REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

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LEBANON'S SECOND NATIONAL COMMUNICATION TO THE UNFCCC

MINISTRY OF ENVIROMENT
2011

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Ministry of Environment

Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change

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The Ministry of Environment

Service of Environmental Technology

Department of Air Quality

Beirut, Lebanon

Phone: +961-1-976555

Fax: +961-1-976530

www.moe.gov.lb/Climatechange

www.undp.org.lb

Project Team

Vahakn Kabakian - Project Manager

Lea Kai - Project Assistant

Youssef Naddaf - National Focal Point

Rola Sheikh - National Focal Point

Design

Nayla Saroufim

www.naylasaroufim.com

Printing

Salim Dabbous Printing Company

FOREWORD

It is my pleasure to present Lebanon's Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC), which is formulated in accordance with the guidelines adopted by the Parties to the Framework Convention on Climate Change. It presents basic facts about Lebanese society and reviews the various economic sectors according to the classification commonly used in the context of climate. Emissions of different greenhouse gases (GHGs) are presented for each sector for the year 2000 and as an aggregate figure for each year from 1994 to 2004. The SNC describes Lebanon's vulnerability and what needs to be done to adapt to climate change. The material on which the national communication is based has been obtained through extensive work undertaken by government agencies, academic institutions, the private sector and non-governmental organizations, led by the Ministry of Environment. Most of the work on the SNC was carried out during the period extending from the summer of 2007 to the fall of 2010.

Since Lebanon's ratification of the UNFCCC, successive governments have implemented various policies and measures to fulfill Lebanon's commitments under the Convention. In comparison to the First National Communication, this Communication includes new chapters, actions, policies and measures. It is hoped that this new approach identifies Lebanon's real needs under the Convention, and brings forward a set of mitigation and adaptation plans at a relatively early stage that would allow Lebanon to prepare for the unavoidable consequences of climate change early on.

Climate change is a serious global challenge that will require sustained action by all high GHG emitting nations over many generations. Lebanon's SNC comes to ascertain once again that Lebanon's GHG emissions are insignificant at the global level. Nevertheless, a set of prioritized measures are recommended to bring GHG emissions reduction, cut energy demand and increase energy supply, contribute to sustainable development and enable Lebanon to mobilize resources under the Convention in order to mitigate climate change. We believe that combating climate change is a shared responsibility that rests on all our shoulders. It is more important to find a common solution than to debate the relative responsibility of each of us. For that reason, we have voluntarily committed in Copenhagen in 2009 to increase our renewable energy mix to 12% by 2020.

The impact of global climate change on Lebanon is tremendous. Temperatures are projected to increase between 1°C and 5°C from now till the end of the century, and rainfall is projected to decrease by 25 to 50% over the same period. Such drastic changes in climate will only aggravate the already existing environmental, social and economical challenges Lebanon is facing today.

Considerable experience has been gained, national momentum on climate change has developed and many lessons were learnt. This exercise has become a necessary tool for mainstreaming climate change related issues into national sectoral development policies and plans.

Mohammad Rahal, February 2011
Minister of Environment

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National Greenhouse Gas Inventory chapter:

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Vulnerability and Adaptation, Mitigation, Other Information Relevant to the Achievement of the Objective of the UNFCCC and Constraints, Gaps and Related Financial, Technical and Capacity Needs chapters:

National Team:

Earth Link and Advanced Resources Development (ELARD): Ramez Kayal, general manager; Ricardo Khoury, team leader; Rana Zbeidy, project coordinator; Hanadi Musharrafiyeh, environmental economist; Josee Abdel Massih, Manal Kahi, and Cady Nasr, junior environmental consultants.

Experts: Fady Asmar, terrestrial biodiversity expert; Ronald Diab, energy expert; Farid Karam, water expert; Salim Roukoz, GIS expert; and Jean Stephan, agriculture expert.

Peer reviewers: Dr. Carla Khater, NCSR, forestry sector; Dr. Sally Zgheib, MoEW/UNDP, water sector; Dr. Hassan Harajli, CEDRO/UNDP, energy sector.

International Team:
Energy, Environment and Water Research Center (EEWRC) – Cyprus Institute: Dr. Panos Hadjinicolaou, hydrometeorology expert; Dr. Manfred Lange, climate change expert.

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List of Acronyms

ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
AFDC	Association for Forestry Development and Conservation
AMR	Automatic Meter Reading
AR4	Fourth Assessment Report
AUB	American University of Beirut
AUM	Animal Unit Month
Avg	Average
B-RHIA	Beirut Rafic Hariri International Airport
CBD	Central Beirut District
CCGT	Combined Cycle Gas Turbine
CDM	Clean Development Mechanism
CDR	Council for Development and Reconstruction
CoM	Council of Ministers
CREEN	Centre Régional de l'Eau et de l'Environnement de l'Université Saint-Joseph
DF	Distant Future
DGUP	Directorate General of Urban Planning
DJF	December January February
EDL	Electricité Du Liban
EE	Energy Efficiency
EEWRC	Energy Environment and Water Research Center
EI	Energy Industries
ELARD	Earth Link and Advanced Resources Development
ESCWA	Economic and Social Commission for Western Asia
ESU	Epidemiological Surveillance Unit
ETP	Evapotranspiration
EU	European Union
EWARS	Early Warning Alert and Response System
FAO	Food and Agriculture Organization
GB	Green Building
GBA	Greater Beirut Area
GCM	Global Climate Model
GDP	Gross Domestic Product
GEF	Global Environment Facility

GHG	Greenhouse Gas
GIS	Geographic Information System
GoL	Government of Lebanon
GPG-LULUCF	Good Practice Guidance for Land Use, Land Use Change and Forestry
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GW	Gigawatt
GWh	Gigawatt-hour
GWP	Global Warming Potential
HEV	Hybrid Electric Vehicle
HFO	Heavy Fuel Oil
HRC	Higher Relief Council
ICARDA	International Center for Agricultural Research in the Dry Areas
IEA	International Energy Agency
IMF	International Monetary Fund
INC	Initial National Communication
INSEE	National Institute of Statistics and Economic Studies
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IUCN	International Union for Conservation of Nature and Natural Resources
IWRM	Integrated Water Resources Management
JICA	Japan International Cooperation Agency
JJA	June July August
KP	Kyoto Protocol
kVA	Kilovolt amperes
kW	Kilowatt
kWh	Kilowatt-hour
LARI	Lebanese Agricultural Research Institute
LAU	Lebanese American University
LBP	Lebanese Pounds
LCC	Lebanese Commuting Company
LCEC	Lebanese Center for Energy Conservation
LEAP	Long-range Energy Alternatives Planning system
LEDO	Lebanese Environment and Development Obvservatory
LFG	Landfill Gas

LMS	Lebanese Meteorological Station
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
LRA	Litani River Authority
LU	Lebanese University
LUCF	Land Use Change and Forestry
LULUCF	Land Use, Land Use Change and Forestry
MAM	March April May
MENA	Middle East and North Africa
MIC	Manufacturing Industries and Construction
Mm^3	Million cubic meters
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities
MoPH	Ministry of Public Health
MoPWT	Ministry of Public Works and Transport
MoSA	Ministry of Social Affairs
MoT	Ministry of Tourism
MSW	Municipal Solid Waste
MW	Megawatt
MWh	Megawatt-hour
NA	Not Available
NAPPA	National Action Plan for Protected Areas
NCCCD	National Committee for Climate Change and Desertification
NCMS	National Center for Marine Sciences
NCSR	National Council for Scientific Research
NDU	Notre Dame University
NF	Near Future
NGO	Non Governmental Organization
NPMPLT	National Physical Master Plan for the Lebanese Territories
NS	Not Specified
O&M	Operations and Maintenance

OCGT	Open Cycle Gas Turbine
OEA	Order of Engineers and Architects
OWL	Other Wooded Land
P	Precipitation
Pa	Active Precipitation
PHC	Primary Health Care
PM	Particulate Matter
PRECIS	Providing REgional Climates for Impacts Studies
Q	Quotient of Emberger
RCM	Regional Climate Model
RE	Renewable Energy
RP	Recent Past
SES	Socio-economic Status
SLM	Sustainable Land Management
SLR	Sea Level Rise
SNC	Second National Communication
SON	September October November
SRES	Special Report on Emissions Scenarios
SST	Sea Surface Temperature
SWDS	Solid Waste Disposal Sites
T_{max}	Maximum Temperature
T_{min}	Minimum Temperature
T_{MM}	Minimum mortality temperature
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollars
USEK	Université Saint-Esprit de Kaslik
USJ	Université Saint Joseph
WHO	World Health Organization

EXECUTIVE SUMMARY

1. National Greenhouse Gas Inventory

The national inventory of Lebanon's anthropogenic emissions by sources and removals by sinks for the year 2000 of all GHGs covered by the Kyoto Protocol (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) in addition to the indirect GHGs (CO, NO_x, SO_2, and NMVOCs) has been calculated.

The inventory is based on the revised 1996 Intergovernmental Panel on Climate Change guidelines for National Greenhouse Gas Inventories and on the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Tier 1 approach is adopted in calculating the GHG emissions where the appropriate default emission factors are selected from the guidelines. Tier 2 approach is only used for the calculation of emissions from the cement industry where precise data allowed the development of a national emission factor.

The activity data for the various sectors are collected from various sources (public and private institutions) by conducting sectoral tailored surveys, and complemented by secondary sources such as scientific reports/publications, and academic studies. Estimations, interpolations and extrapolations are made for the sectors characterized with data gaps. Choice of activity data is validated through thorough stakeholders' consultations engulfing the public and private sectors, as well as academic and NGO communities.

Greenhouse Gas inventory by Sector and Gas

In the year 2000, Lebanon's total GHG emissions recorded 18,507 Gg (18.5 Million tonnes (Mt)) of CO_2 equivalent (CO_2 eq.), recording an average of 2.77% per year increase from 1994 (15,901 Gg CO_2 eq.). The energy sector is the main source of GHG emissions, accounting for 74.86% of the national emission (53.45% energy production and 21.41% transport). This is followed by industrial processes and waste sectors which account for 9.62% and 9.40% respectively. Emissions from agriculture and land use change and forestry make up 5.76%, and 0.36% of total CO_2 eq. respectively.

Carbon dioxide is the main emitted GHG with 84.13% of emissions in 2000, while CH_4 and N_2O constitute 10.19% and 5.68% respectively. The main contributors of CO_2 emissions are energy production and transport with 63% and 25% respectively whereas the waste sector constitutes the main source of CH_4 emissions (88%). The main contributor to N_2O emissions is the agriculture sector with 88%.

GHG Emissions by sector

Energy sector

The energy sector is the most important contributor to GHG emissions. In 2000, energy industries emitted 5,773 Gg CO_2 eq. (42% of total emission from the energy sector and 31% of total national emissions), manufacturing industries and construction generated some 2,830 Gg CO_2 eq. in 2000, comprising 20% of total emissions from the energy sector, and 15% of total national GHG emissions. The energy industries subsector contributed to 61.19 Gg of SO_2 in 2000 or 66% of the total SO_2 emissions from the energy sector and 65% of national SO_2 emissions, while MIC's SO_2 emissions accounted for 25% of total national SO_2 emissions.

Transport is a major sub-sector contributing to GHG emissions from fuel combustion. In 2000, 3,962.64 Gg CO_2 eq. were emitted into the atmosphere from transport in Lebanon, comprising 28.6% of total emissions from the energy sector, and 21% of total national GHG emissions. The transport sector is also the main source of CO, NO_x and NMVOC emissions from this category. The other sectors category, which includes emissions from commercial, institutional, residential and agriculture/forestry/fishing sub-categories, generated 1,280 Gg of CO_2 eq., representing 9% and 7% of the emissions from the energy sector and of total national GHG emissions respectively.

Industrial Processes

In 2000, emissions from the industrial processes sector amounted to a total of 1,781Gg of CO_2 eq. at 9.62% of Lebanon's total GHG emissions. The emissions primarily entail the CO_2 gas, with the largest contributor being cement production with 91.6%, followed by iron and steel production with

7.2%. The emissions from steel production may be over or underestimated since a simple approach was used in the calculation due to the absence of data on the consumption of reducing agents in this industry. Since direct and indirect emissions from the industrial processes sub-categories are insignificant, they are not reported in the inventory.

Refrigeration and air conditioning are the only sources of HFC gas emissions recorded in Lebanon since HFC 134a is serving as an alternative to ozone depleting substances being phased out under the Montreal Protocol. The total HFC emissions in 2000 are insignificant in absolute terms (0.01 Gg) but amount to approximately 11 Gg CO_2 eq. when converted to CO_2 eq. emissions since they have a high global warming potential. However, they were not reported as part of this national inventory.
As for SF_6 emissions for the year 2000, they are estimated to be null since SF_6 has only been imported to Lebanon starting the year 2002.

Cement industries are also the main emitters of SO_2 within this sector while road paving and food production the main emitters of NMVOCs.

Solvents and Other Product Use

In the year 2000, NMVOC emissions generated from solvents and other products use amount to 3.97 Gg or around 3% of Lebanon's total NMVOC emissions. Degreasing and dry cleaning are the major source of NMVOC with 2.47 Gg, followed by paint application (0.98 Gg) and printing industries (0.54 Gg).

Agriculture

The agricultural sector is a significant contributor to national GHG emissions, with 1,065.5 Gg CO_2 eq., representing 5.76% of national emissions in 2000. The main source of GHG emissions is "agricultural soils" with 77.1% of the sectoral emissions, and 4.4% of total national emissions, followed by enteric fermentation (11.9% sectoral and 0.7% national emissions), and manure management (10.9% sectoral and 0.63% of national).

Emissions of NO_x and CO result from field burning of agricultural residues, where it is estimated that 10% of the residues of wheat, barley and oats are burned every year. Other residues are not taken into account since they are collected and used either as a source of energy in rural areas (could not be estimated) or as animal feed and bedding. The NO_x and CO emissions from field burning of residues are estimated at 0.03 Gg and 0.77 Gg respectively.

Land Use Change and Forestry

Due to unavailability of data to accurately estimate how changing land use patterns affects CO_2 emissions and removals, the Good Practice Guidance for Land use, Land-use Change and Foresty could not be used in this inventory. The only available and complete national information is the land-use land-cover map which is not sufficient to make a comparative analysis on land changes for the year 2000. Therefore, the CO_2 removal data presented in this category must be treated with caution.

In Lebanon, the land use change and forestry sector acts as both a source and a sink where results of the year 2000 show that 807.6 Gg CO_2 are removed by sinks and 663.73 Gg CO_2 are emitted from forest fires. The net result labels this sector as a sink with -143.87 Gg CO_2 as a net removal. Emissions of CO_2, CH_4, N_2O, NO_x and CO are emitted as GHGs and precursors from biomass burning, which emanates mainly from natural and man-made forest fires.

Waste

The emissions from the waste sector are calculated using the mass balance approach which results in an overestimation of the emissions since it does not account for time factors in the waste accumulation and decomposition.

The waste sector is the largest source of CH_4 emissions in Lebanon, accounting for 87.5% of the total national CH_4 emissions. The sector generated 1,739.36 Gg CO_2 eq. in 2000, or 9.4% of the total GHG emissions for the same year. Solid waste disposal on land remains the highest emitting category, constituting 94.3% of waste emissions in 2000, or 1,640 Gg CO_2 eq., with CH_4 being the main gas emitted.

Emissions from wastewater handling emitted 96.3 Gg CO_2 eq. in 2000, where 59.3% of wastewater

is estimated to be discharged directly in the sea, 26.1% is collected in septic tanks, and 14.6% is discharged in rivers.

As for waste incineration, although open burning of municipal waste is commonly practiced in Lebanon, data on such practices are unavailable. Therefore, this inventory only records emissions from the controlled incineration of medical waste, which constituted in 2000 0.2% of all waste GHG emissions, or 3 Gg CO_2 eq.

2. Greenhouse Gas Mitigation Strategy

The purpose of this chapter is to provide an analysis of the measures to reduce GHG emissions and enhance carbon sinks in Lebanon. The analysis is based on 2 types of scenarios: the baseline scenarios and the mitigation scenarios.

The baseline scenarios are constructed based on the current sectoral plans, policies and projected trends and are different from the business-as-usual scenario since the government of Lebanon has committed itself to long-term plans which introduce major changes to the existing structure of the economy. Some of these changes may be considered as a baseline scenario, such as in the energy sector while some plans are considered as a mitigation scenario such as the national waste management plan that still needs time for its execution. The GHG abatement analysis is made for 20 years, i.e. till the year 2030. The projection of trends uses 2004 as the base year and project forecasts the values to 2030, taking into account demographic, social, and economical assumptions available in official documentation.

The mitigation scenarios are proposed plans and projects that have a potential for sectoral emission reduction or sink enhancing. Mitigation options are selected and analyzed according to their direct and indirect economic impact, consistency with national development goals, economical feasibility, and compatibility with implementation policies, sustainability and other specific criteria. Various methods and tools are used to evaluate each mitigation option in terms of technological and economical implications.

Baseline and mitigation scenarios for the different sectors

Electricity

The energy baseline scenario is based on the MoEW's Energy policy paper. The most important points are found below:

- Increase installed capacity to 4,000 MW by 2014 and 5,000 MW thereafter to meet projected demand corresponding to an annual load growth of 7%, and 15% of peak load reserve;
- Possibility of renting 250 MW (barges, small generators or imports) between 2010 and 2013;
- 2/3 of the fuel mix is based on natural gas with multiple sources of supply;
- More than 12% of the fuel mix to be supplied by renewable energy sources;

Projected emissions are expected to reach 32,569 Gg CO_2 eq. by 2030 under the baseline scenario. Two mitigation scenarios have been developed. Mitigation scenario 1 consists of the implementation of MoEW's latest policy paper for the electricity sector, in addition to capacity expansion (around 3,500 MW between 2015 and 2030 based on the 2/3 natural gas fuel mix, in addition to 11.4% of renewable energy by 2030) post-2015 to keep up with demand. Mitigation scenario 2 consists again of implementation of MoEW's policy paper but with a full switch of oil-fired power plants to natural gas by 2030, an increase in the penetration rate of renewable energy technologies (17% by 2030) and no electricity imports.

The emissions reduction from the mitigation scenario 1 adds up to 177,912 Gg of CO_2 eq. between 2011 and 2030, while the reduction resulting from the implementation of the mitigation scenario 2 adds up to 204,768.3 Gg of CO_2 eq. between 2011 and 2030.

Manufacturing Industries and Construction

The manufacturing industries and construction sector covers private self-generation of electricity which accounts for around 33% of the total electricity generation. Since a significant amount of private generation is derived from manufacturing

industries, this chapter addresses measures to increase the efficiency of power generation in the industrial sector, especially in cement industries which constitute one of the major energy intensive industries in the country, the baseline scenario being business-as-usual. Two mitigation scenarios have been developed. Scenario 1, which is based on waste heat recovery and utilization for power generation in cement plants, has a potential reduction of CO_2 emission in the order of 230-380 Gg. The mitigation scenario 2 is based on partial substitution of fossil fuels with alternative fuels or less carbon intensive fuels. The potential emission reduction of scenario 2 has not been calculated.

Transportation

Baseline scenario is the business-as-usual, under which the projected number of vehicles will reach 1,600,000 by 2030, whereas the average number of daily motorized trips per person, and the share of passenger-trip by private vehicles, will both grow by almost 60% and 90% respectively. Two mitigation scenarios have been developed, the first being the revitalization of the public transport system whereby the distribution of passenger-trips traveled by bus and car would be reversed (more than half of personal trips to be traveled by bus). The second mitigation scenario developed is the implementation of a car scrappage program, which would reduce the overall energy intensity of the vehicle fleet, and consequently GHG emissions from the sector.

Building Envelops

The baseline scenario is the business-as-usual, while there is only one mitigation scenario developed, which stipulates the implementation of the already developed thermal standards for buildings in Lebanon. Unfortunately, the standards are still not mandatory. The impact of the application of the thermal standards on GHG emissions at the macroeconomic level was forecasted. Over a 20-year period (2010-2029), the application of the Thermal Standards for Buildings can lead to the avoidance of around 7,000 Gg of CO_2 (or around 343.5 Gg of CO_2/yr).

Industry

The cement industry is the most important industrial source of CO_2 emissions in Lebanon, and therefore two baseline scenarios (2% growth against a 4% growth projection) are suggested to portray possible future clinker production and CO_2 emissions from the cement industry in Lebanon until year 2030, where the emissions are projected to be 3,607 Gg of CO_2 eq. and 5,976 Gg of CO_2 eq. for scenario A and scenario B respectively. The only mitigation scenario proposed for the cement industry relates to the increase of additive blend in cement production which can reduce CO_2 emissions by an estimated average of 1.32%.

Agriculture

The baseline scenario assumes that the trend in the number of livestock and poultry will stay stable and expected emissions by 2030 will reach 244 Gg of CO_2. Emissions from agricultural soils and field burning of agricultural residues are not expected to increase either. By 2030, GHG emissions from agriculture soils could be at 60% less than the emissions in the baseline year, without taking into consideration CO_2 emissions or sequestration.

Two parallel mitigation scenarios are proposed: 1) field level measures such as farm manure management which would reduce some 79 Gg of CO_2 in 2030, plowing which would reduce emissions by 60%, and efficient irrigation, and 2) research, education, assistance, infrastructure, and institutional measures.

Forestry

The baseline scenario is based on the existing reforestation/afforestation plans which would increase the total carbon uptake increment to 347.32 kt by 2030. Three mitigation scenarios have been developed. Mitigation scenario 1 consists of maintaining and conserving existing forest carbon sinks which would bring the total CO_2 uptake increment to 1,273.5 kt. Mitigation scenario 2 consists of measures proposed under afforestation and reforestation while mitigation scenario 3 proposes substitution of fossil fuels by forest-based biofuels. The latter two scenarios' emission reduction potentials have not been developed.

Waste

The baseline scenario considers that the infrastructure and installations are being set up to realize the national solid waste management plan of 2006, which consists of establishing regional sanitary landfills, sorting and composting facilities while rehabilitating existing dumpsites. The emissions from the waste sector are expected to reach 5,969 Gg of CO_2 eq. by 2030. The proposed mitigation options tackle both the waste and energy sectors as it considers energy recovery as an alternative waste management option. Mitigation scenario 1 deals with gas recovery for electricity generation which would result in 2,984 Gg CO_2 eq. reduction in 2030. Mitigation scenario 2 deals with waste incineration and energy production. The effective cumulative avoided emission is calculated to be 11,771 Gg of CO_2 eq. for the period extending from 2015 to 2030.

3. Vulnerability and Adaptation

Future climate risks for Lebanon

Climate change scenarios have been developed for Lebanon through application of the PRECIS model. According to the model and in relation to the present climate, by 2040 temperatures will increase from around 1°C on the coast to 2°C in the mainland, and by 2090 they will be 3.5°C to 5°C higher. Comparison with LMS historical temperature records from the early 20th century indicates that the expected warming has no precedent. Rainfall is also projected to decrease by 10-20% by 2040, and by 25-45% by the year 2090, compared to the present. This combination of significantly less wet and substantially warmer conditions will result in an extended hot and dry climate. Temperature and precipitation extremes will also intensify. In Beirut, hot summer days (T_{max} > 35°C) and tropical nights (T_{min} > 25°C) will last, respectively, 50 and 34 days more by the end of the century. The drought periods, over the whole country, will become 9 days longer by 2040 and 18 days longer by 2090.

Agriculture

Agriculture in Lebanon is one of the most vulnerable sectors to climate change due to the limited availability of water and land resources and the pressure exerted by population growth and urbanization. The results of the assessment conducted show that higher temperature, reduced precipitation and high evapotranspiration will decrease soil moisture and increase aridity, which will affect the overall agricultural yield of crops. A decrease in productivity is expected for most of the crops and fruit trees especially for wheat, tomatoes, cherries, apples and olive. Chilling needs for mountainous fruit trees such as cherries and apples will not be met, leading to a risk of failure of blossom pollination and fecundation by up to 50%. High temperatures and reduced precipitation may also affect the quality of grapes, thus jeopardizing the quality of wine produced. Changes in climate will also lead to increased infestation of fungi and bacterial diseases for most of the crops. Irrigated crops will face water shortages due to increased water demand and decreased water availability for irrigation. Rainfed crops will show either no change or a decrease in their surface area or productivity (e.g., olive, wheat and cherry). Changes in temperature and rainfall will also affect the grazing period and the quality of the pastures, changing the species composition in favor of woody less palatable plants. However, increase in temperature will lead to an expansion of the coastal plantations such as banana and tomatoes to higher altitudes and herders would benefit from a longer pasture season in the mountains due to the reduced thickness and residence time of snow cover.

In order to reduce the consequences of climate change and increase the resilience of the agriculture sector, it is necessary to implement the following adaptation measures: 1) select and introduce more drought and heat-resistant species and hybrids; 2) change planting dates and cropping patterns; 3) adopt sustainable agricultural practices and integrated pest management techniques; 4) elaborate a national rangeland program; 5) enhance genetic selection of local breeds; 6) and promote mixed exploitations. Proposed adaptation measures include policy and legislation options, research topics for improved vulnerability assessment and monitoring, and adapted infrastructure.

Electricity

The forecasted rise in ambient temperatures would lead to higher cooling demand in summer, driving the peakload up in addition to the increase resulting from the natural growth in population, consumption rates and oil prices. This would in turn put pressure on the power production and supply system to meet the additional increase in demand, and consequently drive the cost of power production up. The increase in total consumption from increased cooling consumption will be 1.8% for a 1°C increase in temperature, and 5.8% for a 3°C increase in temperature. This will consequently necessitates an expansion of installed capacity between 87 and 438 MW. As for the forecasted reduction in precipitation, it would limit the hydropower generation potential, which would jeopardize the government's plans to increase this capacity. However, the predicted insignificant changes in wind speed and cloud cover are not likely to lead to any potential change in solar and wind energy.

Efforts of the power sector to adapt to the impacts of climate change converge and complement mitigation measures that entail ensuring a 24-hour supply of electricity, reducing budget deficit, and reducing dependence on imported oil consumption. Therefore, adaptation efforts should mainly be directed at implementing the Policy Paper of the Ministry of Energy and Water and the thermal standards for buildings proposed by Directorate General of Urban Planning.

Water

The effect of climate change on water resources is expected to be significant as a result of decrease in precipitation and projected changes in its spatial and temporal distribution, in addition to an increase in evapotranspiration. Droughts are predicted to occur 15 days to 1 month earlier, which will negatively affect the existing water shortage due to urbanization and population growth. The already dry regions such as the Bekaa, Hermel and the South will be mostly affected. A reduction of 6 to 8% of the total volume of water resources is expected with an increase of 1°C and 12 to 16% for an increase of 2°C. In addition, a decline in total and active precipitation is forecasted as well as a shift in rainfall consisting of higher precipitation in November and December, and a steep reduction from January onward.

Climate change will induce a reduction of 40% of the snow cover of Lebanon with an increase of 2°C in temperature and will reach 70% decrease in snow cover with an increase of 4°C. This will have adverse impacts on rivers and groundwater recharge, especially that snow melt will occur in early spring, which does not coincide with high demand for irrigation water such as the summer season. In addition, snow will shift from 1,500 m to 1,700 m by 2050 and to 1,900 m by 2090, affecting the recharge of most springs. The change in rainfall regimes will increase the manifestation of extreme events: winter floods can increase up to 30%, and hot summer days and tropical nights can last at least two months longer. This combination of significantly less wet and substantially warmer conditions will result in an extended hot and dry climate and in an intensification of the temperature extremes.

The main adaptation measures of the water sector include 1) the protection of groundwater from salinization in coastal areas; 2) the implementation of water demand side management strategies to reduce water demand in the domestic, industrial and agriculture sectors; 3) the development of watershed management plans; and 4) the implementation of pilot initiatives to demonstrate the feasibility of alternative sources of water supply and develop necessary standards and guidelines.

Coastal zones

The main climate change factors affecting costal zones are the potential increases in sea level and sea surface temperature due to the projected higher temperatures. Sea levels have been continuously rising at an average rate of approximately 20 mm/yr in the Levantine basin. If it were to continue in the future, it can reach up to 30-60 cm in 30 years, which will have an impact on the sand beaches in the south, and on the coastal natural reserves such as the Palm Islands and the Tyre nature reserves. This will also lead to seawater intrusion into aquifers which will affect not only urban areas but also coastal irrigated agriculture. The potential impacts of climate change on the coastal zone include coastal flooding and inundation during

storms, sea water intrusion and salinization of coastal aquifers, coastal erosion and loss of sand beaches, degradation of coastal ecosystems and nature reserves and economic losses in coastal and marine activities such as tourism, agriculture, fisheries, transportation and other essential services.

The main adaptation strategy for coastal zones is the adoption of integrated coastal zone management to organize and control the urbanization of the coast. More specific measures against sea level rise consist of pulling back human activities from the coast through the creation of buffer zones, moving sources of urban, industrial and agriculture pollution away from the coast, introducing effective early warning systems for coastal hazards, and creating protective structures to limit potential damage.

Forestry

Forests in Lebanon 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. The expected changes in temperature and rainfall are expected to be accompanied by a significant change in bioclimatic levels in Lebanon. The Oromediterranean level is projected to disappear from Lebanon by 2080, while the Arid bioclimatic level is expected to increase from 5 to 15 % in area. The most vulnerable forest stands are the upper zone coniferous forests (*Cedrus libani; Abies cilicica*) and high mountain formations (*Juniperus excelsa*) and the most vulnerable areas are North Lebanon (Akkar) and Hermel, where a shift in bioclimatic level from sub-humid to semi-arid is expected. Moreover, Tannourine and Arz el Chouf nature reserves will severely be impacted by increased temperatures as they are mainly composed of cedar forests. Horsh Ehden will be less impacted due to diversity of its tree communities. Prolonged drought periods will increase the frequency and periodicity of fire events, especially for *Pinus halepensis* and *Juniperus* stands. The regeneration rate, overall area and population density of *Juniperus excelsa*, *Cedrus libani*, *Abies cilicica* as well as *Quercus cerris*, *Fraxinus ornus* and *Ostrya carpinofolia* are also expected to decrease.

Adaptation measures are targeted to assist the natural resilience of forests, anticipate future changes and promote landscape scale and mainly consist of 1) strengthening the legal and institutional framework to integrate climate change needs; 2) integrate landscape levels planning in local/regional development plans; 3) strengthen awareness and education and support research and 4) develop forest management plans for most vulnerable ecosystems.

Public Health

The direct and indirect effects of climate change 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 that affect agriculture and other water-borne and rodent-borne diseases related to scarcity of clean water. In addition, changing patterns in rainfall and temperature can cause the proliferation of vector-borne diseases such as Malaria and Dengue fever. The average mortality caused by increases in temperatures is expected to range between 2,483 and 5,254 additional deaths/year between 2010 and 2030. Vulnerable population groups, especially the elderly and people living in socio-economically deprived areas, in semi-arid areas and in areas with lower access to health services are more at risk as a result of their high sensitivity and low adaptive capacity.

The main adaptation measures to be taken in Lebanon include 1) strengthening the epidemiological surveillance system and surveillance for temperature-related mortality and morbidity; 2) developing and implementing an emergency heat warning system; 3) improving access to health care and proper sanitation; and 4) enhancing the Early Warning Alert and Response System (to improve the capacity of the current system to respond to unexpectedly occurring disasters.

Tourism

Climate change affects the tourism sector by inflicting damage on a wide range of environmental resources that are critical attractions for tourism. Warmer temperatures and reduced precipitation are expected to lead to a decrease in the intensity, residence time (from 110 days to 45 days with a warming of 2ºC) and thickness of the snow cover in

the mountains of Lebanon thus shortening the skiing season, which is the key attraction for tourism during winter. Climate change can also provoke the loss of natural attractions, reduce ecotourism activities and impinge on the livelihoods of the communities. In addition, sea level rise may inflict damage on the touristic attractions located on the shore and sandy public beaches and can cause coastal erosion and structural damage to national archaeological heritage.

General adaptation measures are mainly targeted to strengthening the role of related public institutions, creating financial incentives to encourage investment in more sustainable touristic activities and facilitating communication between the private and public sector. More specific measures include: 1) moving ski areas to higher altitudes or to colder north slopes; 2) improving insurance coverage in the face of extreme events for high mountain areas and winter tourism destinations at risk; 3) implementing soft and hard protection measures for coastal and island destinations and 4) developing and promoting alternative and sustainable types of tourism, supporting protected area management, and enhancing and restoring the forest cover in order to promote sustainable tourism for natural areas at risk.

Human Settlements and infrastructure

The most likely impacts of climate change on infrastructure and human settlements are caused by changing patterns in precipitation, sea level rise and increased frequency and intensity of storms which inflict significant damages to buildings and public infrastructure. These impacts can cause inundation of coastal settlements and buildings, disruption of operation at the airport and damages in the transport infrastructure, water and wastewater networks. They can also increase the risk of floods, mudslides and rockslides. The related socio-economic impacts include a reduction of the quality of life due to financial losses in the infrastructure supporting the different economic activities, and an increase in the cost of living in urban agglomerations.

Adaptation measures require the adjustments of current settlements and infrastructure to future climatic changes. These include 1) integrating the transportation and land-use planning at the level of planning of new infrastructure or rehabilitation of those affected by climate change; 2) adopting protective measures against sea level rise and other extreme weather events and 3) anticipating floods in vulnerable areas through hard and soft engineering measures.

4. Other Information: Public Awareness, Education and Capacity Building

Within this section, a description on existing institutional and policy framework pertaining to climate change is done. In order to strengthen the loose or even non-existing coordination among the ministries, the creation of a National Committee for Climate Change and Desertification is proposed.

In terms of access to technology, barriers are identified and policy options to overcome these barriers are proposed.

The existing climatic observation network is described, spanning the entire spectrum of organisations (governmental and academic) that contribute in conducting and providing information related to primarily meteorological information. In general, the country lacks proper funding within this area.

In terms of research, education, training and awareness, the role of higher education is highlighted, where the lack of funds and proper research in the climate change arena remains a main hindrance.

5. Constraints, gaps and related financial, technical and capacity needs

Several barriers need to be overcome in order to enable Lebanon to comply with the fundamental principles of the Convention. At present existing main barriers can be categorized into three groups: constraints for the preparation of national communications, difficulties in implementing the proposed mitigation and adaptation measures, and financial constraints.

CONTENTS

List of Figures

List of Tables