of climate change on:

1. Agriculture and food consumption
2. Water
3. Natural disasters
4. Tourism
5. Electricity
6. Human health
7. Society
8. Ecosystems

### *3.3.1. Costs from impacts of climate change on agriculture and food consumption*

#### *3.3.1.1 Reductions in Lebanon's overall agricultural production*

Anticipated changes in climate would reduce Lebanon's agricultural production by raising ambient temperatures and reducing precipitation to levels harmful to both crops and livestock. Further impacts on production might occur through the impacts of more severe storms and floods, and the effects of climate-related spreading of diseases and pests.

#### *Results*

The estimated costs presented in Table 66 derive from Haddad et al. (2014), which modeled changes in agricultural production and their ripple-effects through the overall economy. The projections focus on the effects of climate change on five main crop types: cereals, fruit trees, olives, industrial crops, such as sugar beets[4] and tobacco, and vegetables, such as potatoes (a strategic crop).

In 2020, the value of farm production would fall about USD 80 million below the level that would occur without the anticipated changes in climate. This reduction would ripple through the economy, with the manufacturing and services sectors, combined, experiencing a reduction in production of about USD 220 million. The overall reduction in GDP would total USD 300 million. Of this total reduction in GDP, USD 16 million would materialize as reductions in funds available for general spending on government programs. Reductions in economic activity—in agriculture and other sectors—would lead to reductions in household incomes. As a consequence, household consumption of food and other goods and services would fall throughout Lebanon by about USD 170 million, or USD 130 per household on average. Exports, primarily of agricultural products, would fall by USD 72 million, while imports would increase by USD 10 million, and economy-wide investment would fall by USD 47 million. The total reduction in GDP from anticipated effects of climate change on Lebanon's agricultural sector would equal about USD 860 million in 2040, and USD 2,300 million in 2080.

[4] Although Lebanon does not currently produce sugar beets, this analysis takes them into consideration because they were included in the data underlying Haddad et al. (2014), which serves as the basis for the analysis.

**Table 66:** Potential economic costs per year from climate-related reduction in Lebanon's agricultural output (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Costs per year to crop and livestock producers in Lebanon (millions) | USD 80 | USD 180 | USD 480 |
| Costs per year to manufacturing and service sectors in Lebanon (millions) | USD 220 | USD 690 | USD 1,900 |
| Total costs (reduction in GDP) per year in Lebanon (millions) | USD 300 | USD 860[a] | USD 2,300[b] |
| Reduced government expenditure in Lebanon (millions) | USD 16 | USD 30 | USD 80 |
| Reduced household consumption in Lebanon (millions) | USD 170 | USD 370 | USD 1,000 |
| Reduced consumption per household in Lebanon | USD 130 | USD 260 | USD 720 |
| Reduced exports per year in Lebanon (millions) | USD 72 | USD 160 | USD 430 |
| Increased imports per year in Lebanon (millions) | USD 10 | USD 5 | USD 14 |
| Reduced investment per year in Lebanon (millions) | USD 47 | USD 300 | USD 810 |

Numbers reflect rounding.
Calculation details available in MoE/UNDP/GEF, 2015g
[a]Because of rounding, the total, USD 860 million differs slightly from the sum of USD 180 million and USD 690 million.
[b]Because of rounding, the total, USD 2,300 million, differs slightly from the sum of USD 480 million and USD 1,900 million.

Figure 59 shows the components of the reduction in GDP in 2020 from two perspectives. The left graph shows the reductions in output in the agriculture, manufacturing, and service sectors. The right graph shows the reduction in expenditures by households, government, net exports (exports minus imports) and investment.

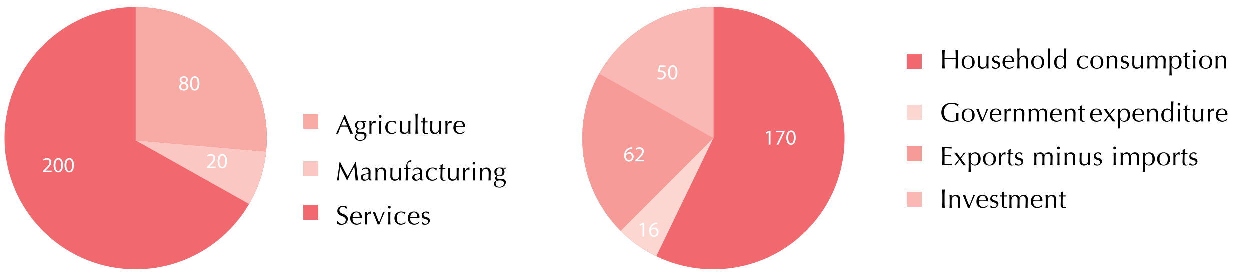



**Figure 59:** Components of the 2020 reduction in GDP in million USD, by sector of the economy and by expenditure category

## *Discussion*

Costs might be higher than those shown in Table 66, for example, if changes in temperature and precipitation were to occur, or to reduce agricultural production, more quickly than expected. Conversely, actual costs might be lower if farmers were to develop replacement crops resistant to these changes in climate. Some farmers have already undertaken steps to adapt to hotter and drier growing conditions by increasing the area of unirrigated vineyards, shifting from citrus to banana production, and shifting from sugar-beet production to the production of crops that require less water.

Reductions in agricultural production would reduce the net incomes of farmers, farmworkers, and those associated with related businesses. Costs directly linked to climate-related reductions in agricultural output would affect rural households most directly and deeply. Urban households would also be affected, insofar as they remain economically integrated with rural family relatives, pay more for locally produced food as it becomes more scarce, or see jobs disappear as urban businesses that handle farm products cut back as rural farm production dwindles.

#### *3.3.1.2 Reductions in production of wheat and maize*

The Second National Communication concludes that changes in temperature and rainfall will decrease productivity of lands currently used to produce most crops and fruit trees—especially wheat, cherries, tomatoes, apples, and olives—and may affect the quality of grapes. This analysis presents the anticipated reductions in Lebanon's production of wheat and maize. The focus on these two crops reflects the availability of data from relevant modeling of the anticipated effects of higher ambient temperature on irrigated lands and of higher ambient temperature and lower precipitation on unirrigated lands. Due to lack of relevant information, no cost has been estimated on the impacts of climate change on fruit trees, which represent more than half of Lebanon's agriculture area.

#### *Results*

The numbers in Table 67 rest on the results of modeling conducted by IFPRI (2009) for the Middle East and North Africa (MENA) region. The modeling compared production expected under one of the GHG-emissions scenarios, A2, developed by the IPCC before it developed the RCP scenarios, relative to a scenario that assumes continuation of climate conditions that prevailed in 2000.

The comparison shows the reductions in crop production intensify over time as temperatures increase and precipitation decreases. Maize is expected to experience the largest reductions: 23% in 2020, 40% in 2040, and 64% in 2080. Wheat would decline by 8% in 2020, 16% in 2040, and 30% in 2080. Insofar as the changes in climate under the IPCC's highest-emissions scenario, RCP8.5, would be greater, so would be the percentage reduction in the production of the two crops.

**Table 67:** Reduction in value of Lebanon's production of wheat and maize (2015 USD).

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Percentage reduction in volume of annual crop production in Lebanon | | | |
| Wheat | 8% | 16% | 30% |
| Maize | 23% | 40% | 64% |
| Value of reduction in value of annual crop production in Lebanon | | | |
| Wheat (millions) | USD 10 | USD 17 | USD 28 |
| Maize | USD 85,000 | USD 162,900 | USD 299,500 |

Numbers reflect rounding.

### *Discussion*

The impacts of climate change on wheat and maize production would be larger than indicated in Table 67 if, in the absence of climate change, farmers would adopt techniques that would increase their yield. All else equal, the value of the reduction in grain production would be greater to the extent that global prices increase more than projected. Under the A2 scenario, GHG emissions would grow more slowly than under RCP8.5. Hence, if human-caused GHG emissions follow the path underlying IPCC's highest-emission scenario, RCP8.5, households likely would experience larger reductions in income than those shown in Table 67.

The impacts of climate change on wheat and maize production would be smaller than indicated if, absent climate change, Lebanon's crop production would decline for other reasons, such as the encroachment of urban land uses onto farmland. Farmers might be able to offset costs stemming from the effects of climate change on wheat and maize production by switching to other crops, such as barley, that are less sensitive to hotter and drier growing conditions.

This analysis does not distinguish between costs that would be borne by the farmers who experience reductions in production and government, which might offset the loss through a crop subsidy or other compensation.

The costs to wheat and maize producers might differ substantially from the costs to other agricultural commodities, reflecting differences in the availability of water and other factors of production, sensitivity to changes in temperature and precipitation, and markets.

### *3.3.1.3 Reductions in fish harvest*

Increases in the temperature of inland and coastal waters, along with changes in nutrient flows, will reduce Lebanon's fish harvest from its aquaculture facilities and coastal fishery.

### *Results*

The numbers in Table 68 represent the reductions in the value of Lebanon's fish harvest that would occur if the rate of decline projected for 2010–2030 (DARA and Climate Vulnerability Forum, 2012) were to extend through 2080. If current trends in GHG emissions continue, and fish stocks were unlimited, the costs in Lebanon would total USD 13 million in 2020, USD 93 million in 2040, and USD 4,500 million in 2080. These costs would soon outstrip the fish stocks, however, insofar as the Lebanese coastal harvest is about USD 28 million (Pinello and Dimech, 2013, adjusted to 2015 USD), and annual aquaculture output in Lebanon has a value of about USD 4 million (FAO, 2015). Hence, Table 68 shows costs hitting a ceiling of USD 32 million in 2040 and 2080.

**Table 68:** Potential costs from climate-related reductions in Lebanon's fish harvest (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Value of reduction in fish harvest per year in Lebanon (millions) | USD 13 | USD 32 | USD 32 |

Numbers reflect rounding.

### *Discussion*

Costs might be higher if, for example, changes in climate reduce fish stocks faster than anticipated. They might be smaller, though, if the reductions were to occur more slowly or if other fish species were to move into local waters to replace those depleted by climate change.

### *3.3.1.4 Increases in the prices Lebanon's consumers pay for food because of climate-related increases in global food prices*

Anticipated changes in global climate are expected to reduce world food supplies and increase food prices. Higher temperatures would generally reduce growth rates for livestock, and for all crops experiencing more than 3°C of local warming, although some crops might show variation in effects from lower temperature increases (Porter et al., 2014). According to Nelson et al. (2014), changes in climate would cause global crop prices to increase 20% from 2005 to 2050, and the increase in food prices would cause food consumption to drop 3%.

Table 69 shows the potential economic cost to Lebanon's consumers that would materialize as global GHG emissions under the highest-emissions scenario increase global food prices relative to prices expected with unchanging climate. The average cost per household ranges from USD 360 in 2020 to USD 3,600 in 2080.

**Table 69:** Potential costs to Lebanon's consumers from climate-related increases in global food prices (2015 USD and 2015 LBP)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Climate-related increase in food prices | 1.6% | 12% | 44% |
| Total cost to Lebanese consumers per year (millions) | USD 470 | USD 1,700[a] | USD 5,000[b] |
| Price-induced reduction in food consumption (millions) | USD 310 | USD 340 | USD 330 |
| Increase in cost of food that is consumed (millions) | USD 160 | USD 1,300 | USD 4,700 |
| Cost per Lebanese household per year | USD 360 | USD 1,200 | USD 3,600 |

Numbers reflect rounding.

[a] Because of rounding, the total, USD 1,700 million differs slightly from the sum of USD 340 million and USD 1,300 million.

[b] Because of rounding, the total, USD 5,000 million, differs slightly from the sum of USD 330 million and USD 4,700 million.

### *Discussion*

Uncertainty about the costs arises largely from the lack of sufficient information and resources to account for all the climate-related effects on crop production. For example, it overlooks the potentially offsetting effects of increased crop production from higher $CO_2$ concentrations and decreased production from increased ozone concentrations, increased attacks from pests, and more frequent extreme weather events. There are reasons, however, to believe that, overall, the omitted effects will, in actuality, push costs higher. Recent research suggests that the higher $CO_2$ concentrations generally will not result in the higher crop yields previously anticipated because soils generally will have insufficient nutrients to support the higher yields (Weider et al., 2015). Some field research has found that the productivity of some crops falls markedly if temperatures surpass some threshold. A warming of 1°C, for example, might render 40% of the area currently used to grow maize no longer suitable for this crop (Potsdam Institute, 2013). An overall assessment of climate-related risks to crop production concluded that "most of the factors not taken into account in the models – and the projections – are likely on balance to have a negative effect" (Porter, Montesino, and Semenov, 2015).

## *3.3.2. Costs from impacts of climate on water*

### *3.3.2.1 Reductions in agricultural and domestic/industrial water supply*

Reductions in Lebanon's water supply would materialize as changes in climate diminish the amount of precipitation falling in Lebanon and higher temperatures accelerate evapotranspiration. This analysis describes one indicator of the resulting economic cost: the cost of securing replacement quantities of water for domestic/industrial uses.

### *Results*

Anticipated changes in climate would reduce the nation's exploitable supplies of water by about 1% in 2020, 8% in 2040, and 29% in 2080 (MoE/UNDP/GEF, 2011). The analysis assumes that, for 2020, the impact of the lost water on supplies available to consumers would be offset at a cost of USD 1 per cubic meter. This amount represents the cost of investments that would reduce leakage from the water system and improve water conservation (adapted from World Bank, 2010). For 2040 and 2080, the analysis assumes that offsetting the impact of the lost water on supplies available to consumers would require investments in wastewater reuse or desalination, at a cost of USD 2 per cubic meter (adapted from World Bank, 2010).

Households would realize costs by forgoing productive uses of water no longer available and through the environmental degradation that would accompany efforts to offset the decline in water supplies, government would realize a reduction in revenues and increases in costs. The analysis assumes a distribution of costs—60% and 40%, respectively—which reflects the current distribution of costs associated with inadequacies in the water system (adapted from World Bank, 2010) and assumes it would extend into the future.

**Table 70:** Climate-related reductions in water supply and costs to replace the lost water in Lebanon (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Reduction in exploitable water supply per year in Lebanon | | | |
| Percent | 1 | 8 | 29 |
| Volume (million cubic meters per year) | 20 | 160 | 580 |
| Cost per year to replace the lost water in Lebanon | | | |
| Total (millions) | USD 21 | USD 320 | USD 1,200 |
| Households (millions) | USD 12 | USD 190 | USD 720 |
| Government (millions) | USD 8 | USD 130 | USD 480 |

Numbers reflect rounding.
Calculation details available in MoE/UNDP/GEF, 2015g

### *Discussion*

The actual costs might be higher or lower than those shown in Table 70. All else equal, costs would likely be higher, insofar as insufficient information exists for this analysis to describe other potential costs from the impacts of climate change on water, such as reductions in water quality and changes in the spatial and temporal distribution of precipitation.

Several factors might intensify the costs of climate-related reductions in water supplies. With higher temperatures and tighter water scarcity, for example, the value of each incremental reduction in water supplies might increase, perhaps steeply. Greater variability in precipitation, temperatures, and evapotranspiration might result in periods and places with extreme mismatches between water supply and demand, with severe shortages causing abnormally high economic costs.

### *3.3.2.2 Reductions in water supply for generation of hydroelectricity*

Lebanon's supply of hydroelectricity will diminish as changes in climate declining precipitation and rising temperatures reduce the water in rivers available to drive hydropower plants. The electricity sector and consumers will incur costs to secure replacement supplies of electricity.

### *Results*

The anticipated climate-related reductions in water flows would reduce Lebanon's hydroelectricity generation by 15 gigawatt-hours (GWh) in 2020, 150 GWh in 2040, and 540 GWh in 2080. The electricity sector and its customers would incur costs of USD 3 million in 2020, USD 30 million in 2040, and USD 110 million to obtain replacement electricity from other sources.

**Table 71:** Climate-related reduction in hydroelectricity generation and replacement cost in Lebanon (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Reduction in water flow in Lebanon per year (%) | 1 | 8 | 29 |
| Reduction in hydroelectricity generation (%) | 1 | 8 | 29 |
| Reduction in hydroelectricity generation (GWh) | 15 | 150 | 540 |
| Cost to replace lost electricity per year (millions) | USD 3 | USD 31 | USD 110 |
| Cost per year per household in Lebanon | USD 2 | USD 31 | USD 110 |

Numbers reflect rounding.
Calculation details available in MoE/UNDP/GEF, 2015g

### *Discussion*

The actual impact of climate change on hydroelectricity production would depend not just on the reduction in stream flows but also on the quantity and configuration of the hydroelectric dams. The actual cost of replacement supplies of electricity would depend on the type(s) of generation employed. The costs of replacement electricity from other sources might rise initially, for example, but then decline as new technologies, such as solar, become more efficient. Costs also will be sensitive to changes in the supply and prices of natural gas and other fuels. The government likely would directly bear the costs of central generating facilities integrated into the grid. Households and businesses likely would indirectly bear some of these costs through payments for electricity consumed from the grid. They also would directly bear costs of generating replacement supplies of electricity from privately-owned generators.

## *3.3.3. Costs from climate-related natural disasters*

Lebanon will experience economic costs as anticipated changes in climate cause natural-resource disasters, such as more severe storms, floods, droughts, wildfires, and outbreaks of disease and insects. The costs will materialize in several ways. Direct costs would materialize as disasters destroy buildings, homes, equipment, bridges, and other physical capital. Some disasters might kill and injure humans, livestock, fish, or wildlife. Most will require clean-up. All will divert the attention and efforts of workers, families, businesses, and communities that otherwise could have been productive doing other things. Additional costs will materialize as affected individuals endure short-term suffering and the long-term effects of anxiety and post-traumatic stress, reducing the wellbeing and productivity of themselves, their families, and their communities.

### *Results*

The costs shown in Table 72 reflect the value of lost crops, damage to structures, and other damage from climate-related droughts, floods/landslides, and storms, if recent trends in the global GHG emissions continue unabated, as well as the value of disaster-related deaths.

**Table 72:** Potential costs to Lebanon from climate-related natural disasters (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Total cost of damage from natural disasters in Lebanon (millions) | USD 7[a] | USD 36 | USD 1,600[b] |
| Damage from droughts, floods, landslides, and storms (millions) | USD 5 | USD 35 | USD 1,600 |
| Damage related to deaths caused by disasters (millions) | USD 1 | USD 1 | USD 1 |

Calculation details available in MoE/UNDP/GEF, 2015g
This analysis does not include the costs from flooding associated with climate-related rise in sea levels.
Numbers reflect rounding.
[a] Because of rounding, the total, USD 7 million differs slightly from the sum of USD 5 million and USD 1 million.
[b] Because of rounding, the total, USD 1,600 million, differs slightly from the sum of USD 1,600 million and USD 1 million.

#### *Discussion*

It seems reasonable to conclude that actual costs likely would be higher than those shown in Table 72, insofar as this analysis does not describe all the ways in which these disasters would impose costs on Lebanon. For example, these disasters would create psychological distress for most of those directly affected and a long-term legacy of post-traumatic stress for many (Doppelt, forthcoming), but the currently available information on these effects cannot support calculation of the associated economic costs. Other long-term costs of these disasters likely would materialize as they diminish education, productivity, and earnings for individuals who are children when a disaster strikes (Vivid Economics, 2010).

### *3.3.4. Costs from impacts of climate change on tourism*

This analysis describes the reduction in GDP that might result as changes in climate reduce the intrinsic recreational and environmental attractiveness of Lebanon's coastal areas to domestic and international tourists (Bosello and Eboli, 2013). This outcome would materialize as changes in climate reduce biodiversity—the number of coastal terrestrial species, especially birds and mammals, and the richness of coastal habitat—and the attractiveness of coastal cultural heritage sites (Onofri, Nunes, and Bosello, 2013).

Regional analyses representative of Lebanon have found that potential climate-related reductions in biodiversity might reduce tourism demand by about 1.4% in 2050 (Bosello and Eboli, 2013; p. 7). Reduced tourism spending in coastal areas has ripple effects throughout the economy. Some of these effects depress spending in sectors linked to coastal tourism, such as transportation and the production of food for international tourists. To some extent, though, lower coastal spending might be offset if tourists spend more in other parts of the country.

A search for relevant information found too little to support a reliable analysis of the potential effects of climate change on other elements of tourism in Lebanon. This is especially the case for the winter tourism industry. General assessments have concluded that anticipated changes in climate likely would have mixed impacts on the industry (Burki, Elassser, and Abegg, 2003). It would exacerbate uncertainty about the availability of suitable levels of snow at low-elevation

ski areas, but perhaps increase the attractiveness of existing and proposed ski areas at medium- and high-elevation locations.

A reliable analysis of the overall effects and costs would require an estimate of the quantity and the value of winter tourism that would be lost, solely because of climate change, in 2020, 2040, and 2080. These data do not seem to be readily available. Existing data describe, at best, the number of visitors to ski resorts in past years. They do not provide a reliable baseline estimate of the expected number of visitor-days, absent climate change, or of the number of visitor-days that would be displaced by anticipated changes in climate. Existing data also do not support reliable quantification of the two components of value important to economic analysis: the spending per visitor-day, and the extent to which the benefit consumers enjoy per visitor-day exceeds what they spend.

#### *Results*

Table 73 shows the potential effect of climate change on GDP if current trends in global GHG emissions continue to reduce the terrestrial biodiversity and, hence, attractiveness, of Lebanon's coastal areas.

**Table 73:** Potential reduction in GDP that would occur as changes in climate reduce the attractiveness to tourists of Lebanon's coastal resources (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Reduction in GDP from fewer tourists in Lebanon's coastal area (millions) | USD 22 | USD 160 | USD 1,800 |

Numbers reflect rounding.

#### *Discussion*

Actual costs might be lower if, for example, climate change has greater impacts on coastal biodiversity in other countries, thereby improving Lebanon's relative attractiveness to tourists. They might be higher, for example, if global GHG emissions cause sea levels to rise more than indicated by previous research (Hansen et al. in review). Higher temperatures resulting from global GHG emissions also might reduce the attractiveness of Lebanon's coastal areas relative to comparable sites further from the equator that experience smaller increases in temperature. Potentially negative impacts on other components of Lebanon's tourism sector, a reduction in snow on its mountains in winter, also likely would increase the negative impacts on GDP.

### *3.3.5. Costs from impacts of climate change on electricity consumption*

According to the SNC, as the increase in temperature will take place in both winter and summer seasons, a reduction in heating demand can be expected. However, the increase of occurrence of extreme events, notably cold spells, would increase peaks in heating, which would balance the overall yearly demand. Therefore, the analysis below focuses only on the increase in cooling demand.

### *Results*

The anticipated climate-related increases in temperature would increase electricity use for cooling by 0.5 billion kilowatt-hours (kWh) in 2020, 4.3 billion kWh in 2040, and 168 billion kWh in 2080. Lebanon's electric utilities and consumers would incur costs of USD 110 million in 2020, USD 900 million 2040, and USD 34,800 million 2080 to generate the electricity required to meet climate-related demand for cooling.

**Table 74:** Cost of electricity to meet climate-related increase in demand for cooling (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Increased electricity consumption for cooling in Lebanon (billion kWh) | 0.5 | 4.3 | 168 |
| Cost of additional electricity consumption in Lebanon (millions) | USD 110 | USD 900 | USD 34,800 |

Numbers reflect rounding.

### *Discussion*

Future generation of additional electricity will likely involve technologies other than combustion of heavy fuel oil, but it is not clear if the generation costs would be higher or lower than those shown in Table 74. The demand for cooling and, hence the cost of producing the necessary electricity may be higher than indicated if demand grows faster than temperatures.

Increased average annual temperatures will impose costs other than those linked to higher demand for cooling. They generally will lower the efficiency of thermal power plants, increase electricity losses in transmission lines, and reduce the efficiency of electrical motors and devices. An energy audit check list for all the possible effects of a change in the average temperature on all the types of electromechanical equipment would set the path for a more precise assessment on quantified effects of temperature increase on the entirety of the electricity sector.

## *3.3.6. Costs from impacts of climate change on the health of Lebanon's citizens*

### *3.3.6.1 Risk of death*

Available information supports calculation of economic costs resulting from increases in the risk of death for two ways. One would occur when higher temperature and humidity increases the risk of death directly, through hyperthermia, and indirectly, through respiratory or cardiovascular malfunctions. Most of this increase in mortality risk would fall on people over age 65. The other would occur when changes in climate increase the risk of death through malnutrition, diarrhea, malaria, floods, and cardio-vascular disease. This type of mortality risk can affect people of different ages, although children constitute the bulk of those who die from diarrhea and malaria. There may be some overlap between the two types of estimates, insofar as they both consider interactions between climate change and cardiovascular disease.

By estimating the value of the increased risk of death, this analysis is not placing a monetary value on the lives of the individuals who may die prematurely because of climate change.

Instead, it reflects the overall risk to society. The cost estimates represent how much people throughout society are willing to pay for small reductions in their risk of dying, or, alternatively, how much compensation they would require to willingly accept an increase in risk, including the lost enjoyment of life, forgone contributions to family and community, as well as lost labor production.

Studies have found that the willingness to pay for risk reductions generally is lower in poor countries than in rich countries not because poor people value life less but because their ability to pay is lower. This difference raises concerns when choosing any value to represent the value of mortality risk, especially when rich countries emit much of the GHGs that increase mortality risk, and most of the risk of climate-related deaths occurs in poor countries. Accordingly, the IPCC (2001) has recognized that it might be appropriate to use an "equity-adjusted" average value across all countries of about USD 1.35 million per potential death (adjusted to 2015 USD). The costs would be three times larger if the analysis applied the value the OECD (2011) uses to evaluate mortality risk in rich countries as a whole, and six times larger if it applied the value the U.S. Environmental Protection Agency (2015) uses to evaluate mortality risk in the U.S.

### *Results*

Regional estimates of mortality risk developed by the World Health Organization (Campbell-Lendrum and Woodruff, 2007) indicate that, if current trends in GHG emissions continue, climate change might cause about 34,900 deaths per year in Lebanon by 2020, 40,500 by 2040, and 45,500 by 2080. Most of these would occur through increases in malnutrition, diarrhea, malaria, and floods, and interactions with cardiovascular disease. The costs associated with climate-related increases in mortality risk total USD 47,200 million in 2020, USD 54,700 million in 2040, and USD 61,400 million in 2080.

**Table 75:** Potential economic costs of climate-related risk of death in Lebanon (deaths per year and 2015 USD) under the IPCC's highest-emissions scenario

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Number of climate-related deaths per year in Lebanon | | | |
| Heat stress | 3,900 | 6,600 | 12,200 |
| Malnutrition, diarrhea, malaria, floods, cardiovascular disease | 31,100 | 33,900 | 33,300 |
| Total | 34,900[a] | 40,500 | 45,500 |
| Costs of increased risk of death in Lebanon | | | |
| Heat stress (millions) | USD 5,200 | USD 9,000 | USD 16,400 |
| Malnutrition, diarrhea, malaria, floods, cardiovascular disease (millions) | USD 41,900 | USD 45,800 | USD 45,000 |
| Total (millions) | USD 47,200[b] | USD 54,700[c] | USD 61,400 |

Numbers reflect rounding.

Calculation details available in MoE/UNDP/GEF, 2015g

[a] Because of rounding, the total, 34,900 differs slightly from the sum of 3,900 and 31,100.

[b] Because of rounding, the total, USD 47,200 million differs slightly from the sum of USD 5,200 million and USD 41,900 million.

[c] Because of rounding, the total, USD 54,700 million differs slightly from the sum of USD 9,000 million and USD 61,400 million.

### *Discussion*

If temperatures rise higher than expected, the resulting increase in heat stress, malnutrition, and disease might increase the risk of death. Researchers examining climate-related mortality risk in the Los Angeles, USA, area, for example, conclude that heat-stress deaths may increase seven-fold by mid-century, relative to the 1990s (Hayhoe et al., 2004). Changes in Lebanon's demographic profile, with elderly cohorts becoming a larger percentage of the total population, also may have an effect, insofar as elderly people often are more sensitive to heat stress (Sheridan and Allen, 2015). To the extent that anticipated changes in climate would yield warmer temperatures in winter, this effect may reduce the risk of cold-related mortality (Sheridan and Allen, 2015). Some research suggests, though, that this reduction may be minimal (Kinney et al., 2015).

Several factors would likely affect the impacts of temperature and humidity on human mortality. For example, investment in air conditioning may diminish the number of people exposed to heat and development of appropriate health-care facilities and technologies may diminish the effects of heat stress. This analysis does not account for defensive actions that might be taken to offset the increased risk.

Most of the health costs likely would be borne by individuals and family, with some borne by community and government.

### *3.3.6.2 Risk of illness and disability*

Economic costs would materialize as anticipated changes in climate increase the risk of illness and disability for Lebanon's citizens. These costs include direct costs associated with an illness or disability, such as healthcare expenses. They also include indirect costs, such as the affected individuals' forgone enjoyment of life, their reduced ability to earn income, their inability to contribute to the wellbeing of family and community, and the forgone earnings of family members who provide them with in-home healthcare. By estimating the value of the increased risk of illness and disability, this analysis is not placing a monetary value on the wellbeing of the specific individuals who may become ill or disabled because of climate change.

Available information supports estimation of costs associated with two general ways in which climate change can increase the risk of illness and disability. One involves the increase in heat stress from higher temperatures and humidity. The other involves increases in malnutrition, diarrhea, malaria, and flooding.

This analysis measures climate-related risk of illness and disability using a widely accepted metric, the Disability-Adjusted Life Year (DALY) for people living with the illness or disability or its consequences. One DALY represents one person losing one year of a healthy life. Costs measured using estimates of the value of a DALY indicate the treatment costs and pain and suffering associated with illness or disability.

### *Results*

The loss of healthy lives, measured in DALYs would total 812,300 in 2020, 886,800 in 2040, and 874,000 in 2080. Most of this loss would occur because of climate-related increases in malnutrition, diarrhea, malaria, and floods. The economic costs associated with these losses of a healthy life would total USD 177,900 million in 2020, USD 194,300 million in 2040, and USD 191,500 million in 2080 (Table 76).

**Table 76:** Potential costs of climate-related risk of illness or disability in Lebanon (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Number of disability-adjusted life years (DALY) lost per year in Lebanon | | | |
| Heat stress | 620 | 1,300 | 3,300 |
| Malnutrition, diarrhea, malaria, floods | 811,600 | 885,400 | 870,700 |
| Total DALY | 812,300[a] | 886,800[b] | 874,000 |
| Costs of increased risk of illness and disability in Lebanon | | | |
| Heat stress (millions) | USD 140 | USD 300 | USD 730 |
| Malnutrition, diarrhea, malaria, floods (millions) | USD 177,800 | USD 194,000 | USD 190,700 |
| Total (millions) | USD 177,900[c] | USD 194,300 | USD 191,500[d] |

Numbers reflect rounding.
Calculation details available in MoE/UNDP/GEF, 2015g
[a] Because of rounding, the total, 812,300 differs slightly from the sum of 620 and 811,600.
[b] Because of rounding, the total, 886,800 differs slightly from the sum of 1,300 and 885,400.
[c] Because of rounding, the total, USD 177,900 million differs slightly from the sum of USD 140 million and USD 177,800 million.
[d] Because of rounding, the total, USD 191,500 million differs slightly from the sum of USD 730 million and USD 190,700 million.

### *Discussion*

Costs not reflected in this analysis may occur through increases in vector-borne diseases, such as malaria, dengue fever, and yellow fever. DARA and Climate Vulnerable Forum (2012) conclude, however, that the increases in these diseases would be negligible in Lebanon through 2030. Changes in climate would likely impose additional costs on Lebanon through other types of illness/disability, such as short-term water shortages and long-term effects of depression, anxiety, and post-traumatic stress disorder among people who have suffered severe floods and storms (Watts et al. 2015).

Most of these costs would be borne by individuals and families, with some borne by community and government. Most of this increase in heat-related risk likely would fall on elderly individuals. People of all ages would experience the risk of illness and disability from the other causes, although children constitute the bulk of those who suffer from diarrhea and malaria.

### *3.3.7. Costs from impacts of climate change on ecosystems*

Lebanon's aquatic and terrestrial ecosystems provide many valuable services that contribute to human wellbeing (Millennium Ecosystem Assessment, 2005). Services derived from ecosystems directly improve the quality of life and reduce the cost of living for Lebanon's citizens, reduce costs and increase profits for many businesses, and lower government's costs of providing healthcare and other services. The availability of ecosystem services also affects the overall level of economic development and levels of poverty (Roe and Elliot, 2004).

As the climate changes in response to global GHG emissions, it would alter the ecosystems and reduce their ability to provide services. Anticipated changes in temperature and precipitation also would increase soil erosion, stimulate outbreaks of pests and diseases, encourage the proliferation of invasive species, and increase the risks associated with wildfires. As a result, households, businesses, communities, and government would either go with the contribution these services would have made to their wellbeing or incur costs to replace the lost services. Limitations in relevant data prevent a comprehensive analysis of the potential effects of climate change on services derived from Lebanon's ecosystems, and the associated economic costs. This analysis examines only the economic costs associated with three categories of ecosystem change: the loss of biodiversity, land degradation and its impacts on the productivity of cropland, rangeland, and forests, and rising sea levels.

#### *Results*

In 2020, the three categories of costs would total about USD 150 million, with rising sea levels and the loss of biodiversity each imposing costs of about USD 60 million in 2020, and desertification imposing costs about half that amount (Figure 60).

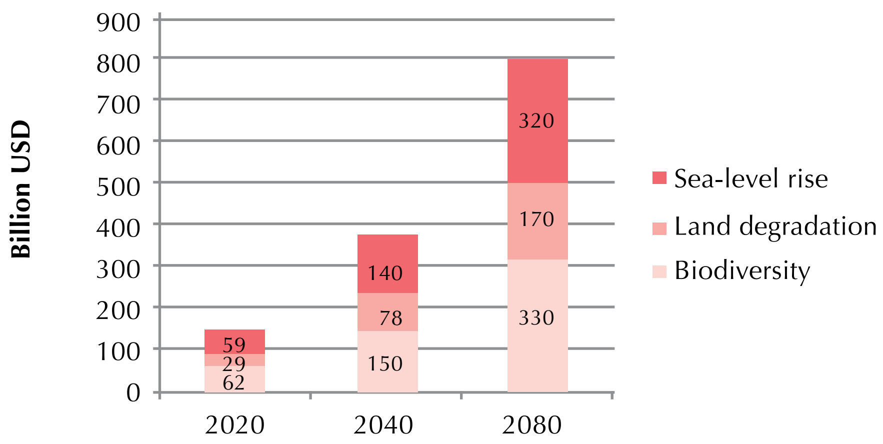



**Figure 60:** Potential costs (million USD) from some of the effects of global GHG emissions on Lebanon›s ecosystems

### *Discussion*

Mounting evidence suggests it would be reasonable to conclude that the costs likely would be higher than those shown in Figure 60. Hansen et al. (in review), for example finds that, if global GHG emissions continue current trends, sea level might rise faster and generate greater economic damage than indicated by prior research. Estimates of costs associated with reductions in biodiversity reflect the use, by DARA and Climate Vulnerability Forum (2012), of the average per-hectare values reported by Costanza et al. (1997). More recent research, e.g., DeGroot et al. (2012) and Costanza et al. (2014), suggests that the ecosystem actual costs likely would be higher, but the DARA Climate Vulnerability Forum has not yet integrated this research into its analytical framework. Even higher estimates would result if the per-hectare value rises as services derived from ecosystems become scarcer.

## *3.3.8. Costs from impacts of climate change on society*

### *3.3.8.1 Costs from the effects of climate-related heat stress on the productivity and earnings of Lebanon's workers*

Climate incurred costs will materialize as higher temperatures and humidity reduce workers' capacity to complete physical work, increase the risk of mental errors and accidents, and lower their overall productivity. Productivity also can fall when workers, of their own volition or under directions from supervisors, reduce the intensity of their work-effort or increase the frequency of their rest periods. Heat-stress reductions in productivity can affect those working outdoors, especially workers directly exposed to sunlight, as well as those working indoors in spaces that are not air-conditioned. If workers bear the full burden of these effects, then their earnings would fall by an amount equal to the reductions in productivity.

### *Results*

Total costs to all affected workers would rise from about USD 43 million in 2020 to USD 1,400 million in 2080 (Table 77). The average cost per worker (employed in the formal sector and self-employed) would rise from about USD 30 in 2020 to USD 930 in 2080.

**Table 77:** Potential economic costs to Lebanon from reductions in workers' productivity and earnings associated with climate-related heat stress (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Total reduction in productivity and earnings per year in Lebanon (millions) | USD 43 | USD 160 | USD 1,400 |
| Cost per worker per year in Lebanon | USD 30 | USD 100 | USD 930 |

Calculation details available in MoE/UNDP/GEF, 2015g.
Numbers reflect rounding.

### *Discussion*

Costs might be lower if labor-market characteristics, such as the incidence of outdoor work and indoor air-conditioning, would lower the number of workers exposed to high temperatures. This outcome would materialize if the number of workers in outdoor industries, such as agriculture and construction, were to decline as the number of workers in air-conditioned buildings increased. Costs might be higher, however, if, as temperatures increase, Lebanon's electricity sector would be unable to meet the rising demand for air-conditioning so that more indoor workers would experience heat stress. This analysis calculates the costs assuming that 2010's labor-market characteristics remain unchanged.

All else equal, however, actual costs would likely be higher, insofar as this analysis does not consider other related costs stemming from the effects of climate change on workers' productivity. For example, climate-related increases in disease might complement or magnify the effects of heat stress on productivity and earnings.

### *3.3.8.2 Costs from the effects of climate-related undernourishment of children on their productivity and earnings as adults*

Changes in climate can increase the number of children suffering from undernourishment by reducing crop production, disrupting food production and distribution systems, increasing food prices, displacing families from their farms, and increasing poverty. As these effects become more intense, they will increase the number of people who persistently consume too little food, or not the right kinds of food, to satisfy minimum dietary requirements for a healthy life. Lack of sufficient nourishment for pregnant women and young children will increase the number of babies born with low birth weight and infant deaths. The stunted development of children who survive but endure persistent undernourishment will, relative to other individuals, experience greater incidence of disease, more extensive learning disabilities, reduced physical capabilities. These effects will lower their productivity at home and work, increase their healthcare costs, shorten their work life, and reduce their earnings.

This analysis describes only one of these effects: the reduction in productivity and earnings that materialize as undernourished children become adults.

### *Results*

The percentage of workers affected by climate-related undernourishment would grow from about 0.57% in 2020, to 1.12% in 2080, imposing a cost of up to USD 280 million in terms of lost earnings.

**Table 78:** Reduction in productivity and earnings of workers who experienced climate-related undernourishment as children in Lebanon (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Percent of workers undernourished as children in Lebanon | 0.57 | 0.72 | 1.12 |
| Number of workers undernourished as children in Lebanon | 8,200 | 11,200 | 17,200 |
| Total earnings lost (millions) | USD 22 | USD 51 | USD 280 |
| Earnings lost per worker | USD 2,600 | USD 4,500 | USD 16,300 |

Numbers reflect rounding.

### *Discussion*

The actual costs might be higher or lower than those shown in Table 78. All else equal, however, they likely would be higher, insofar as this analysis does not consider several types of costs that would accompany climate-related undernourishment of children:

- Increased risk of infant death.
- Increased neonatal care.
- Increased risk of subsequent illness and disability.
- Loss of lifetime productivity and earnings because of smaller stature.
- Loss of lifetime productivity and earnings because of limited education and impaired mental development.
- Increased risk that children, born of parents who have diminished earnings because they were undernourished when they were children, will also experience diminished earnings.

### *3.3.8.3 Costs from climate-related internal migration*

If current trends in global GHG emissions continue, the resulting changes in climate, such as droughts, storms, diseases, malnutrition, and higher sea levels, would leave some of Lebanon's households unable to sustain their livelihoods and force them to relocate. Some may relocate to live with relatives or friends, but others may lack such options. Relocating households likely would realize a loss of income and incur other economic costs, such as loss of assets.

Because of limitations in data regarding the potential number of households that might be displaced by climate change, this analysis focuses on just a subset of those households. It draws on the research (Haddad et al., 2014) underlying the analysis of climate-related reductions in Lebanon's overall agricultural production. As that research estimated the reduction in agricultural output and the earnings of farmers and workers in related industries, it also estimated the number of individuals that would have to relocate for the overall level of average income of the remaining households to equal what it would have been without the effects of climate change.

Reliable research regarding the economic costs borne by forced migrants is very limited, but it suggests that, on average, they experience a loss of income of about 45% (World Bank et al., 2012).

### *Results*

**Table 79:** Potential number of internal migrants and their loss of income from climate-related impacts on Lebanon's food production (2015 USD)

| Year | 2020 | 2040 | 2080 |
|---|---|---|---|
| Potential number of internal migrants[a] | | | |
| Lebanon | 6,900 | 14,600 | 35,600 |
| Beirut | 970 | 2,100 | 5,000 |
| Mount Lebanon | 2,800 | 6,000 | 14,700 |
| Northern Lebanon | 1,200 | 2,500 | 6,000 |
| Bekaa | 800 | 1,700 | 4,100 |
| Southern Lebanon | 740 | 1,600 | 3,800 |
| Nabatieh | 380 | 800 | 2,000 |
| Potential lost income for migrants[b] (millions) | | | |
| Lebanon | USD 57 | USD 130 | USD 320 |
| Beirut | USD 10 | USD 23 | USD 51 |
| Mount Lebanon | USD 26 | USD 60 | USD 148 |
| Northern Lebanon | USD 9 | USD 21 | USD 52 |
| Bekaa | USD 6 | USD 13 | USD 30 |
| Southern Lebanon | USD 5 | USD 11 | USD 24 |
| Nabatieh | USD 3 | USD 7 | USD 16 |

Numbers reflect rounding.
[a] Because of rounding, the total number of migrants for Lebanon differs slightly from the respective sum of the regional numbers.
[b] Because of rounding, the total lost incomes for Lebanon differ slightly from the respective sum of the regional losses.

### *Discussion*

This analysis considers only the potential loss of income Lebanese citizens might incur if climate-related reductions in the country's food production displace them from their homes. Displacement might occur as farm households lose their livelihood and workers in related industries lose their jobs. Because of limitations in the available data, the analysis does not consider other potential costs, such as the loss of assets these individuals might incur, nor does it consider costs family members, the government, or others might incur as these people are displaced. It also does not consider the potential costs that would materialize when other effects of climate changes, such as storms and floods, induce Lebanese people to migrate. This analysis does not consider potential costs associated with climate-related migration of people from other countries to Lebanon.

All else equal, however, actual costs would likely be higher, insofar as this analysis does not consider other related costs stemming from the effects of climate change on workers' productivity. For example, climate-related increases in disease might complement or magnify the effects of heat stress on productivity and earnings.

## 3.4. Summary of costs

**Table 80:** Costs that climate change might impose on different segments of Lebanon's economy and society (million 2015 USD)

| Potential cost | 2020 | 2040 | 2080 |
|---|---|---|---|
| **A. Costs from impacts of climate change on agriculture and food supplies** | | | |
| 1. Reductions in Lebanon's agricultural production | USD 300 | USD 860 | USD 2,300 |
| 2. Reductions in production of wheat and maize | USD 10 | USD 17 | USD 28 |
| 3. Reductions in fish harvest | USD 13 | USD 32 | USD 32 |
| 4. Increases in global food prices | USD 470 | USD 1,700 | USD 5,000 |
| **B. Costs from impacts of climate change on water** | | | |
| 1. Reductions in agricultural and domestic /industrial water supply | USD 21 | USD 320 | USD 1,200 |
| 2. Reductions in water supply for generation of hydroelectricity | USD 3 | USD 31 | USD 110 |
| **C. Costs from climate-related natural disasters** | | | |
| 1. Increases in droughts, floods/landslides, and storms | USD 7 | USD 36 | USD 1,600 |
| **D. Costs from impacts of climate change on tourism** | | | |
| 1. Reductions in attractiveness of Lebanon's coastal resources | USD 22 | USD 160 | USD 1,800 |
| **E. Costs from impacts of climate change on electricity consumption** | | | |
| 1. Increases in demand for cooling | USD 110 | USD 900 | USD 34,800 |
| **F. Costs from impacts of climate change on human health** | | | |
| 1. Increases in risk of death | USD 47,200 | USD 54,700 | USD 61,400 |
| 2. Increases in risk of illness and disability | USD 177,900 | USD 194,300 | USD 191,500 |
| **G. Costs from impacts of climate change on ecosystems** | | | |
| 1. Reductions in biodiversity | USD 62 | USD 150 | USD 330 |
| 2. Increases in land degradation | USD 29 | USD 78 | USD 170 |
| 3. Increases in sea level | USD 59 | USD 140 | USD 320 |
| **H. Costs from impacts of climate change on society** | | | |
| 1. Increases in violence from higher temperatures | USD 38 | USD 840 | USD 8,600 |
| 2. Reductions in workers' productivity from heat stress | USD 43 | USD 160 | USD 1,400 |
| 3. Reductions in workers' productivity from childhood undernourishment | USD 22 | USD 51 | USD 280 |
| 4. Increases in internal migration | USD 57 | USD 130 | USD 320 |

Numbers reflect rounding.

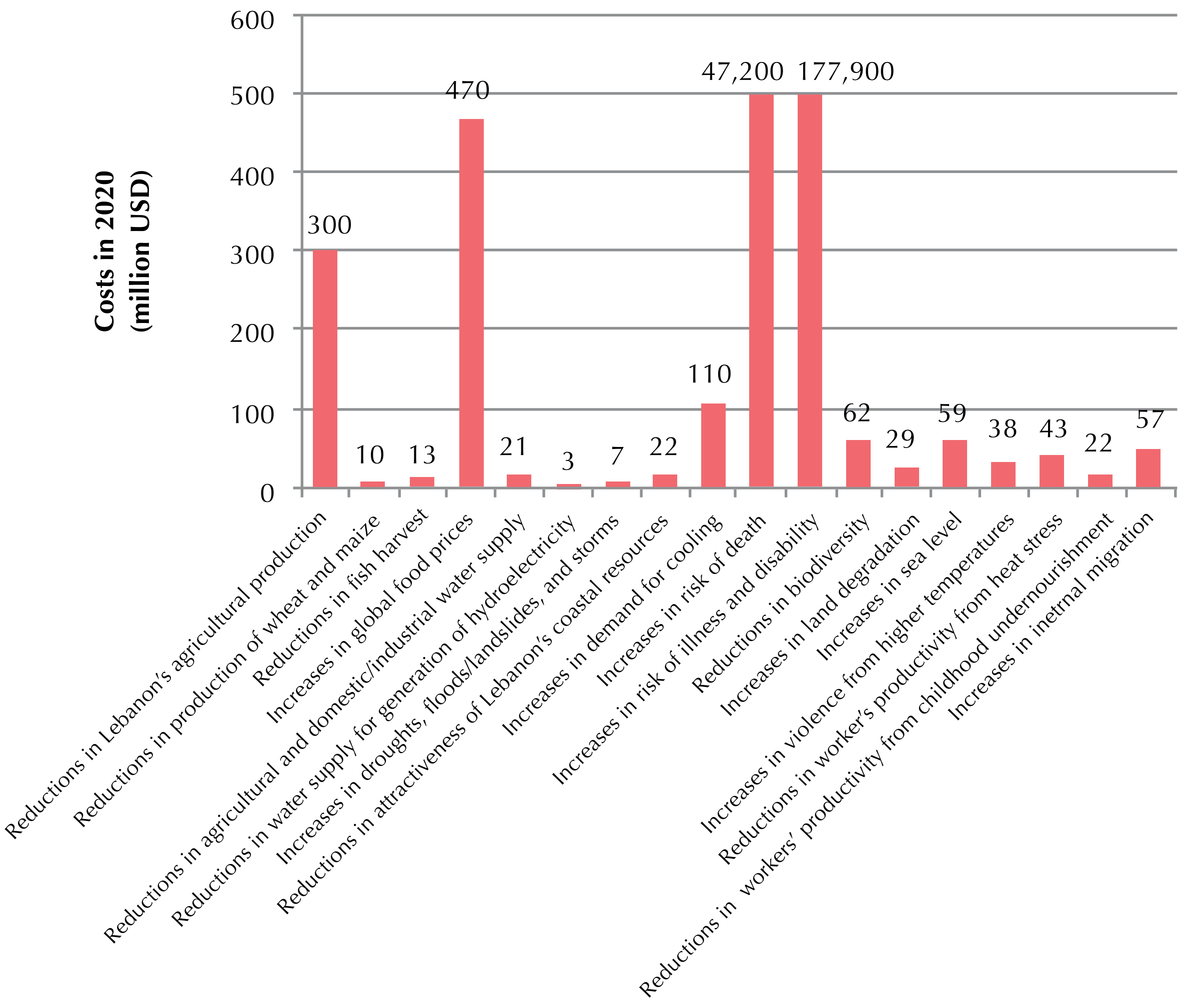



**Figure 61:** Summary of the economic cost of climate change to Lebanon

## 4. Adaptation actions

The Second National Communication (SNC) (MoE/UNDP/GEF, 2011) has identified potential adaptation actions that would minimize the burden imposed by climate change on the various sectors of the economy. One year later, the Technology Needs Assessment (TNA) (MoE/URC/GEF, 2012) identified potential adaptation technologies that would enhance adaptation to climate change for the 2 prioritized sectors, water and agriculture. These potential efforts generally aim to reduce the vulnerability of Lebanon's capital resources to climate change and increase their resilience. Similar to the minimal changes in future climate risks, minimal changes in vulnerabilities of the various sectors are expected. Since the publication of Lebanon's SNC and TNA, several governmental initiatives have sprouted with an attempt to strategically organize the development of each sector, while increasing resilience to adverse impacts of climate change, taking into consideration the recommendations of these two reports.

In this section, a short brief of potential adaptation options identified in the SNC and TNA for vulnerability reduction is presented for each sector. In addition, new sectoral initiatives that have been established after the publication of these two reports are described when applicable.

### 4.1. Water resources

MoE/UNDP/GEF (2011) presents several recommendations to enhance the water sector adaptation to climate change in Lebanon. These include reducing the likelihood that coastal freshwater aquifers will experience saltwater intrusion as sea level rises, increasing the water-use efficiency of domestic, industrial, and agricultural sectors, developing watershed-managed plans appropriate for expected changes in climate, investigating the feasibility of alternative sources of water supply, and improving the available information about Lebanon's water resources and water systems. The TNA prioritized rainwater harvesting from roads and greenhouse tops and the establishment of water user's associations as key appropriate actions to increase the water sector's resilience to adverse impacts of climate change.

The MoE has installed rainwater harvesting systems in 3 pilot sites of agricultural greenhouses in different locations in Lebanon. Following positive encouraging results, the MoE aims at disseminating these practices to a wider pool of beneficiaries once funding is made available. Guidelines and lessons learned from the pilot project have been drafted for this purpose.

Activities related to rainwater harvesting from roads have been included in the AGRICAL project, which was planned to start in 2012 at the MoA through a funding from the Adaptation Fund. Unfortunately, the project has still not been launched to date.

According to an assessment on updating the national adaptation plan to climate change in the water sector conducted under CapWater project (funded by the World Bank and implemented by the CNRS), several obstacles have been identified that prevented the implementation of previous adaptation measures within the water sector and that will influence any current or future attempts to adapt to climate change effects within the water sector (Table 81).

**Table 81:** Barriers to national actions to adapt to climate change within the water sector

| Barrier | Description | Influence | Measures to overcome |
|---|---|---|---|
| Institutional and policy options | Understaffing of the MoEW leading to poor implementation and follow up of relevant strategies and policies | High | Vacant positions in MoEW filled with skilled individuals. |
| | Lack of coordination between ministries on key water issues and common priorities | High | Activate communication mechanisms such as inter-ministerial committees and mainstream nexus approaches between interlinked sectors. |
| | Tariffs policies of flat rates have long discouraged conservation measures | High | Speed up the implementation of the new tariffs measures proposed by the MoEW. |
| | Minimal success in limiting illegal groundwater abstraction | High | Impose stricter control of wells, increase staffing within water establishments and build the capacity of staff on monitoring of unlicensed wells.<br>Operationalize cooperation mechanisms established with the internal security forces to speed up closure of illegal wells. |
| | Lack of standards on wastewater reuse | Medium | Establish standards for wastewater reuse using regional standards as a baseline. |
| | Lack of localized management of water resources | Medium | Establish water users association. |
| Technical | Lack of centralized data systems and poor maintenance of water monitoring systems | High | Establish one centralized entity for water data collection, management and analysis. The entity will be also responsible for long term monitoring of water systems such as rivers, wells and so on. Human resources and financial resources need to be secured in addition to the pertinent infrastructure. |
| | Weak knowledge of Integrated Water Resources Management | High | Build capacity of key technical staff on IWRM across basins and their implications at the local levels. |
| | Weak knowledge on wastewater, grey water, groundwater recharge and storm water reuse (IWRM) | High | Build the capacities of key staff and establish efficient cooperation mechanisms with research institutions. Cooperate with regional and international partners with relevant experience. Use the results of the technology needs assessment where relevant. |
| Financial | Financial constraints | High | Solicit international donor agencies for support.<br>As for sector priorities, given how enormous the capital investments that are needed, the government needs to secure funds from its own means or ask for loans from banking institutions such as the World Bank. One option that remains to be explored is the public-private financing mechanisms. |
| Social | Lack of awareness on water conservation measures | Medium to high | Impose new tariffs to encourages behavioral changes.<br>Increase awareness campaigns. |
| Political | Political instability, border conflicts, refugees' crisis | High | These factors go beyond any action plan but certainly affect it. However, a clear action plan is formed of several phases, some of which can still well function even with certain political problems going on, for example capacity building activities, increased awareness campaigns on water conservation measures and so on. |

Source | Adapted from CNRS, 2015.

The assessment proposes an action plan for the period 2021-2016 to consolidate the national adaptation framework in the water sector. Main areas of work identified in the action plan are:

- Restructure the water governance towards a climate responsive water sector
- Implement climate change adaptation and vulnerability reduction measures for water resources and infrastructure
- Improve surface and groundwater quality
- Improve equitable access to sustainable water supply
- Enhance knowledge and capacity for climate change adaptation in the water sector.

During the 21st Conference of the Parties in Paris in December 2015, a strong broad coalition of 290 nations, river basin organisations (including cross-border), business and civil society and funding agencies announced the creation of the Paris Pact on Water and Climate Change Adaptation (Box 3). The objective of the pact is to make water systems – the very foundation of sustainable human development - more resilient to climate impacts. Lebanon is one of the countries that joined the initiative, which is led by the International Network of Basins Organisations (INBO).

**Box 3:** Paris Pact on Water and Adaptation - strengthening adaptation in basins of rivers, lakes and aquifers

The pact encompasses individual commitments to implement adaptation plans, strengthening water monitoring and measurement systems in river basins and promoting financial sustainability and new investment in water systems management. These major collaborative projects combined represent over USD 20 million in technical assistance and potentially over USD 1 billion in financing.

The project Lebanon is involved in under the Pact is the **Mediterranean Water Knowledge Platform**, a 7-year commitment to assess the state and trends of water resources. The establishment of a Mediterranean Water Knowledge Platform is a prerequisite to the development of sustainable policies for integrated water resources management and climate change adaptation. It aims to provide a common basis for the development of national water information systems in four pilot countries, and to deliver an assessment of water resources management and use (i.e., drafting of a white paper) by collecting and exploiting data of these systems. It will allow for an evaluation of best practices, joint management of transboundary resources, and follow-up on regional or sub-regional projects and policies in the Mediterranean region, on a voluntary basis. The European Commission supports the project. The project will be contributing to several **Sustainable Development Goals**, and currently it is financed by USD 3.9 million for implementation.

## 4.2. Agricultural sector

Potential options to increase climate resilience of the agricultural sector include: increasing the water-use efficiency of irrigation systems; developing species and hybrids more tolerant of high temperatures and drought; changing the timing of planting, irrigation, and harvesting; adopting sustainable agricultural practices and integrated pest management techniques; developing rangeland-management practices that recognize the effects of climate change; and providing farmers with better, timely information about pending extreme weather events (MoE/UNDP/GEF, 2011).

In an effort to include these specific recommendations in its planning, the Ministry of Agriculture (MoA) updated its strategy (MoA, 2015) for the years 2015-2019 based on the achievements and lessons learned from previous strategies. The Ministry of Agriculture introduced for the first time "Responding to climate change impacts" as one of the central courses of action for the next five years. MoA plans to assist the agricultural sector in many areas of intervention to better adapt to the impacts of climate change and to reduce its emissions, mainstream MoA activities related to climate change, introduce the adaptation measures through various implemented programmes, and conduct a study to estimate the greenhouse gas emissions from the agricultural sector, land use changes and forestry (Box 4). In addition, 33 out of the remaining 103 activities related to the 7 areas of interventions have also been linked to climate change.

**Box 4:** Ministry of Agriculture strategy for the years 2015-2019

**Course of Action VIII: Responding to climate change impacts**

Areas of intervention:

8.1.1 Mainstreaming of the Ministry of Agriculture activities related to climate change

- Establish a Climate Change Committee that includes the Mutual Fund for the insurance of the agricultural sector against natural disasters, agriculture research, MoA, Ministry of Environment, CNRS, and others, with the mandate to steer all climate change adaptation efforts and initiatives (4 meetings per year)
- Coordinate climate change mitigation through afforestation, rational use of fertilizers, recycling of farm wastes into compost
- Identify in depth research priorities of the impact of the climate change on the main agricultural sectors

8.1.2 Introducing adaptation measures in the work of the Ministry of Agriculture

- Prepare an inclusive guide on the response and adaption measures
- Take into consideration the climate change while preparing new programmes, projects and legislations

8.1.3 Estimating greenhouse gas emissions from the agricultural sector, land use changes and forestry

- Train a group of MoA staff
- Conduct the study and provide recommendations

Source | MoA, 2015

As for the agriculture adaptation technologies recommended in the TNA, three of them have been tackled under the AGRICLIMAs regional project funded by the European Union (EU) and implemented by the Lebanese Agriculture Research Institute (LARI): conservation agriculture, good agriculture practices and selection of adapted varieties and rootstocks. Indeed, the project has experimented the adoption of good agricultural practices and conservation agriculture in over 80 hectares of agricultural land and with 28 farmers in the Bekaa region. Following positive encouraging results, LARI and the Ministry of Environment (MoE) aim at disseminating these practices to a wider pool of beneficiaries once funding is made available. As for the selection of adapted varieties and rootstocks, some limited efforts have been undertaken to assess the survival rate of different species of wheat and barley under different seasonal conditions and agricultural practices. More research is still needed in this area, once funding is made available.

### 4.3. Forest resources and biodiversity

Potential options to increase climate resilience of the forest cover in Lebanon include: reducing fragmentation, protecting biodiversity, developing and implementing appropriate strategies for managing increased risk of fire, pest, and disease, and improving knowledge about and awareness of the ecosystem services derived from forests (MoE/UNDP/GEF, 2011).

Along those lines and in compliance with the objectives of the National Reforestation Program established in 2005, the Ministry of Agriculture in partnership with the Food and Agriculture Organization (FAO) launched in December 2012 a national initiative to plant 40 million forest trees for recovering lost forest areas in the last decade (MoA/FAO, 2013) (Box 5). By increasing the green cover, this program aims at both increasing the resilience of forests to the impacts of climate change and reducing national GHG emissions by creating additional carbon sinks.

**Box 5:** The National Afforestation and Reforestation Program - The 40 million forest trees initiative

The initiative aims at increasing forests from 13% of Lebanon's total area (currently) to 20% over a period of 20 years. The program maintains two integrated phases:

**1- Elaboration of a master plan for reforestation in Lebanon** able to respond to the local needs through the development of scientific based tools for identifying the proper site selection, the assessment of the field conditions, the selection of suitable native species, the elaboration on the suitable planting techniques, the development of adapted maintenance, follow up and evaluation practices for the successful implementation of any reforestation activities. All of these are based on the expected function attributed to the Lebanese forests.

**2- Implementation of the master plan for reforestation in Lebanon** at the national level in partnership with the national stakeholders of public and private sector from ministries, NGOs, private banks, private investors, local community members etc. This approach is expected to merge all efforts of stakeholders towards contributing to the utmost goal of planting 40 million forest trees in 70,000 hectares of public land in the coming 20 years.

Source| MoA/FAO, 2013

Besides conserving forest trees and forest cover in the country, conservation of biodiversity is a key adaptation element to face negative impacts of climate change on ecosystem services, including health, leisure, cultural heritage, tourism among others. The MoE has therefore updated its National Biodiversity Strategy and Action Plan (NBSAP) for the period 2016-2030 as required under the Convention on Biological Diversity (CBD). Climate change was identified as one of the priority areas of the NBSAP with an overarching objective of developing and implementing adaptation plans for ecosystems vulnerable to climate change by 2030 (Box 6).

**Box 6:** Lebanon's National Biodiversity Strategy and Action Plan

**Vision:**
By 2030, Lebanon's biodiversity is valued and sustainably managed for the preservation and conservation of its ecosystems and habitats and the species they harbor in order to adequately respond to anthropogenic and natural pressures and to ensure Lebanese citizens equal access to ecosystem goods and services.

**Priority areas:**
- Threatened species
- Genetic diversity
- Protected areas
- Sustainable management and use of natural ecosystems and resources
- Ecosystem restoration
- Access and benefit sharing
- Invasive alien species
- Communication, education and public awareness
- Mainstreaming biodiversity into national and sub-national policies and plans
- Climate change
- Research and knowledge transfer
- Institutional and legal framework
- Resource mobilization

Source| MoE/UNEP/GEF, 2016

## 4.4. Public health

Adaptation measures for the health sector quickly became a priority after having been identified as one of the most affected sectors by climate change (MoE/UNDP/GEF, 2015g). Measures recommended to increase the adaptive capacity of this sector include: improving knowledge about and awareness of the interactions between climate change and public health, strengthen systems for monitoring and responding to the effects of climate change on public health, encouraging development strategies that protect and promote health, and strengthen institutions responsible for preparing for and responding to the effects of climate change on public health.

A regional strategy on health and the environment and plan of action for the period 2014–2019 in the Eastern Mediterranean Region (EMR) has been recently developed and endorsed. The strategy tackles recommendations of the SNC as presented in Box 7.

**Box 7:** Regional strategy on health and the environment

**Main objective:** support countries of the region to reduce the burden of disease attributed to environmental risk factors by:
(a) reducing environment-related communicable diseases,
(b) controlling environmental risks for non-communicable diseases and injuries,
(c) protecting the most vulnerable population groups from environment-related diseases, and
(d) strengthening the resilience of the health system and reinforcing the capacities for emergency preparedness and response.

**Environmental health priorities addressed:** water, sanitation and health, air pollution, chemical safety, waste management and environmental health services, environmental health emergency management, climate change and health, and sustainable development and health.

**List of actions proposed for Lebanon under climate change:**
Develop a clear defined mandate for the Climate Change Coordinating Unit (CCCU) with developed policies and procedures and a clear mechanism for reporting to the Council of Ministers including:

- Assessing the vulnerability of public health sector to climate change, identifying the current and future health effects and establishing early warning systems
- Conducting health vulnerability assessment to identify the short, medium, and long term additional direct and indirect threats to health from climate change
- Conducting interdisciplinary applied research and demonstration projects on health vulnerability to climate change and on effectiveness of health protection measures
- Building the capacity of health sector professionals (technical people, authorities and policy makers) in the identification of health impacts from other sectors (e.g. transport, energy, food, water, housing and urban development)
- Mapping health resources available to cope with additional burden of climate
- Mapping and identifying gaps that challenge health systems' preparedness to handle priority groups of diseases: water-borne diseases, food-borne disease, malnutrition associated with food insecurity, health effects of heat waves and extreme cold conditions, respiratory and other diseases associated with air pollution, vector-borne diseases and health effects of climate related disaster
- Empowering and ensuring sustainability of existing environmental health functions and services to face challenges of water security for health, water quality degradation, droughts, heat waves, food security and safety, vectors redistribution, air quality degradation, floods and other climate related natural disasters

- Upgrading health system monitoring and coordinating the development of early warning on a specific set of indicators such as meteorological conditions, environmental determinants related to energy, emissions, pollution standards index, water security indicators, vector profile distribution and food security (e.g. Heat-Health action plans)
- Upgrading epidemiological surveillance to incorporate new health outcomes in the Epidemiological Surveillance Unit
- Developing a mechanism to incorporate climate data in the national health information system
- Raising awareness on the health effects of climate change (starting with the accredited health care facilities) through organizing awareness events and training health care practitioners
- Develop health system response strategies, plans and projects and integrate them into national health strategies including:
  - Developing a clear documented mechanism for mainstreaming of climate change response into all national and subnational planning regimes
  - Integrating climate change impacts in emergency health contingency plan
  - Developing a functional mechanism for prioritization of climate actions (both mitigation and adaptation) that have positive potential on job creation, poverty alleviation and/or general economic impacts
  - Developing a clear system for mainstreaming science-policy interface and knowledge to ensure that climate change response decisions are informed by the best available information with stronger cooperation with the academic sector
  - Developing a feedback system to involve citizens and communities (NGOs) in setting policies for mitigating and adapting to climate changes.

Source | WHO, 2015

## 4.5. Electricity sector

Lebanon's SNC recommended increasing the resilience of the electricity sector through improving the energy-use efficiency of buildings and transportation systems and developing energy-supply systems that are less vulnerable to the disruptions of extreme weather events, higher average temperatures, and other aspects of climate change.

Following the publication of the SNC, two National Energy Efficiency Action Plans (NEEAP) were developed. The first one for the period 2011-2015, the second (published in March 2016) for 2016-2020. These national documents summarize national efforts that are taking place in Lebanon and set the road map to be followed by the country towards reaching its objectives in energy efficiency (MoEW/LCEC, 2016). The current NEEAP (2016-2020) includes a number of energy efficiency initiatives distributed along two major axes dedicated to primary energy savings and end-use measures. While the primary energy saving measures are in the generation, transmission, and distribution sectors of the Lebanese power network, the section on end-use measures deals with energy saving measures in buildings industries, Small and Medium Enterprises (SMEs), agriculture, mobility and transport, and public services and facilities (MoEW/LCEC, 2016). In addition, the

MoEW's National Renewable Energy Action Plan (NREAP) that was launched in 2016 sets the stage for the expansion of renewable energy in Lebanon to meet at a minimum its 12% target by 2020. The implementation of some measures has already started, as described in Lebanon's Biennial Update Report (Moe/UNDP/GEF, 2015).

### 4.6. Coastal communities and ecosystems

The vulnerability of coastal communities and ecosystems could be reduced by developing and implementing plans for pulling human activities back from coastal areas that will be exposed to expected rises in sea level, creating coastal marine reserves to strengthen the ability of coastal habitats and species to adapt to changes in climate, reducing the stress on coastal resources from the emission of pollutants and other human activities, developing and implementing a strategy for protecting capital and people unlikely to move, e.g., essential transportation structures and highly urbanized areas, and providing coastal residents with better, timely information about pending extreme weather events (MoE/UNDP/GEF, 2011)

The MoE conducted an analysis of the current land use and socio-economic activities of the coastal zone, in addition to an assessment of the coastal sensitive areas in Lebanon. The work was performed in 2012 under the "Environmental Resources Monitoring in Lebanon" project. These studies resulted in a classification allowing the identification of hot-spot coastal municipalities by integrating levels of land use changes and socio-economic pressures (high, medium and low risk municipalities) (MoE/UNEP, 2013a). Moreover, the analysis assessed the status of coastal sensitive areas of interest in Lebanon in terms of ecological systems, and identified the main threats with the focus on land-based sources of pollution especially river discharges in the coastal and marine environments. Finally, this study showed the important deficiency in the information system about coastal and marine environments. Therefore, achieving a better and Integrated Coastal Zone Management (ICZM) urgently requires detailed data collection to improve the knowledge on the biological features and the existing habitat types of sensitive sites in particular and marine ecosystems in general (MoE/UNEP, 2013b). A monitoring programme has been developed as part of the project to look into the marine part of the coastal ecosystems (mainly on the benthic habitats) as these reflect the ecological quality of coastal water bodies. A science-based ecosystem approach to the management of human activities has been proposed for the monitoring and evaluation of ecological quality status of coastal waters in Lebanon, specifically the biological communities of the seafloor (MoE/UNEP, 2013c). A draft law on ICZM in Lebanon has been prepared by the MoE and is awaiting administrative procedures for adoption by Council of Ministers and Parliament.

### 4.7. Tourism sector

Potential options to increase climate resilience of the tourism sector include developing better insurance and other short-run tools for managing risks to tourism, such as disruptions from coastal storms or lack of snowfall at mountain resorts, developing appropriate long-run plans for managing risks, such as moving coastal tourism facilities away from potential storm surges and winter facilities to higher altitudes, reducing the stress on climate-sensitive natural resources important to tourism from e.g., erosion and urban sprawl, and providing the tourism industry with better, timely information about pending extreme weather events (MoE/UNDP/GEF, 2011).

# 5 GAPS, CONSTRAINTS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY BUILDING NEEDS

# 5 GAPS, CONSTRAINTS AND RELATED FINANCIAL, TECHNICAL AND CAPACITY BUILDING NEEDS

Several constraints need to be tackled in order to enable Lebanon to sustainably implement its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). Constraint removal and filling of gaps will be possible in the medium and longer term with continuous national efforts and sustained support from bilateral and multilateral partners and donor agencies. Three types of barriers have been identified: those related to reporting (national communications, biennial update reports and review of intended nationally determined contributions) and their related institutional and Measuring, Reporting and Verifying (MRV) arrangements, those related to implementation of planned adaptation and mitigation actions (especially actions that Lebanon committed to under its Intended Nationally Determined Contribution (INDC)), and financial constraints.

## 1. Gaps and constraints related to reporting and related institutional and MRV arrangements

The main challenges faced in the preparation of the Greenhouse Gas (GHG) inventory are still the same since the preparation of the country's first inventory in 1994 and are mainly related to unavailability, inaccessibility and inconsistency of activity data and emission factors. Although some improvements have been achieved both at the technical and institutional levels, nevertheless, barriers still exist. In addition, since the inclusion of the Biennial Update Report (BUR) as a new reporting tool, new challenges have arisen, mainly from the collection and consolidation of information related to existing mitigation actions. These are related to lack of reporting and coordination between institutions working directly or indirectly on climate change and the difficulty in quantifying the emission reduction achieved by the implementation of each action. Table 82 presents the key challenges identified in the preparation of the Third National Communication (TNC) and the BUR.

Since the preparation of the Second National Communication, progress has been observed only in the area of capacity building for individuals and institutions whose experts were trained on the preparation of GHG inventories. Capacity building activities were usually organized by international organizations through regional projects (EU-ClimaSouth, UNDP-Low Emission Capacity Building (LECB) project, etc.) or by the secretariat of the UNFCCC.

Other types of support to tackle other technical and institutional constraints are very limited. The United Nations Development Programme (UNDP) LECB project is supporting the Ministry of Environment (MoE) to develop a national GHG inventory system and an MRV system. However, progress is slow and institutional arrangements take time given the unstable political situation of the country. As a result, Lebanon still does not have a clearly defined system for data collection and processing, quality assurance and control, or a reporting and monitoring system. Some initiatives (described in the national circumstances section) have been established, namely with the Ministry of Industry (MoI) and MoE

decision 99/1 to institutionalize reporting of data, however the system is still in its fetal phase. Proper regulations that would fully define competences and responsibilities in this area are needed. In addition, the sustainability in the involvement of dedicated and competent individuals in all relevant institutions is crucial to ensure good quality reporting. Currently, institutions do not have sufficient technical equipment (in terms of appropriate software and hardware) and human resources to undertake the preparation of their relevant parts of the national GHG inventories.

**Table 82:** Key gaps and constraints in the preparation of Lebanon's TNC and BUR

| Technical constraints |
|---|
| - Unavailability of activity data<br>- Lack of disaggregated activity data<br>- Inconsistency of data between different official sources<br>- Underdeveloped sectoral databases<br>- Deficiencies in technical expertise<br>- Discontinuity in data series<br>- Difficulty in estimating uncertainty for activity data and emission factors<br>- Inaccuracy of emission factors to reflect national circumstances<br>- Difficulty in estimating emission reductions induced by the implementation of mitigation activities<br>- Difficulty in assessing climate impacts on the various sectors<br>- Challenges in running and accessing climate forecast models<br>- Lack of gender disaggregated data especially for vulnerability assessment<br>- Lack of indicators to monitor gender mainstreaming in climate change issues |
| **Institutional constraints** |
| - Lack of institutional arrangements for data monitoring and reporting<br>- Scattering of data throughout national agencies<br>- Absence of willingness to share data between public/private institutions<br>- Time delays in accessing and compiling data<br>- Overlapping mandates of different agencies<br>- Lack of consistency in assigning contact persons in governmental institutions<br>- Lack of sufficient documentation on data sources from previous national communications reports<br>- Lack of cooperation between different research bodies<br>- Lack of knowledge of the main institutions about Lebanon's commitments under the UNFCCC<br>- Lack of staff, budget and institutional arrangements to plan for gender and climate change mainstreaming. |

Table 83 presents the key needs for Lebanon for an enhanced compliance with UNFCCC reporting requirements.

**Table 83:** Key needs for the preparation of Lebanon's Third National Communication and BUR

| **Administrative needs** |
|---|
| - Establish a permanent climate change and MRV unit. |
| **Technical needs** |
| - Conduct surveys in order to elaborate specific emission factors.<br>- Develop GHG emission estimation models with local research institutes to create Lebanon-specific methodologies using advanced bottom-up approaches for inventory preparation.<br>- Undertake surveys to determine missing activity data at the national level.<br>- Develop research capacity and fund relevant research.<br>- Conduct training for relevant institutions involved in planning, preparation, and analysis of GHG inventory.<br>- Create a national GHG emission inventory review system by an independent team of experts. |
| **Institutional needs** |
| - Create a national system for the preparation of the GHG inventory, empowering the Central Administration for Statistics (CAS), the relevant ministries and concerned public authorities to develop monitoring indicators.<br>- Homogenize statistics between public, private, and international agencies.<br>- Standardize/centralize data reporting and develop protocols for data accessibility.<br>- Issue the necessary authorizations for the creation of individual emission databases in relevant institutions.<br>- Provide continued investment in hardware and training of personnel for data collection, measurement and management. |

## 2. Constraints related to implementation of policies and projects

Implementing climate related projects and policies, especially those listed in Lebanon's INDC, requires strong coordination between institutions to support sectors with the planning and implementation of mitigation and adaptation actions, the assessment and communication of support needs (nationally and internationally) and the MRV related to the INDC implementation. This will also include further mainstreaming of mitigation and adaptation, promoting climate actions, improving the cooperation among ministries as well as mobilizing support for planning and implementation. While the institutional structures for the coordination remain to be agreed on, Lebanon currently envisages a dedicated coordination unit located in the MoE, aligned with the governance arrangements for the implementation of the National Sustainable Development Strategy currently under preparation (Table 84). Line ministries would remain accountable for the implementation of sectoral strategies and action plans, both at the national and local levels. Currently, the measures described remain at the proposal level, which hinders the smooth and guaranteed implementation of policies. The support of the international community in order to successfully continue the efforts put in place is needed in addition to pursuing national efforts in earmarking funds for this purpose.

There is a need for the MRV of the implementation of mitigation and adaptation actions to include planning and implementation of activities, assessment of impacts (GHG and non-GHG) as well as tracking of support (both national and international). Most of these activities are in some form already addressed by Lebanon's response to UNFCCC reporting requirements for National Communications and Biennial Update Reports. Through the establishment of a permanent MRV unit at the Ministry of Environment, Lebanon aims to integrate the necessary MRV activities into the existing processes and structures for the international reporting to ensure an efficient and consistent approach, and for ensuring a harmony and synergy between all implementation activities.

**Table 84:** Tasks of the proposed MRV unit in Lebanon

| |
|---|
| **MRV of emissions:**<br>- Improve the basis of information.<br>- Identify areas and quantify potential for further mitigation action.<br>- Clearly define roles and institutional responsibilities to ensure the smooth flow and standardization of information to all entities producing, reporting and verifying GHG estimates. |
| **MRV of actions:**<br>- Account and assess the overall effectiveness of mitigation actions (i.e. emission reductions and progress to achieving objectives and co-benefits).<br>- Identify challenges and opportunities.<br>- Coordinate individual mitigation activities of bottom-up actions (private sector) and policies and top-down goals.<br>- Develop and assign indicators for each activity, whether it seeks to measure GHG reductions or other benefits. |
| **MRV of finance:**<br>- Provide a clearer overview of technology transfer, capacity building, financial flows, trends, sources, and purposes of international and domestic climate support.<br>- Assess impacts of the provided support and allocated funds.<br>- Calculate mitigation costs based on proven or credible methods and using the best available data. |

## 3. Financial gaps and constraints

Additional financial resources are needed to continue to develop and consolidate existing technical and institutional capacities in order to implement planned climate actions and monitor their progress and impacts on national emissions. Currently, most climate change projects (from reporting to implementation) run on a project basis, with specific guidelines from donor agencies.

Direct financial support related to the preparation of the BUR, INDC or TNC is not sufficient to develop both GHG inventories and mitigation action plans in addition to assessing impacts and vulnerability and planning proper adaptation actions. The lack of funds impels the project management team to cut on expenses and eliminates any opportunity to undertake surveys or in-depth studies to generate new data. Therefore, there is an urgent need to increase the funds available for countries and increase flexibility to encourage the initiation of new activities that aim at improving the quality of these reports, which serve as a basis for policy planning.

With respect to implementation, it is evident that Lebanon needs drastic reforms, especially in the key mitigation and adaptation sectors like energy, transport, forestry, water and agriculture. It is very seldom that a country receives grants that are sufficient for the refurbishment of the entire infrastructure and legal framework of a certain sector. The ongoing political turmoil in the region has also made it difficult for the Government of Lebanon to regularly assign budget and staff to work on the implementation of policies. As a result, strategies are implemented in a fragmented manner (i.e. a wastewater plant is built without being connected to the network; pilot projects are implemented without follow up; afforestation takes place without proper monitoring of overall variation of forest cover in the country, etc.). In addition, the discontinuity of funds threatens the sustainability of the teams involved in the various activities, and increases the risk of losing the momentum and technical wealth that was amassed throughout the years.

Securing funding for a permanent climate change and MRV unit is needed to ensure timely reporting that is not project bound and to put in place a sustainable flow of reliable data that allows proper monitoring of climate action and progress of implementation of commitments.

On the other hand, the government has yet to estimate the financial requirements for many of the sectoral policies. The strategies' documents upon which the INDC is based, do not always provide details on funding requirements. Some estimations have been assessed as part of the INDC development. The next key steps towards an NDC climate finance framework entail matching national as well as international funding with the measures outlined in the INDC and further assessing funding requirements for complex measures (e.g. related to a bus rapid transit system for Lebanon). In other words, assessing main costs that are not estimated to date remains one of the most urgent needs, specifically for cost of adaptation measures which have not yet been estimated, and costs of the set-up and operation of the coordination unit, including tasks related to MRV.

# REFERENCES


ACAPS, (2013). Syria Needs Analysis Project – Lebanon Baseline Information. Available: http://www.acaps.org/en/pages/syria-snap-project [Accessed 2 December 2014].

ACSAD-GTZ, January 2010. Conservation Agriculture in Lebanon, Fact Sheet No 10.

AFDC/MoE, (2009). Lebanon's National Forest Fire Management Strategy. Mitri G. (Ed.). Association for Forest Development and Conservation, Ministry of Environment. Beirut, Lebanon.

Al-Hassan, R. (2011). A National Consultancy on the Fertilizer Supply Chain in Lebanon. Survey Report submitted to Food and Agriculture Organization (FAO).

Asmar, F. (2011). FAO Country Pasture/Forage Resource Profiles: Lebanon. Available: http://www.fao.org/ag/AGP/AGPC/doc/counprof/lebanon/lebanon.html [Accessed 28 November 2014].

Baaj, H. (2002). Restructuring the Lebanese Railway and Public Transport Authority: From Losing Operator to Effective Regulator. Transport Reviews: A Transnational Transdisciplinary Journal, 22:1, 103-113.

Basch, G., Kassam, A., Gonzales-Sanchez, E.J., Streit, B., (2012). Making Sustainable Agriculture Real in CAP 2020: The Role of Conservation Agriculture. The European Conservation Agriculture Federation (ECAF).www.ecaf.org

Bashour, I and M. Nimah, (2004). Fertigation Potentials in the Near East Region. IPI regional Workshop on Potassium and Fertigation development in West Asia and North Africa; Rabat, Morocco, 24-28 November, 2004.Beirut port statistics, (2014). Annual Number of Incoming Ships from 2009 to 2013. Retrieved from www.portdebeyrouth.com [Accessed, April, 2014].

Bosello, F. and Fabio, E., (2013). Economic Impacts of Climate Change in the Southern Mediterranean. MEDPRO Technical Report No. 25.

Burke, Marshall, Solomon M. Hsiang, and Edward Miguel, (2015). "Global non-linear effect of temperature on economic production." Nature.

Burki, R., Elsasser, H. and Abegg, B. (2003). Climate Change and Winter Sports: Environmental and Economic Threats.: 5th World Conference on Sport and Environment. Turin.

Campbell-Lendrum, D., and Woodruff, R. (2007). Climate Change: Quantifying the Health Impact at National and Local Levels.

CAS, (2014). Monthly Data Per Year From 2000 To 2012. Central Administration of Statistics. Retrieved from www.cas.gov.lb

CAS, (2015). The Average Household Size in Lebanon in 2007. Central Administration of Statistics. Retrieved from http://www.cas.gov.lb/index.php/en/did-you-know-category-en/100-did-you-know-1

CDR, (2006). Municipal Solid Waste Management in Lebanon. Council for Development and Reconstruction.

CDR, Ramboll. (2012). National Strategy for Solid Waste Management In Lebanon. Feasibility study – Phase 1

CNRS, (2015). Updating of the National Adaptation Plan to Climate Change in the Water Sector. Centre National de la Recherche Scientifique.

Costanza, R., Darge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., Oneill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and Van den Belt, M. (1997). The Value of the World's Ecosystem Services and Natural Capital. Nature. 387, 253–260.

Costanza, R., de Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. and Turner, R.K.(2014). Changes in the Global Value of Ecosystem Services. Global Environmental Change. 26: 152-158.

DARA and Climate Vulnerable Forum, (2012). "Lebanon." Climate Vulnerability Monitor. http://daraint.org/climate-vulnerability-monitor/climate-vulnerability-monitor-2012/country-profile/?country=Lebanon.

Darwish, T., Atallah, T., Hajhasan, S., Chranek, A., Skaf, S., Haidar, A., 2002. Irrigation schedule of spring potato and impact of fertigation on efficient water use in central Bekaa, Lebanon. In: Fifth Arab Conference 17/11/2000, Beirut, pp. 93–105.

Darwish, T., Atallah, T., Hajhasan, S., Chranek, A., 2003. Management of nitrogen by fertigation of potato in Lebanon. Nutr. Cycl. Agroecosyst. 67, 1–11.

Darwish T.M. , T.W. Atallah , S. Hajhasan , and A. Haidar. 2006. Nitrogen and water use efficiency of fertigated processing potato. Agricultural Water Management 85: 95-104.

De Groot, R., Brander, L., Van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, N., Hein, L., Hussain, S., Kumar, P., McVittie, A.,Portela, R., Rodriguez, L.C., ten Brink, P., Van Beukering, P. (2012). Global Estimates of the Value of Ecosystems and their Services in Monetary Units. Ecosystem Services. 1:1 (July), pp. 50-61.

Doppelt, Bob. (Forthcoming). How Building Human Resilience Can Safeguard Society and provide New Meaning, Purpose, and Hope. London: Earthscan.

EastMED, (2012). Report of the FAO EastMED Support to the Fishing Trials Carried Out of the South Lebanese Coasts. Retrieved from www.faoeastmed.org

ESCWA, (2014). The demographic profile of Lebanon. Retrieved from www.escwa.un.org (Last accessed, march, 2014). Economic and Social Commission for Western Asia (2012)

ESCWA, (2015). Climate Projections and Extreme Climate Indices for the Arab Region, Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR). United Nations Economic and Social Commission for Western Asia (ESCWA).

El Fadel, M., and Sbayti, H. (2000). Economics of Mitigation Greenhouse Gas Emissions from Solid Waste in Lebanon. Waste Management and Research (18), 329-340.

FAO, (2001). The economics of Conservation Agriculture.

FAO, (2005). National Forest and Tree Resources Assessment 2003-05 (TCP/LEB/2903). Working paper 95, Forest Resources Assessment, Forestry. Food and Agriculture Organization.

FAO, (2006). Near East Fertilizer Use Manual.

FAO, (2010). Global Forest Resources Assessment 2010. Country Report: Lebanon, Forestry Department. Food and Agriculture Organization.

FAO, (2011a). Lebanon Country Pasture/Forage Resource Profiles. Author: Fady Asmar. http://www.fao.org/ag/AGP/AGPC/doc/Counprof/lebanon/lebanon.html. Food and Agriculture Organization.

FAO, (2011b). FAOSTAT- Lebanon- Land Use: Accessed April 12, 2014. Food and Agriculture Organization Beirut, http://faostat3.fao.org/faostat-gateway/go/to/browse/area/121/E

FAO, (2015). Lebanon: National Aquaculture Sector Overview.

Haddad, E. A., Farajalla, N., Camargo, M., Lopes, R. and Vieira, F. (2014). Climate Change in Lebanon: Higher-Order Regional Impacts from Agriculture.

Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., Russell, G., Tselioudis, G., Cao, J., Rignot, E., Velicogna, I., Kandiano, E., von Schuckmann, K., Kharecha, P., Legrande, A. N., Bauer, M. and Lo, K.-W. In review. Ice Melt, Sea Level Rise and Superstorms: Evidence from Paleoclimate Data, Climate Modeling, and Modern Observations that 2°C Global Warming is Highly Dangerous. Atmos. Chem. Phys. Discuss., 15, 20059–20179.

Hasanbeigi, A., Menke, A., & Price, L. (2010). The CO2 abatement cost curve for the Thailand cement industry. Journal of Cleaner Production, 10: 1509-1518.

Hayhoe K., Cayan, D., Field, C.B., Frumhoff, P.C., Maurer, E.P., Miller, N.L. (2004). Emissions Pathways, Climate Change, and Impacts on California. Proceedings of the National Academy of Sciences. 101(34):12422–12427.

Hendriks, C.A., Worell, E., De Jager, D., & Riemer, P. (2004). Emission Reduction of Greenhouse Gases from the Cement Industry (Adobe Digital Editions version). Retrieved from http://www.ieagreen.org.uk/prghgt42.htm

Huntzinger, D. and Eatmon, T. (2009). A life-cycle assessment of portland cement manufacturing: comparing the traditional process with alternative technologies. Journal of Cleaner Production, 17: 668-675.

ICARDA. 2012. Research to Action 2. Conservation Agriculture: Opportunities for intensifying farming and environmental conservation in dry areas.

IFPRI, (2009). Impact of Climate Change on Agriculture–Factsheet on Middle East and North Africa. International Food Policy Research Institute. http://www.agrifeeds.org/en/news/impact-climate-change-agriculture-factsheet-middle-east-and-north-africa.

IMF, (2014). Subsidy Reform in the Middle East and North Africa: Recent Progress and Challenges Ahead. International Monetary Fund, Middle East and Central Asia Department.

Interagency Working Group on Social Cost of Carbon, United States Government. (2015). Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866: Update. July.

IPCC (1997). Revised 1996 IPCC guidelines for national greenhouse inventories. Houghton J.T., Meira Filho L.G., Lim B., Tréanton K., Mamaty I., Bonduki Y. et al. (Eds). London: Intergovernmental Panel on Climate Change WGI technical support unit.

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, (2001). Costing Methodologies. [Markandya, M., K. Halsnaes, A. Lanza, Y. Matsuoka, S. Maya, J. Pan, J. Shogren, R.S. de Motta, and T. Zhang]. Climate Change 2001: Mitigation. Contributions of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. pp. 451-498.

IPCC, (2013). "Annex II: Climate System Scenario Tables." [Prather, M., G. Flato, P. Friedlingstein, C. Jones, J.-F. Lamarque, H. Liao and P. Rasch (eds.)]. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. pp. 1410-1412.

Kabakian, V., McManus, M. and Harajli, H. (2015). Attributional Life Cycle Assessment of Mounted 1.8 Kwp Monocrystalline Photovoltaic System with Batteries and Comparison with Fossil Energy Production System. Applied Energy 154 (2015) 428–437.

King, D., Schrag, D., Dadi, Z., Ye, Q.and Ghosh, A. (2015). Climate Change: A Risk Assessment. http://www.csap.cam.ac.uk/media/uploads/files/1/climate-change--a-risk-assessment-v9-spreads.pdf.

Kinney, P. L., Schwartz, J., Pascal, M., Petkova, E., Le Tertre, A., Medina, S. and Vautard, R. (2015). Winter Season Mortality: Will Climate Warming Bring Benefits? Environmental Research Letters. 19 June.

Kubursi, A. (1999). Lebanon's Agricultural Potential: A Policy Analysis Matrix Approach.

Millennium Ecosystem Assessment, (2005). Ecosystems and Human Well-being: Synthesis. http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

MoA, (2010a). Ministry of Agriculture, Lebanon. Strategy 2010-2014. http://www.agriculture.gov.lb/Arabic/AboutUs/Strategy_2010_2014/Pages/default.aspx.

MoA, (2010b). Agriculture Census 2010. Ministry of Agriculture, Lebanon. http://www.agriculture.gov.lb/Arabic/DataAndAgriStatistics/OverallAgriStatistics/Pages/defaul.aspx.

MoA, (2015). Ministry of Agriculture, Lebanon. Strategy 2015- 2019. http://www.agriculture.gov.lb/Arabic/AboutUs/Strategy_2015_2019/Pages/default.aspx.

MoA/FAO, (2013). National Afforestation Reforestation Programme; 40 Million Forest Trees Planting Programme. Ministry of Agriculture and Food and Agriculture Organization.

MoE, (2010). Country Report on the Solid Waste Management in Lebanon. Ministry of Environment.

MoE, (2012). Lebanon's National Report to the United Nations Conference on Sustainable Development - RIO+20. Lebanon: Wide Expertise Group. Ministry of Environment

MoE (2014). The number of registered vehicles in Lebanon: Ministry of Environment.

MoE/ELARD, (2004). National Inventory on Persistent Organic Pollutant (Dioxins and Furans Releases) in Lebanon. Ministry of Environment.

MoE/UNDP, (2015a). Optimal Renewable Energy Mix of the Power Sector by 2020: Investment Cost Implications on Lebanon. Beirut, Lebanon.

MoE/UNDP, (2015b). Mobility Cost: A Case Study for Lebanon. Beirut, Lebanon.

MoE/UNDP/ECODIT, (2011). State of Lebanon's Environment Report 2010, Beirut, Lebanon.

MoE/UNDP/ELARD, (2011). Provision of consultancy services for the Preparation of a Master Plan for the Closure and Rehabilitation of Uncontrolled Dumps throughout the country of Lebanon.

MoE/UNDP/GEF, (1999). Lebanon's Initial National Communication Report to the UNFCCC. Beirut, Lebanon.

MoE/UNDP/GEF, (2011). Lebanon's Second National Communication Report to the UNFCCC. 228pp. Beirut, Lebanon.

MoE/UNDP/GEF, (2015). Lebanon's First Biennial Update Report. Beirut, Lebanon.

MoE/UNDP/GEF, (2015a). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Energy Sector in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015b). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Transport Sector in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015c). National Greenhouse Gas Inventory Report and Mitigation Analysis for Industrial Processes in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015d). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Agriculture Sector in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015e). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Land Use, Land Use Change and Forestry in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015f). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Waste Sector in Lebanon. Beirut, Lebanon.

MoE/UNDP/GEF, (2015g). Economic Costs to Lebanon from Climate Change: A First Look. Beirut, Lebanon.

MoE/UNEP, (2013a). Environmental Resources Monitoring in Lebanon (ERML) project, Analysis of the current land use and socio-economic activities in the coastal zone.

MoE/UNEP, (2013b). Environmental Resources Monitoring in Lebanon (ERML) project, Improving the understanding, management and monitoring in the coastal zone in Lebanon.

MoE/UNEP, (2013c). Environmental Resources Monitoring in Lebanon (ERML) project, Development of ecosystem based coastal monitoring system.

MoE/UNEP/GEF, (2016). National Biodiversity Strategy and Action Plan.

MoE/URC/GEF, (2012). Lebanon Technology Needs Assessment Report for Climate Change. Ministry of Environment. Beirut, Lebanon.

MoEW, (2010a). National Water Sector Strategy. Ministry of Energy and Water.

MoEW, (2010b). Energy Policy Paper. Ministry of Energy and Water.

MoEW/LCEC, (2016). National Energy Efficiency Action Plan. Ministry of Energy and Water and Lebanese Center for Energy Conservation.

MoF, (2013). Lebanon Country Profile 2013, Ministry of Finance. http://www.finance.gov.lb/en-US/finance/ReportsPublications/DocumentsAndReportsIssuedByMOF/Documents/Sovereign%20and%20Invensment%20Reports/Country%20Profile/Lebanon%20Country%20Profile%202013.pdf.

MoI/ALI/UNIDO, (2010). The Lebanese Industrial Sector: Facts and Findings – 2007. 71pp.

Moore, F. C., and Diaz, D. B. (2015). Temperature Impacts on Economic Growth Warrant Stringent Mitigation Policy. Nature Climate Change. 12 January.

MoT/USAID/DAI, (2014). Rural Tourism Strategy for Lebanon.Ministry of Toursim.

Myhre, G., Shindell, D., Bréon, F.-M., Collins, W., Fuglestvedt, J., Huang, J., Koch, D., Lamarque, J.-F., Lee, D., Mendoza, B., Nakajima, T., Robock, A., Stephens, G., Takemura, T. and Zhang, H. (2013). Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds.).

Nelson, Gerald C., Hugo Valin, Ronald D. Sands, Petr Havlík, Helal Ahammad, Delphine Deryng, Joshua Elliott, Shinichiro Fujimori, Tomoko Hasegawa, Edwina Heyhoe, Page Kyle, Martin Von Lampe, Hermann Lotze-Campen, Daniel Mason d'Croz, Hans van Meijl, Dominique van der Mensbrugghe, Christoph Müller, Alexander Popp, Richard Robertson, Sherman Robinson, Erwin Schmid, Christoph Schmitz, Andrzej Tabeau, and Dirk Willenbocke, (2014). "Climate change effects on agriculture: Economic responses to biophysical shocks." Proceedings of the National Academy of Sciences. 4 March. pp. 3274-3279.

OECD, (2011). Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications. Organisation for Economic Co-operation and Development.

Onofri, L., Nunes, P. A.L.D. and Bosello, F. (2013). Economic and Climate Change Pressures on Biodiversity in Southern Mediterranean Coastal Areas. MEDPRO Technical Report No. 24 (February).

Osseiran, K. (2016). The electricity policy paper implementation to date. Energy national coordination meeting, LCRP. 24 August 2016.

Pinello, D. and Dimech, M. (2013). Socio-Economic Analysis of the Lebanese Fishing Fleet. http://www.fao.org/docrep/018/ar250e/ar250e.pdf.

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M., Lobell, D.B. and Travasso, M.I. (2014). Food Security and Food Production Systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485-533.

Porter, J. R., Montesino, M. and Semenov, M. (2015). The Risks of Climate Change for Crop Production.In David, K., Schrag, D. Dadi, Z., Ye, Q. and Ghosh, A. (2015). Climate Change: A Risk Assessment. pp. 65-73.

Potsdam Institute for Climate Impacts Research and Climate Analytics, (2013). Turn Down the Heat: Climate Extremes, Regional Impacts, and the Case for Resilience. World Bank. June.

RCP Database, (2015). Data Downloads – emissions for the RCPs. http://tntcat.iiasa.ac.at:8787/RcpDb/dsd?Action=htmlpage&page=download.

Riebe, M. (2011). Climate Change and Tourism in Lebanon. Heinrich-Böll-Stiftung - Middle East Office.

Robalino, D. and Sayed, H. (2012). Republic of Lebanon: Good Jobs Needed. Report No. 76008-LB World Bank Middle East and North Africa Human Development Group.

Rodriguez, N., Alonso, M., Abanades, J.C., Grasa, G. and Murillo, R. (2009). Analysis of a process to capture the CO2 resulting from the pre-calcination of the limestone feed to a cement plant. Science Direct, 1: 141-148.

Roe, D. and Elliot, J. (2004). Poverty Reduction and Biodiversity Conservation: Rebuilding the Bridges. Oryx. 38: 2. (April).

Secretariat of the Convention on Biological Diversity, (2014). An Updated Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity (Eds: S. Hennige, J.M. Roberts & P. Williamson). Montreal, Technical Series No. 75.

Sheridan, S. C. and Allen, M.J. (2015), Changes in the Frequency and Intensity of Extreme Temperature Events and Human Health Concerns. Current Climate Change Reports. 11 June.

SWEEP-Net. (2010). Country Report on the Solid Waste Management in Lebanon.

Tripoli Port Statistics. (2014). Annual Number of Incoming Ships from 2005 to 2009. Retrieved from www.portdetripoli.com.

UNECE (2014). United Nations Economic Commission for Europe. Retrieved from www.unece.org. (Last accessed, July, 2014).

USAID, (2011). Demonstration Drip Irrigation Systems for selected potato and tomato farmers in the Bekaa valley of Lebanon. Report prepared by Robinson Agri and International Resources Group (IRG) as part of Litani River Basin Management Support Program of USAID.

U.S. Environmental Protection Agency, (2015). Frequently Asked Questions on Mortality Risk Valuation. March 27. http://yosemite.epa.gov/EE%5Cepa%5Ceed.nsf/webpages/MortalityRiskValuation.html.

UNFCCC, (2005). Clean Development Mechanism Project Design Document form (CDM-PDD)- Increasing the Additive Blend in cement production by Jaiprakash Associates Ltd (JAL).

Verner, D. and Breisinger C. (2013). Economics of Climate Change in the Arab World: Case Studies from the Syrian Arab Republic, Tunisia, and the Republic of Yemen. World Bank.

Vivid Economics, (2010). Promoting Economic Growth when the Climate is Changing. UK Department of International Development. July. p. 21.

Walley, C. (2001). The Lebanon Passive Margin and the Evolution of the Levantine Neo-Tethys. In: Ziegler, P., Cavazza, W., Robertson, A. and Crasquin-Soleau, S. (eds), Peri-Tethys Memoir 6: Peri-Tethyan Rift/ Wrench Basins and Passive Margins. Mém. Mus. Nat. Hist. Nat., 186, pp. 407-439

Watts, N., Adger, W.N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T.,Collins, M., Cooper, A., Cox, P.M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, M., Hamilton, I., Hunter, A, Jiang, X., Li, M., Kelman, I., Liang, L., Lott, M., Lowe, R., Luo,R., Mace, G., Maslin, M., Nilsson, M., Oreszczyn, T., Pye, S., Quinn, T., Svensdotter, M., Venevsky, S., Warner, K., Xu, B., Yang, J., Yin, Y., Yu, C., Zhang, Q., Gong, P., Montgomery, H. and Costello, A. (2015). Health and Climate Change: Policy Responses to Protect Public Health. The Lancet Commissions.

Wieder, W. R., William R., Cleveland, C., Smith, W.K. and Todd-Brown, K. (2015). Future Productivity and Carbon Storage Limited by Terrestrial Nutrient Availability. Nature Geoscience. 20 April.

WHO , (2015). Health and Environmental Strategy National Framework 2016-2021. Prepared by Dr. Mey Jurdi, December 2015. World Health Organization.

WHO, (2010). Country Cooperation Strategy for WHO and Lebanon 2010-2015.

World Bank, (2009). World Bank (2009). Electricity Sector: Public Expenditure Report.

World Bank, (2010). Republic of Lebanon Water Sector: Public Expenditure Review. Report No. 52024-LB. 17 May.

World Bank, Refugee Centre at the University of Oxford, PRIO, and FAFO, (2012). Assessing the Impacts and Costs of Forced Displacement. May 1. pp. 80-81.

# ANNEXES

# ANNEX I: REPORTING SUMMARY TABLES

**Table 7A** Summary report for national greenhouse gas inventories

**SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)**

| GREENHOUSE GAS SOURCE AND SINK CATEGORIES | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ | HFCs | | PFCs | | $SF_6$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | P | A | P | A | P | A |
| **Total national emissions & removals** | **22,402.38** | **-3,145.06** | **141.10** | **3.12** | **84.67** | **361.97** | **127.09** | **112.04** | **0** | **0** | **0** | **0** | **0** | **0** |
| **1 Energy** | **19,736.19** | **0** | **2.11** | **0.58** | **84.66** | **361.20** | **73.28** | **110.33** | | | | | | |
| A. Fuel combustion (sectoral approach) | 19,736.19 | | 2.11 | 0.58 | 84.66 | 361.20 | 73.28 | 110.33 | | | | | | |
| 1 Energy industries | 7,296.67 | | 0.30 | 0.06 | 19.71 | 1.48 | 0.49 | 64.63 | | | | | | |
| 2 Manufacturing industries and construction | 3,331.34 | | 0.08 | 0.03 | 8.51 | 0.43 | 0.21 | 22.59 | | | | | | |
| 3 Transport | 5,811.95 | | 1.22 | 0.46 | 51.79 | 358.37 | 72.34 | 5.34 | | | | | | |
| 4 Other sectors | 3,296.22 | | 0.51 | 0.03 | 4.64 | 0.93 | 0.23 | 17.78 | | | | | | |
| 5 Other (please specify) | | | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| B. Fugitive emissions from fuels | 0 | | 0 | | 0 | 0 | 0 | 0 | | | | | | |
| 1 Solid fuels | | | 0 | | 0 | 0 | 0 | 0 | | | | | | |
| 2 Oil and natural gas | | | 0 | | 0 | 0 | 0 | 0 | | | | | | |
| **2 Industrial processes** | **2,557.05** | **0** | **0** | **0** | **0** | **0** | **53.81** | **1.71** | **0** | **0** | **0** | **0** | **0** | **0** |
| A. Mineral products | 2,557.05 | | | | | 0 | 41.55 | 1.71 | | | | | | |
| B. Chemical industry | 0 | | 0 | 0 | 0 | 0 | 0.00 | | | | | | | |
| C. Metal production | 0 | | 0 | 0 | 0 | 0 | 0.00 | | 0 | 0 | 0 | 0 | 0 | 0 |
| D. Other production | 0 | | | | 0 | 0 | 12.26 | | | | | | | |
| E. Production of halocarbons and sulphur hexafluoride | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 |
| F. Consumption of halocarbons and sulphur hexafluoride | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 |
| G. Other (please specify) | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | | | | 0 | | 0 |

P = Potential emissions based on Tier 1 approach. A = Actual emissions based on Tier 2 approach.

| SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES - (Gg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GREENHOUSE GAS SOURCE AND SINK CATEGORIES** | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ | HFCs | | PFCs | | $SF_6$ | |
| | | | | | | | | | P | A | P | A | P | A |
| **3 Solvent and other product use** | **0** | | | **0** | | | **4** | | | | | | | |
| **4 Agriculture** | | | **11.32** | **2.06** | **0** | **0** | | | | | | | | |
| A Enteric fermentation | | | 9.55 | | | | | | | | | | | |
| B Manure management | | | 1.77 | 0.49 | | | | | | | | | | |
| C Rice cultivation | | | 0 | | | | | | | | | | | |
| D Agricultural soils | | | | 1.57 | | | | | | | | | | |
| E Prescribed burning of savannas | | | 0 | 0 | 0 | 0 | | | | | | | | |
| F Field burning of agricultural residues | | | 0 | 0 | 0 | 0 | | | | | | | | |
| G Other (please specify) | | | 0 | 0 | | | | | | | | | | |
| **5 Land-use change & forestry [2]** | **108.1 [1]** | **-3,145.06 [1]** | **0.05** | **0.00** | **0.00** | **0.77** | | | | | | | | |
| A Changes in forest and other woody biomass stocks | 0 [1] | 0 [1] | | | | | | | | | | | | |
| B Forest and grassland conversion | 0 | | 0 | 0 | 0 | 0 | | | | | | | | |
| C Abandonment of managed lands | | 0 | | | | | | | | | | | | |
| D $CO_2$ emissions and removals from soil | 0 [1] | 0 [1] | | | | | | | | | | | | |
| E Other (please specify) | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | | |
| **6 Waste** | **1.0450** | | | **127.62** | **0.48** | **0** | **0** | **0** | | | | | | |
| A Solid waste disposal on land | | | 102 | 108.23 | | | | | | | | | | |
| B Wastewater handling | | | 19 | 19.38 | 0.48 | | | | | | | | | |
| C Waste incineration | 1.0450 | | | | | | | | | | | | | |
| D Other (please specify) | | | 0 | 0 | | | | | | | | | | |
| **7 Other (please specify)** | | | | | | | | | | | | | | |

[1] The formula does not provide a total estimate of both $CO_2$ emissions and $CO_2$ removals. It estimates "net" emissions of $CO_2$ and places a single number in either the $CO_2$ emissions or $CO_2$ removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).
[2] Note that if you have used the IPCC Good Practice Guidance on land use, land-use change and forestry, you will have to use a mapping back procedure before entering emission/removals here.

| SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GREENHOUSE GAS SOURCE AND SINK CATEGORIES** | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ | HFCs | | PFCs | | $SF_6$ | |
| | | | | | | | | | P | A | P | A | P | A |
| **Memo items** | | | | | | | | | | | | | | |
| **International bunkers** | **737** | | **0** | **0** | **0** | **0** | **0** | **0** | | | | | | |
| Aviation | 654 | | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| Marine | 83 | | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| **$CO_2$ emissions from biomass** | **16** | | | | | | | | | | | | | |

**Table 7B** Short summary report for national greenhouse gas inventories

| SHORT SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **GREENHOUSE GAS SOURCE AND SINK CATEGORIES** | $CO_2$ Emissions | $CO_2$ Removals | $CH_4$ | $N_2O$ | $NO_x$ | CO | NMVOC | $SO_2$ | HFCs | | PFCs | | $SF_6$ | |
| | | | | | | | | | P | A | P | A | P | A |
| **Total national emissions and removals** | **22,402** | **-3,145** | **141** | **3** | **85** | **362** | **131** | **107** | **0** | **0** | **0** | **0** | **0** | **0** |
| **1 Energy** – Reference approach[1] | **20,507** | | | | | | | | | | | | | |
| **1 Energy** – Sectoral approach[1] | **19,736** | | **2** | **1** | **85** | **361** | **73** | **105** | | | | | | |
| A Fuel combustion | 19,736 | | 2 | 1 | 85 | 361 | 73 | 0 | | | | | | |
| B Fugitive emissions from fuels | 0 | | 0 | | 0 | 0 | 0 | 0 | | | | | | |
| **2 Industrial processes** | **2,557** | | **0** | **0** | **0** | **0** | **54** | **2** | **0** | **0** | **0** | **0** | **0** | **0** |
| **3 Solvent and other product use** | **0** | | **0** | **0** | | | **4** | | | | | | | |
| **4 Agriculture** | **0** | | **11** | **2** | **0** | **0** | | | | | | | | |
| **5 Land-use change & forestry** | **108** | **-3,145** | **0** | **0** | **0** | **1** | | | | | | | | |
| **6 Waste** | **1.05** | | **128** | **0** | | | | | | | | | | |
| **7 Other** (please specify) | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | | | | | | |
| **Memo items** | | | | | | | | | | | | | | |
| **International bunkers** | **738** | | **0** | **0** | **0** | **0** | **0** | **0** | | | | | | |
| Aviation | 654 | | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| Marine | 83 | | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| **$CO_2$ emissions from biomass** | **16** | | | | | | | | | | | | | |

P = Potential emissions based on Tier 1 approach. A = Actual emissions based on Tier 2 approach.

(1) For verification purposes, countries are asked to report the results of their calculations using the reference approach and explain any differences with the sectoral approach. Do not include the results of both the reference approach and the sectoral approach in national totals.

(2) The formula does not provide a total estimate of both $CO_2$ emissions and $CO_2$ removals. It estimates "net" emissions of $CO_2$ and places a single number in either the $CO_2$ emissions or $CO_2$ removals column, as appropriate. Please note that for the purposes of reporting, the signs for uptake are always (-) and for emissions (+).

# ANNEX II: POPULATION, HOUSEHOLDS, AND TEMPERATURE ESTIMATES

This annex describes data, assumptions, and calculations to estimate the population, number of households, and effects of climate change on temperature.

**Population**

This analysis assumes these estimates, from MoE/UNDP/GEF (2015), accurately represent Lebanon's population (millions) for 2007–2012:

| | |
|---|---|
| 2007 | 4.8 |
| 2008 | 4.9 |
| 2009 | 5.0 |
| 2010 | 5.0 |
| 2011 | 5.1 |
| 2012 | 5.2 |

To estimate population for years following 2012, the analysis employs these projections of annual growth, from Economic and Social Commission for Western Asia (2012), applied to the estimate for 2012:

| | |
|---|---|
| 2010-2015 | 3.04% |
| 2015-2020 | -0.71% |
| 2020-2025 | 0.67% |
| 2025-2030 | 0.50% |
| 2030-2035 | 0.33% |
| 2035-2040 | 0.18% |
| 2040-2045 | 0.07% |
| 2045-2080 | -0.03% |

This approach yields these estimates of future population (millions):

| | |
|---|---|
| 2020 | 5.5 |
| 2040 | 6.0 |
| 2080 | 5.9 |

**Households**

The Central Administration of Statistics (2015) estimates that, on average, each household in Lebanon has 4.43 persons. This analysis assumes that this average household size will persist through 2080. Dividing the estimated population by the average household size yields these estimates of the number of households (millions) in future years:

| | |
|---|---|
| 2020 | 1.3 |
| 2040 | 1.4 |
| 2080 | 1.4 |

**Temperature**

This analysis assumes these increases, relative to 1880-1919, in average annual temperature in Lebanon from human-caused climate change:

2010 0.85°C

This estimate represents the globally averaged combined land and ocean surface temperature data (IPCC 2013; p. 5). This analysis applies this estimate to nearby years, such as 2005, 2009, 2011, and 2012.

2020 1°C

This estimate comes from IPCC (2013; p. 18), which assumes the total, human-caused increase in average annual temperature will equal or exceed 1°C for Africa, Europe and Asia.

2040 2°C

This estimate reflects the assessment, from MoE/UNDP/GEF (2011; p. ix) that uses the lower bound from climate-change scenarios developed for Lebanon through application of the PRECIS model. The scenarios predict that, relative to the present climate, "by 2040 temperatures will increase from around 1°C on the coast to 2°C in the mainland...."

2080 5°C

This estimate assumes an additional increase, relative to 2020, of 4°C, which represents a rough approximation of the scenarios from the PRECIS model, which indicates that relative to the present climate, average annual temperatures in Lebanon will be 3.5°C to 5°C higher by 2090 (MoE/UNDP/GEF 2011; p. ix).

Some elements of the analysis consider the effects of changes in temperature from 2010 and nearby years. The changes in temperature are:

| | |
|---|---|
| 2010–2020 | 0.15°C |
| 2010–2040 | 1.15°C |
| 2010–2080 | 4.15°C |