REPUBLIC OF LEBANON
MINISTRY OF ENVIRONMENT

gef

UNDP
Empowered lives.
Resilient nations.

NATIONAL GREENHOUSE GAS INVENTORY REPORT AND MITIGATION ANALYSIS FOR THE LAND USE, LAND-USE CHANGE AND FORESTRY SECTOR IN LEBANON

2015 MINISTRY OF ENVIRONMENT

National Greenhouse Gas Inventory Report and Mitigation Analysis for the Land Use, Land-Use Change and Forestry Sector in Lebanon

May 2015

This document should be referenced as:

MoE/UNDP/GEF (2015). National Greenhouse Gas Inventory Report and Mitigation Analysis for the Land Use, Land-Use Change and Forestry Sector in Lebanon. 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

Leila El Sayyed, Economist

Mary Awad, Project Assistant

Sara El Rayes, Administrative Assistant

UNFCCC focal point

Samar Malek, Acting Head of Service of Environmental Technology

Disclaimer

The contents of this document are the sole responsibility of its authors, and do not necessarily reflect the opinion of the Ministry of Environment or the United Nations Development Programme, who will not accept any liability derived from its use.

This study can be used for research, teaching and private study purposes. Please give credit where it is due.

National Greenhouse Gas Inventory Report and Mitigation Analysis for the Land Use, Land-Use Change and Forestry Sector in Lebanon

Reference projects

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

Lebanon's First Biennial Update Report

Executed by

Ministry of Environment

Funded by

Global Environment Facility

Implemented by

United Nations Development Programme, Lebanon

Main authors

Biodiversity Program (BP) - Institute of the Environment (IOE) – University of Balamand (UOB)

Manal Nader, Ph.D.

George Mitri, Ph.D.

Mireille Jazi, M.Sc.

Roula Al Daia, PhD.

Manale Abou Dagher, M.Sc.

Hisham Bou Kamel, B.Sc.

Lead reviewers

Lea Kai Aboujaoudé

Yara Daou

Reviewer

Vahakn Kabakian

External inventory reviewer

Carlos Lopez

Designers

Nathalie Hamadeh

Palig Haroutunian

Printing

Al Mostakbal Press

Foreword

Ministry of Environment

Through the publications of Lebanon's Initial and Second National Communications to the United Nations Framework Convention on Climate Change, and the Technology Needs Assessment for Climate Change, the Ministry of Environment drew the large climate change picture in the country. The picture shed the light on a number of climate change matters: Lebanon's contribution to global greenhouse gas emissions, the sectoral share of national emissions, the socio-economic and environmental risks that the country faces as a result of climate change, and the potential actions that could and should be undertaken to fight climate change both in terms of mitigation and adaptation.

Through these series of focused studies on various sectors (energy, forestry, waste, agriculture, industry, finance and transport), the Ministry of Environment is digging deeper into the analysis to identify strengths, weaknesses, threats and opportunities to climate friendly socio-economic development within each sector.

The technical findings presented in this report (National Greenhouse Gas Inventory Report and Mitigation Analysis for the Land Use, Land-Use Change and Forestry Sector) will support policy makers in making informed decisions. The findings will also help academics in orienting their research towards bridging research gaps. Finally, they will increase public awareness on climate change and its relation to each sector. In addition, the present technical work complements the strategic work of the National Climate Change Coordination Unit. This unit has been bringing together representatives from public, private and non-governmental institutions to merge efforts and promote comprehensive planning approach to optimize climate action.

We are committed to be a part of the global fight against climate change. And one of the important tools to do so is improving our national knowledge on the matter and building our development and environmental policies on solid ground.

Mohammad Al Mashnouk

Minister of Environment

Foreword

United Nations Development Programme

Climate change is one of the greatest challenges of our time; it requires immediate attention as it is already having discernible and worsening effects on communities everywhere, including Lebanon. The poorest and most vulnerable populations of the world are most likely to face the harshest impact and suffer disproportionately from the negative effects of climate change.

The right mix of policies, skills, and incentives can influence behaviour and encourage investments in climate development-friendly activities. There are many things we can do now, with existing technologies and approaches, to address it.

To facilitate this, UNDP enhances the capacity of countries to formulate, finance and implement national and sub-national plans that align climate management efforts with development goals and that promote synergies between the two.

In Lebanon, projects on Climate Change were initiated in partnership with the Ministry of Environment from the early 2000s. UNDP has been a key partner in assisting Lebanon to assess its greenhouse gas emissions and duly reporting to the UN Framework Convention on Climate Change. With the generous support of numerous donors, projects have also analysed the impact of climate change on Lebanon's environment and economy in order to prioritise interventions and integrate climate action into the national agenda. UNDP has also implemented interventions on the ground not only to mitigate the effects of climate change but also to protect local communities from its impact.

This series of publications records the progress of several climate-related activities led by the Ministry of Environment which UNDP Lebanon has managed and supported during the past few years. These reports provide Lebanon with a technically sound solid basis for designing climate-related actions, and support the integration of climate change considerations into relevant social, economic and environmental policies.

Ross Mountain

UNDP Resident Representative

Acknowledgements

This report comes within the project "Provision of professional services for the preparation of GHG emissions and mitigation chapter of land use, land-use change and forestry (LULUCF)".

The team is grateful to all public authorities and private organizations for their help in documenting relevant information in relation to land cover/land use studies and projects, and for their ideas and guidance.

We wish to extend our recognition to all the entities which provided data to us and answered our numerous questions. We specifically wish to thank the Ministry of Environment (MoE), the Ministry of Agriculture (MoA), the Greenplan, the National Council for Scientific Research (CNRS), the Association for Forests, Development and Conservation (AFDC), the Lebanon Reforestation Initiative (LRI), and the United Nations Development Programme (UNDP).

We would also like to thank all the participants to the expert meeting held on 09-09-2013 at the Ministry of Environment for the assessment of economic instruments and their suitability for the implementation of proposed mitigation scenarios.

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

The research team is grateful for all comments and suggestions provided by colleagues and collaborators during presentations of initial drafts and the final consultations. Particularly we would like to thank the UNDP project management team for their valuable comments.

Finally, the Ministry of Environment would like to thank UNDP/GEF for funding the whole greenhouse gas inventory exercise.

Table of contents

List of figures

List of tables

Acronyms

ABQUAR	Alleviating Barriers for Quarries Rehabilitation
AFDC	Association for Forest, Development and Conservation
AGB	Above-Ground Biomass
BDL	Banque Du Liban
BGB	Below-Ground Biomass
BP	Biodiversity Program
CBO	Community-Based Organization
C	Coniferous
CC	Cropland remaining Cropland
CDR	Council for Development and Reconstruction
CIMA	International Center on Environmental Monitoring
CNRS	National Council for Scientific Research
CoM	Council of Ministers
DAR-IAURIF	Dar Al Handasah – Institut d'Aménagement et d'Urbanisme de la Région Ile-de-France
DEM	Digital Elevation Model
DGUP	Directorate General for Urban Planning
DOM	Dead Organic Matter
DSS	Decision Support System
EFDB	Emission Factors Database
E/R	Emission/Removal
ES	Environmental Service
EU	European Union
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FF	Forest Land remaining Forest Land
FRA	Forest Resources Assessment

FUG	Forest User Groups
GEF	Global Environment Facility
GG	Grassland remaining Grassland
GHG	Greenhouse Gas
GIS	Geographic Information System
GoL	Government of Lebanon
GPG	Good Practice Guidance
GWP	Global Warming Potential
IBA	Important Bird Areas
INC	Initial National Communication
IOE	Institute of the Environment
IPCC	Intergovernmental Panel on Climate Change
IR	Irrelevant
IUCN	International Union for Conservation of Nature
KBDI	Keetch-Byram Drought Index
KIA	Kappa Index of Agreement
LAF	Lebanese Army Forces
LARI	Lebanese Agricultural Research Institute
LC	Lands converted to Cropland
LF	Lands converted to Forest Land
LG	Lands converted to Grassland
LO	Lands converted to Other Land
LRI	Lebanon Reforestation Initiative
LS	Lands converted to Settlements
LUC-LCC	Land-Use Change and Land-Cover Change
LULUCF	Land Use, Land-Use Change and Forestry
LW	Lands converted to Wetland
MoA	Ministry of Agriculture
MoD	Ministry of Defense

MODIS	Moderate Resolution Imaging Spectroradiometer
MoE	Ministry of Environment
MoEd	Ministry of Education
MoET	Ministry of Economy and Trade
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities
MoJ	Ministry of Justice
MoPWT	Ministry of Public Works and Transport
MoEW	Ministry of Energy and Water
MoU	Memorandum of Understanding
MRRS	MODIS Rapid Response System
NAS	National Academies of Science
NASA	National Aeronautics and Space Administration
NC	Non-Coniferous
NCs	National Communications
N/A	Not Available
NEF	National Environmental Fund
NFP	National Forest Plan
NGO	Non-Governmental Organization
NIR	National Inventory Report
NO	Not Occuring
NORAD	Norwegian Agency for Development Cooperation
NRP	National Reforestation Plan
NWFP	Non-Woody Forest Product
OEA	Order of Engineers and Architects
OO	Other Land remaining Other Land
OWL	Other Wooded Land
PEER	Partnerships for Enhanced Engagement in Research
PES	Payment for Environmental Services

QA	Quality Assurance
QC	Quality Control
RISICO	RISchio Incendi e COordinamento
SAR	Second Assessment Report
SDATL	Schéma d'Aménagement du Territoire Libanais
SLM	Sustainable Land Management
SNC	Second National Communication
SS	Settlements remaining Settlements
SWOT	Strengths, Weaknesses, Opportunities and Threats
TNC	Third National Communication
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UOB	University of Balamand
USAID	United States Agency for International Development
USFS	United States Forest Service
WHS	World Heritage Sites
WUI	Wildland-Urban Interface
WWF	World Wide Fund for Nature
WW	Wetland remaining Wetland

Executive summary

In the framework of Lebanon's Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas (GHG) emissions resulting from the Land Use, Land-Use Change and Forestry Sector (LULUCF) in Lebanon were estimated for the period of 1994-2011. The tier 1 approach of the Intergovernmental Panel on Climate Change (IPCC) Guidelines was adopted in the calculation of GHG and consequently for the development of the National Greenhouse Gas Inventory.
The sources of emissions as well as the main removals in this sector were identified in the purpose of targeting the largest contributors. This allowed the development of the potential mitigation actions for the reduction of GHG emissions and for increasing the carbon sequestration effect of the LULUCF sector.

Inventory

GHG estimations results showed a remarkable increase in GHG emissions and decrease in removals from LULUCF over the past two decades, resulting in a net decrease in removals of about 12% from 1994 to 2012 (Figure i).

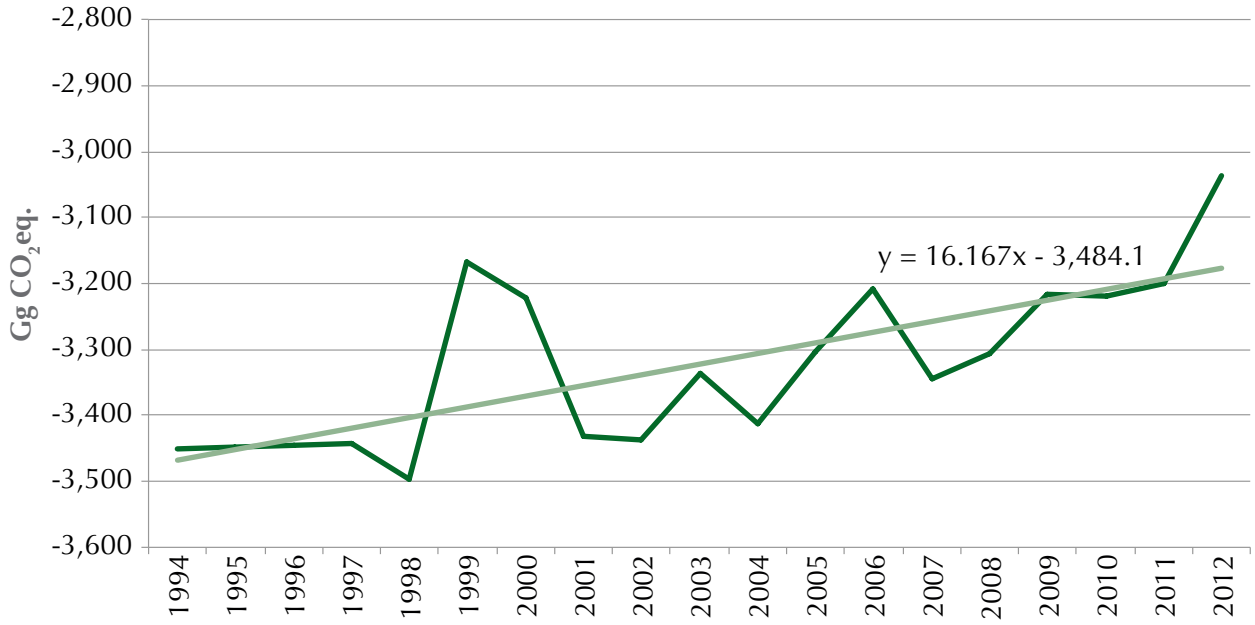


Figure i: Trend analysis for CO_2 emissions/removals over the inventory period 1994-2012

The main findings revealed that wildfires are highly contributing to greenhouse gas emissions (between 60 Gg and 400 Gg CO_2 per year); whereas urbanization (between 10 Gg and 170 Gg CO_2 per year) and fuelwood gathering (about 27 Gg per year) are the main causes of decrease in removals. Greenhouse gas removals were mainly attributed to the growth of forest plantations from afforestation activities (between -7 Gg and -80 Gg CO_2 per year), the growth of existing forest lands (about -2,300 Gg per year), followed by existing cropland (about -1,230 Gg per year).

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

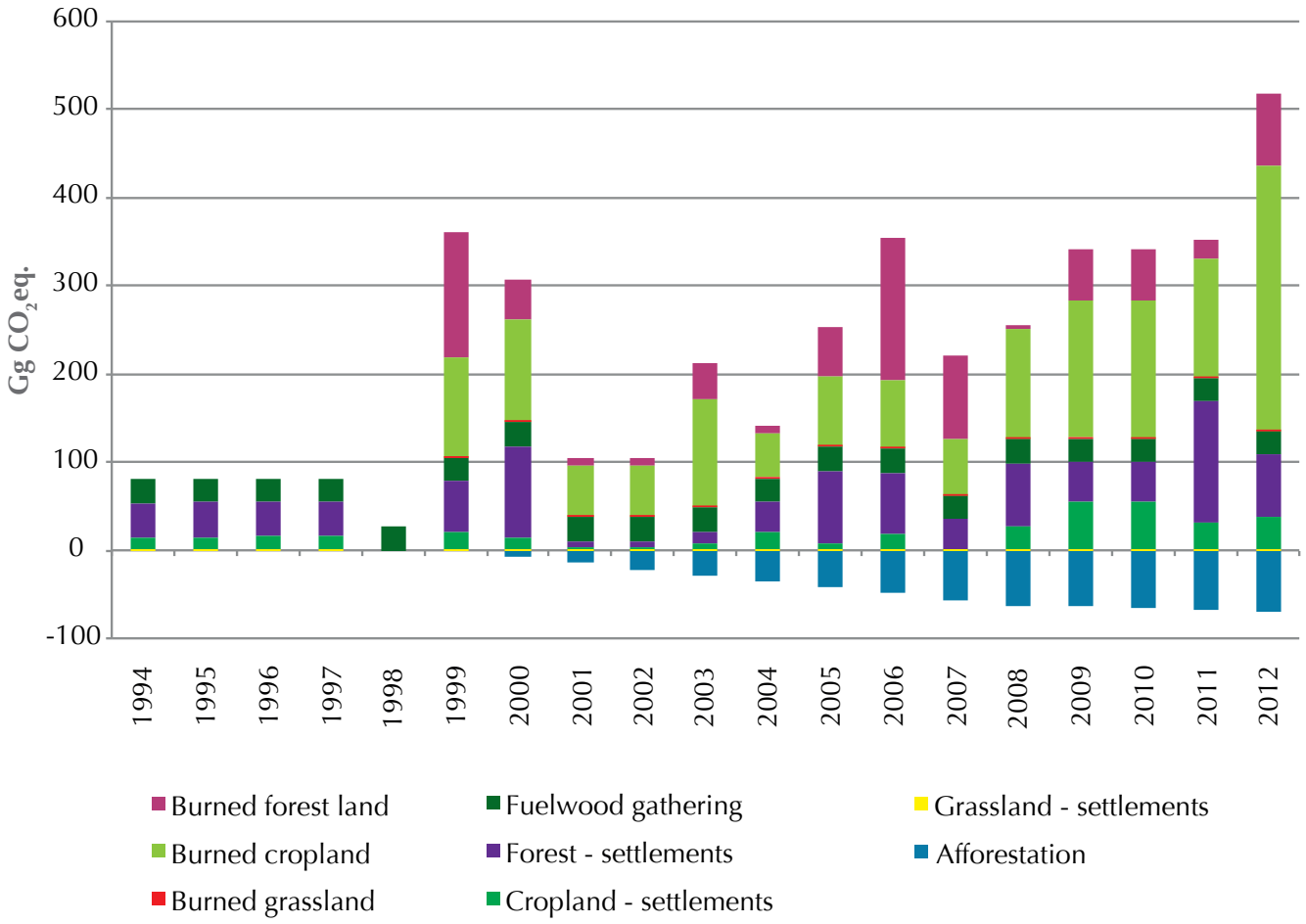


Figure ii: CO_2 emissions/removals from the changes in the LULUCF sector (1994 -2012)

Mitigation

Here lies the necessity for the development of mitigation scenarios which are proposed plans and projects with a potential for emission reduction or sink enhancement of the LULUCF sector.
Taking into consideration the mitigation measures proposed in Lebanon's Second National Communication (SNC) to the UNFCCC, the suggested mitigation actions were directed towards the forest land category which has a major contribution to GHG emissions or removals. The future projections (2013-2030) of the baseline scenario consisted of average areas of forest land converted to settlements, average areas of burned forests and average areas of afforestation based on the trend data of 1999-2012.

Mitigation scenario 1 consisted of maintaining the current extent of Lebanon's forest and other wooded land cover and mitigation scenario 2 consisted in increasing the current extent of Lebanon's forest and other wooded land cover 7% by 2030. Both scenarios involved the implementation of Lebanon's National Strategy for Forest Fire Management (decision no. 52, 2009) which is an essential part in "reducing the risk of intense and frequent forest fires whilst allowing for fire regimes that are socially, economically and ecologically sustainable".

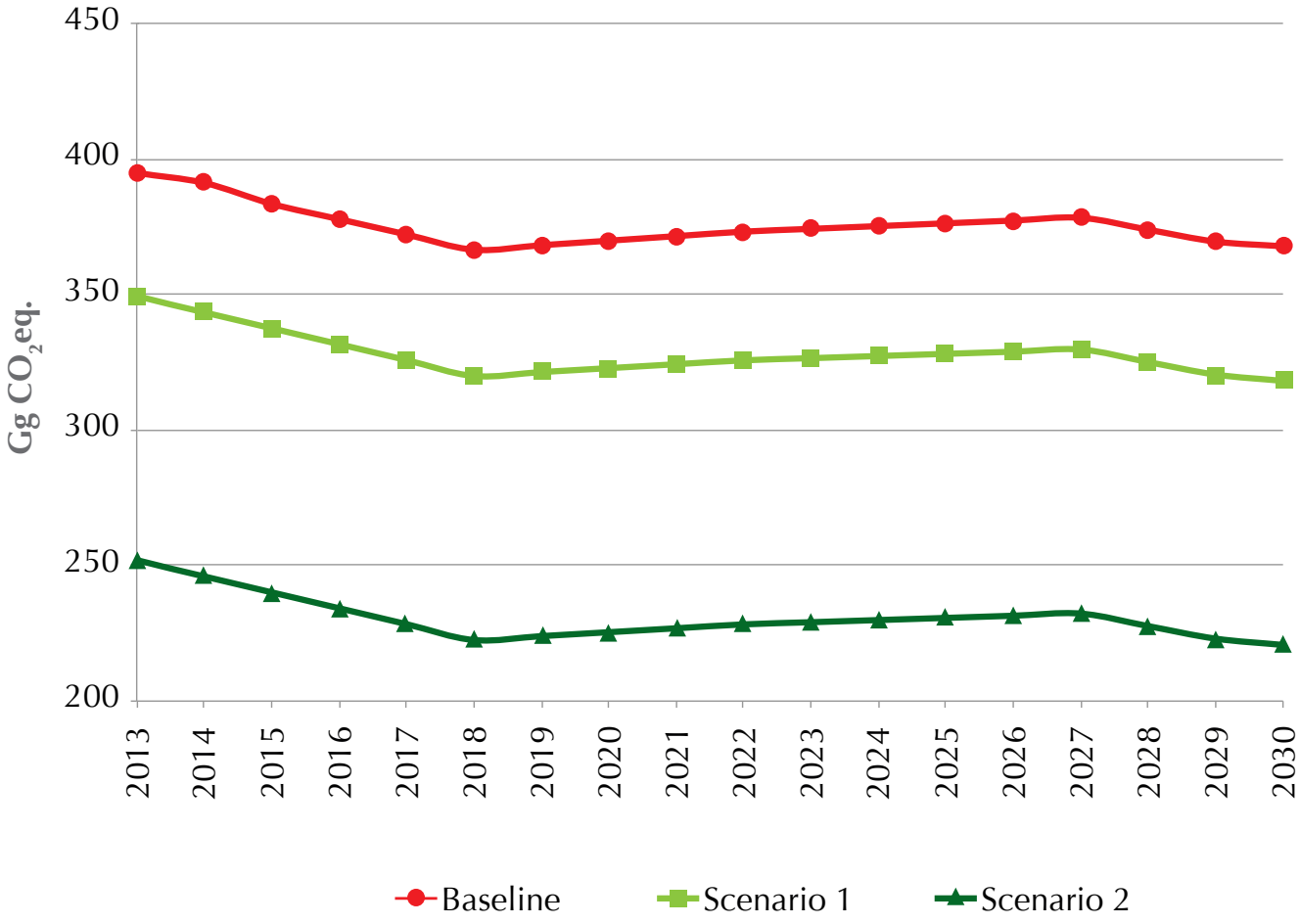


Figure iii: Net emissions from the changes in the LULUCF sector: baseline versus mitigation scenarios

The reduction potential was about 12.57% and 38.5% for scenarios 1 and 2 respectively (Figure iii). Scenario 2 has proved to be more efficient in reducing emissions and increasing removals compared to the baseline scenario; however, scenario 1 was characterized by a shorter term for implementation and may be the first step to limit the increasing losses in the vegetation cover and the increasing GHG emissions from forest fires.

The assessment of potential tools for the achievement of the proposed mitigation scenarios identified four applicable economic instruments in Lebanon: 1) "Payment for Environmental Services" (PES), 2) subsidy for reforestation, 3) conservation payment programs for land conversion and, 4) establishment of community forests. Moreover, the analysis of the main issues in the forestry sector showed that the successful 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" (so-called Sandouk al Tahrij) stipulated by the forest law of 1949 (article 98) represents a promising source for funding in addition to the government, private sector and international funding initiatives.

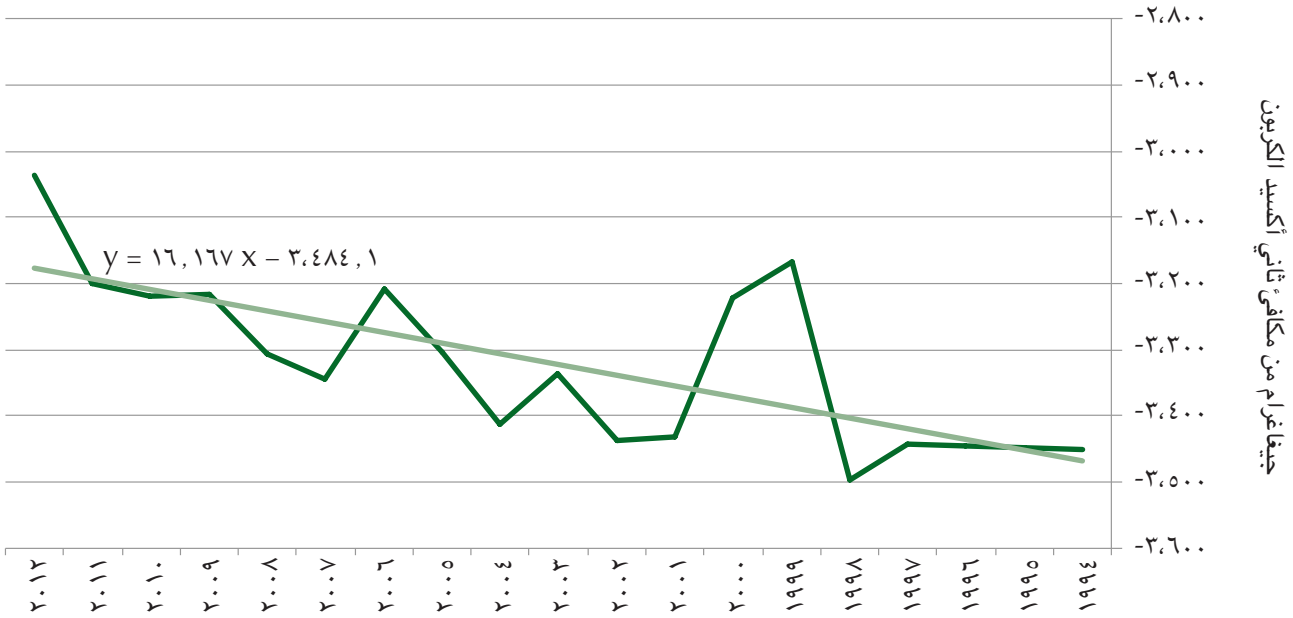
الملخص التنفيذي

في إطار البلاغ الوطني الثالث للبنان إلى اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ، تم تقدير انبعاثات غاز الاحتباس الحراري (الغازات الدفيئة) الناجمة عن استخدام الأراضي وتغيير استخدام الأراضي والحراجة (LULUCF) في لبنان خلال الفترة ١٩٩٤-٢٠١٢. وتم اعتماد المبادئ التوجيهية لمنهجية المستوى ١ للهيئة الحكومية الدولية المعنية بتغير المناخ (IPCC) في احتساب الغازات الدفيئة ومن ثم لتطوير قوائم الجرد الوطنية للغازات الدفيئة.

وقد تم تحديد مصادر الانبعاثات كما وعمليات الإزالة الرئيسية للانبعاثات في هذا القطاع بغية استهداف أكبر المساهمين. وقد سمح ذلك بوضع إجراءات التخفيف المحتملة للحد من انبعاثات الغازات الدفيئة ولزيادة تأثير امتصاص الكربون في قطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة.

قوائم الجرد

أظهرت تقديرات نتائج الغازات الدفيئة ارتفاعًا ملحوظًا في انبعاثات الغازات الدفيئة وانخفاضًا في عمليات الإزالة للانبعاثات من استخدام الأراضي وتغيير استخدام الأراضي والحراجة على مدى العقدين الماضيين، مما أدى إلى انخفاض صافٍ في عمليات الإزالة بحوالي ١٢٪ من العام ١٩٩٤وحتى ٢٠١٢ (الشكل أ).

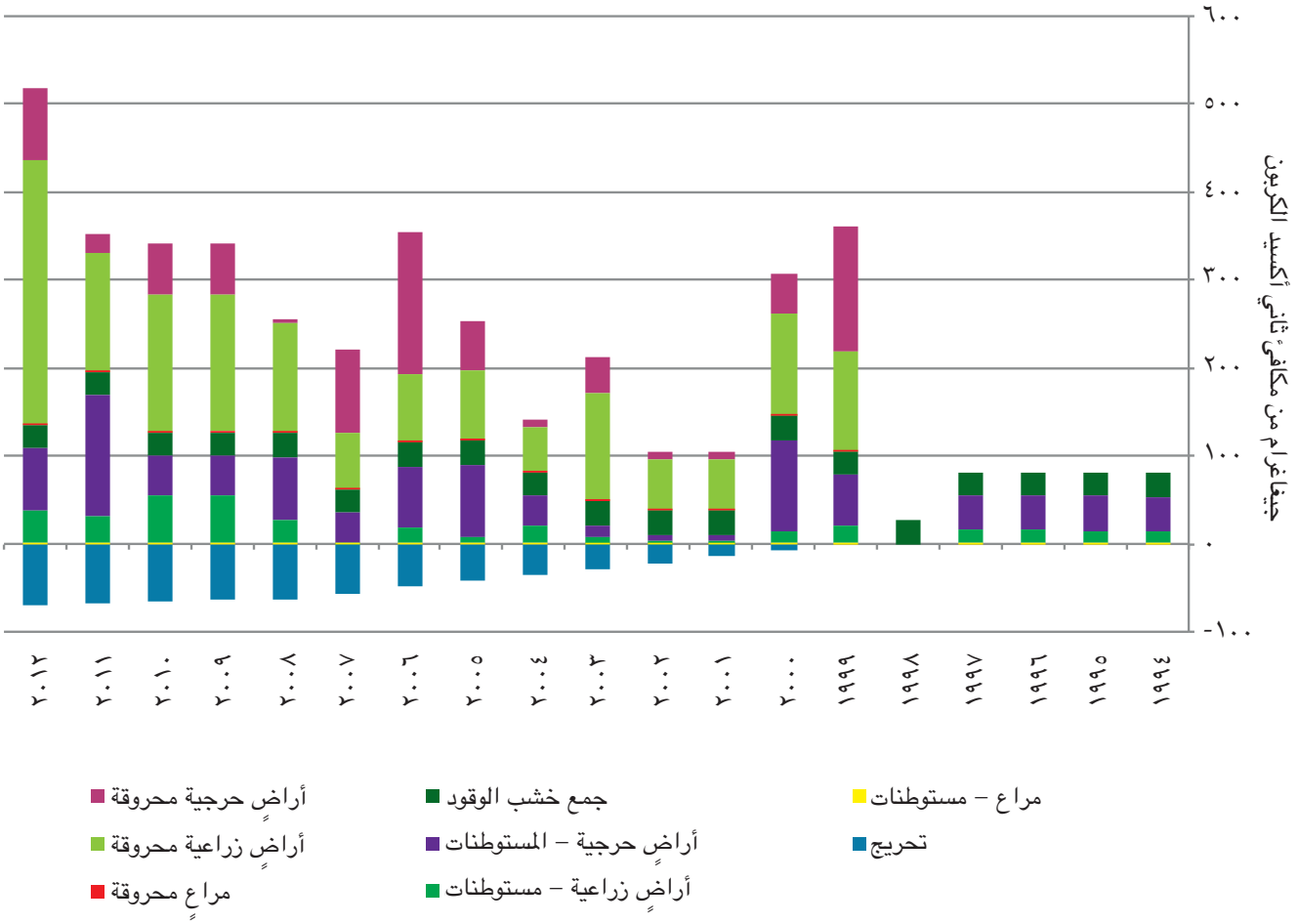


الشكل أ: تحليل الاتجاهات لعمليات إزالة/انبعاثات ثاني أكسيد الكربون خلال فترة قائمة الجرد ١٩٩٤-٢٠١٢

وكشفت النتائج الرئيسية أن حرائق الغابات تساهم إلى حد كبير في انبعاثات الغازات الدفيئة (ما بين ٦٠ جيغاغرام و ٤٠٠ جيغاغرام من مكافئ ثاني أكسيد الكربون في السنة)؛ في حين أن التوسع الحضري (ما بين ١٠ جيغاغرام و ١٧٠ جيغاغرام من مكافئ ثاني أكسيد الكربون في السنة) وتجميع خشب الوقود (حوالي ٢٧ جيغاغرام من مكافئ ثاني أكسيد الكربون في السنة) هي الأسباب الرئيسية للانخفاض في عمليات الإزالة. وتم نسب عمليات إزالة الغازات الدفيئة بشكل رئيسي إلى نمو المزارع الحرجية جراء أنشطة التحريج (بين ٧- جيغاغرام و٨٠- جيغاغرام من مكافئ ثاني أكسيد الكربون في السنة) ونمو الأراضي الحرجية الموجودة (حوالي ٢،٣٠٠- جيغاغرام من مكافئ ثاني أكسيد الكربون في السنة)، ومن ثم الأراضي الزراعية الحالية (حوالي ١،٢٣٠- جيغاغرام من مكافئ ثاني أكسيد الكربون في

السنة).

كما أظهرت مقارنة الانبعاثات بعمليات إزالة التغيرات أن الانبعاثات الناتجة عن تحويلات الأراضي وحرق الكتل الإحيائية وجمع خشب الوقود كانت أعلى بكثير من عمليات الإزالة الناجمة عن نمو مزارع جديدة (التحريج) (الشكل ب). وعلى الرغم من أن صافي الانبعاثات/عمليات الإزالة قد أثبت أن قطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة هو الحوض الأساسي، فقد كانت الانبعاثات الناتجة عن التغيرات في قطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة لا تزال عالية ولم يكن التعويض عنها من خلال أنشطة التحريج ممكناً.



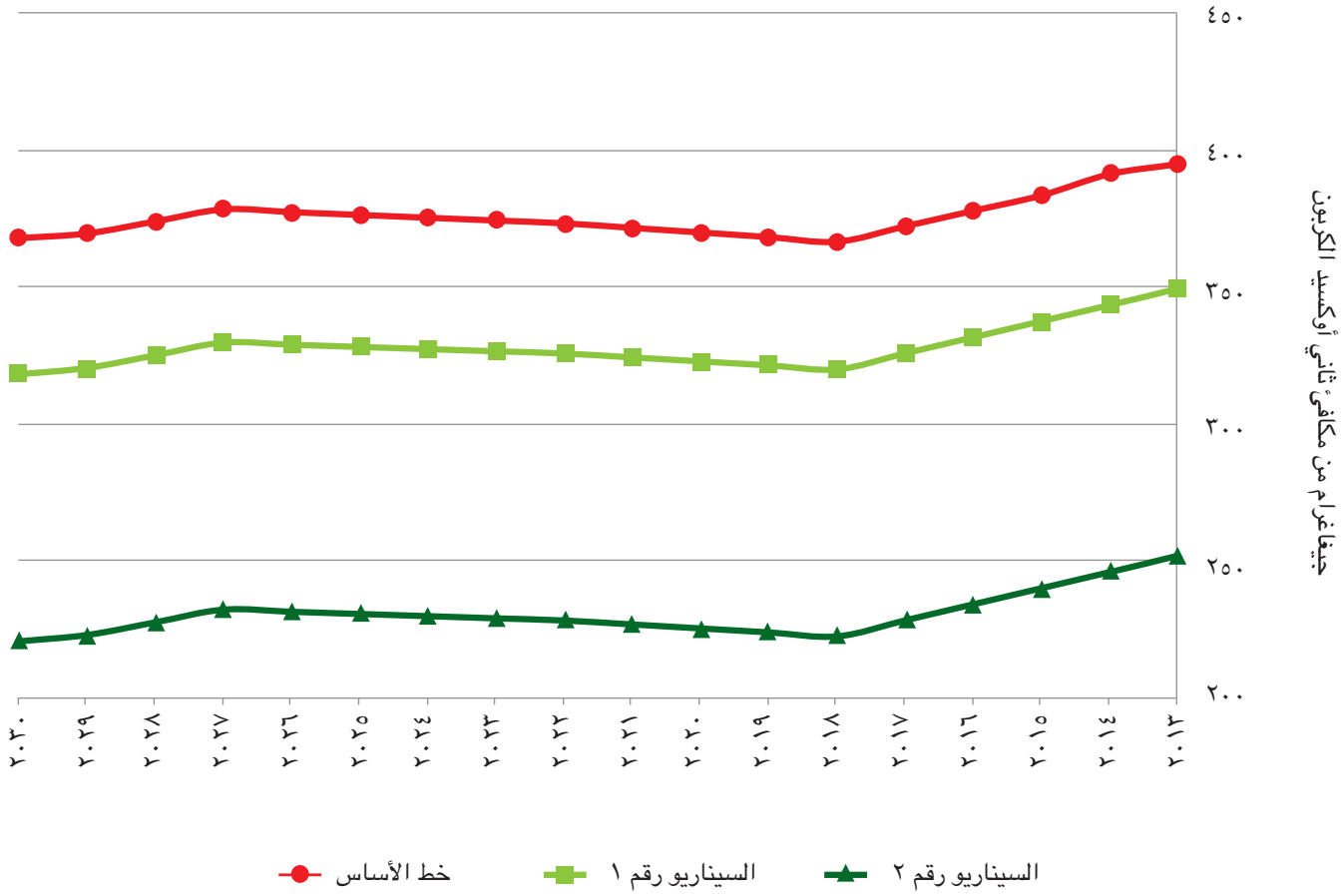
الشكل ب : صافي عمليات إزالة/انبعاثات ثاني أكسيد الكربون في قطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة (١٩٩٤– ٢٠١٢)

تخفيف الانبعاثات

هنا تكمن ضرورة وضع سيناريوهات التخفيف من الانبعاثات وهي خطط ومشاريع مُقترحة مع إمكانية خفض الانبعاثات أو تعزيز الحوض (أي قدرة امتصاص الغازات الدفيئة) لقطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة.

وإذا ما أخذنا بعين الاعتبار تدابير التخفيف المقترحة في البلاغ الوطني الثاني للبنان إلى اتفاقية الأمم المتحدة الإطارية بشأن تغير المناخ، تم توجيه إجراءات التخفيف المقترحة نحو فئة الأراضي الحرجية التي تُعتبر مساهمتها كبيرة في انبعاثات غازات الدفيئة أو عمليات إزالتها. أما التوقعات المستقبلية (٢٠١٣–٢٠٣٠) لسيناريو خط الأساس فقد تألفت من متوسط مساحات الأراضي الحرجية التي تم تحويلها إلى مستوطنات ومتوسط مساحات الغابات المحروقة ومتوسط مساحات مناطق التحريج، استنادًا إلى بيانات الاتجاهات للفترة ١٩٩٩–٢٠١٢.

تألف سيناريو التخفيف رقم ١ من الحفاظ على الحد الحالي من الغابات في لبنان وغيرها من غطاء الأرضي الحرجية، وتمثّل سيناريو التخفيف رقم ٢ في زيادة الحدّ الحالي من الغابات في لبنان وغيرها من غطاء الأرضي الحرجية بنسبة ٧٪ بحلول عام ٢٠٣٠. وشمل كلّ من السيناريوهين تنفيذ الإستراتيجية اللبنانية الوطنية لإدارة حرائق الغابات (القرار رقم ٥٢، ٢٠٠٩) وهي جزء أساسي في «الحد من مخاطر حرائق الغابات الشديدة والمتكررة مع السماح بأنظمة الحريق المستدامة اجتماعيًا واقتصاديًا وبيئيًا».



الشكل ج : صافي الانبعاثات من التغيرات في قطاع استخدام الأراضي وتغيير استخدام الأراضي والحراجة: خط الأساس مقابل سيناريوهات التخفيف

وكان احتمال التخفيف بنسبة حوالي ١٢,٥٧٪ و ٣٨,٥٪ للسيناريو ١ و ٢ على التوالي (الشكل ج). واثبت السيناريو ٢ أنه أكثر فعالية في الحد من الانبعاثات وزيادة عمليات الإزالة بالمقارنة مع سيناريو الخط الأساسي. إلا أن السيناريو ١ اتسم بمدة زمنية أقصر للتنفيذ وقد يكون الخطوة الأولى للحد من الخسائر المتزايدة في الغطاء النباتي وانبعاثات الغازات الدفيئة المتزايدة من حرائق الغابات.

وعمل تقييم الأدوات الممكنة لتحقيق سيناريوهات التخفيف المقترحة على تحديد أربعة أدوات اقتصادية معمول بها في لبنان: ١) الدفع مقابل الخدمات البيئية، ٢) الإعانات لإعادة التحريج، ٣) برامج دفعات المحافظة لتحويل الأراضي و٤) إنشاء الغابات المجتمعية. إضافة إلى ذلك، أظهر تحليل القضايا الرئيسية في قطاع التحريج أن التنفيذ الناجح لإجراءات التخفيف المقترحة إنما يتطلب نهجًا متكاملاً يشمل تنفيذاً محسَّناً للتشريعات والقوانين وتخطيطًا وتثقيفًا وتوعية حول استخدام الأراضي والتقييم الاقتصادي للغابات والتمويل. في هذا السياق، يمثّل «صندوق التحريج» المنصوص عليه في قانون الغابات لعام ١٩٤٩ (المادة ٩٨) مصدر تمويل واعد بالإضافة إلى الحكومة والقطاع الخاص ومبادرات التمويل الدولية.

Part 1: Inventory

1. Scope

The Land Use, Land-Use Change and Forestry (LULUCF) sector is a greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities (UNFCCC, 2013). According to the Intergovernmental Panel on Climate Change (IPCC), the LULUCF sector is described in six broad land-use categories for reporting national inventories (IPCC, 2003): 1) forest land, 2) cropland, 3) grassland, 4) wetland, 5) settlements and 6) other land.

Lebanon has submitted two previous National Communications (NCs) reports (1999 and 2011) to the United Nations Framework Convention on Climate Change (UNFCCC) and the Third National Communication report (TNC), expected to be submitted in 2015, will update the Greenhouse Gas (GHG) inventory of Lebanon. The aim of this work was to produce the National Inventory Report (NIR) of the LULUCF Greenhouse Gas Emission Inventory for the years 1994 up to 2012. Accordingly, the NIR will involve the use of up-to-date remote sensing techniques which are expected to allow more precise estimation of land-use and land-cover change areas, including a trend analysis of the results. Also, it is expected to allow re-calculation of the GHG emissions/removals for the years 1994 through 2004 due to the availability of new data and the adoption of a new approach for calculations.

2. National circumstances

Land use is defined through its purpose and is characterized by management practices such as logging, ranching, and cropping. Land cover is the actual manifestation of land use (i.e., forest, grassland, and cropland) (IPCC, 2000). Land-Use Change and Land-Cover Change (LUC-LCC) involve several processes that are central to the estimation of climate change and its impacts (Turner et al., 1995). In Lebanon, the status of the land cover/land use has been characterized by a continuous change over the last decades. The lack of land management plans and/or adequate urban regulations has strongly affected the natural and built environment. This has facilitated unplanned urban sprawl at the expense of natural landscapes (MoE/UNDP, 2011).

Human intervention has been strong and it is still making a significant impact on current and future vegetation patterns (FAO, 2011; FAO, 2010). Population growth is a major factor impacting land resources. Urban areas have been growing horizontally at the expense of agriculture fields, forested areas, and other natural areas. 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 (MoE) in cooperation with the National Center for Remote Sensing of the National Council for Scientific Research (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 (Figure 1) and 23 subcategories (Annex I). 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 Council for Development and Reconstruction (CDR) published the national land use master plan for Lebanon. The master plan was approved by the Council of Ministers (CoM) in 2009 (decree 2366 dated 20-06-2009).

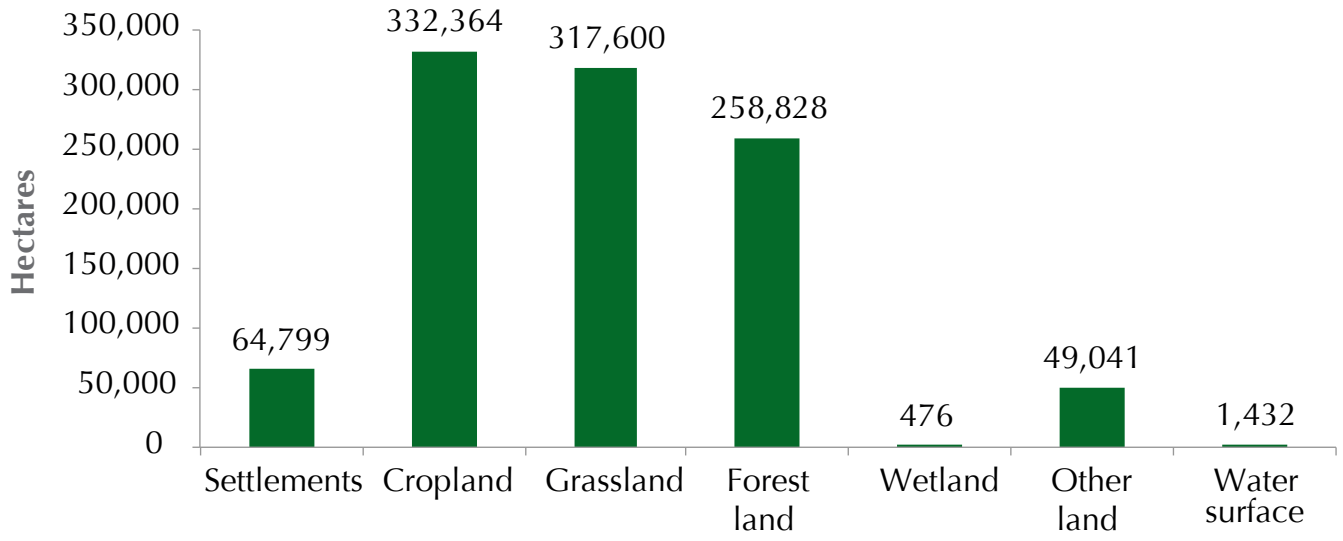


Figure 1: The 1998 land use/land cover categories

The first national Forest Resources Assessment (FRA) was realized in 2005 by the Ministry of Agriculture (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, 2011; FAO, 2010). Broadleaved forests 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, 2011; FAO, 2005).

Increasingly, Lebanon's forests, which include remnants of valuable broad-leaved trees, conifer forests and evergreen trees that cover the Lebanese 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 to Lebanon's forests in recent years, representing one of the most important elements that destroy Lebanon's natural resources. Moreover, the absence of a national forest management strategy and the lack of human and technical resources contribute to the degradation of Lebanon's forests.

The problem of forest fires in Lebanon is complex. It concerns all the aspects related to forest management, prevention, suppression, and post fire management. It is a problem having several authorities involved in this subject from different institutions and a problem of forest policy and legislation, at the administration level, 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 Lebanese 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. Currently, the MoA is in the process of developing a National Forest Plan (NFP) supposed to take into account what has been agreed on in Lebanon's National Strategy for Forest Fire Management (AFDC/MoE, 2009). 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 identity card based on the decision taken by the Presidency of CoM: decision no. 256 dated 01-03-2008. The use of this identity card by involved administrations during post-fire assessment is expected to lead to the unification of information and data. Most recently, the Ministry of Environment (MoE) has started collaboration with the Biodiversity Program (BP), at the Institute of the Environment (IOE), University of Balamand (UOB) to systematically document and analyze fire data with the use of the completed fire identity cards.

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

In an attempt to tackle deforestation and to preserve what is left of natural areas, Lebanon has created, until now, 10 nature reserves, 3 biosphere reserves, 16 protected forests, 16 protected natural sites/landscapes, 4 Ramsar sites, 5 World Heritage Sites (WHS), and 15 Important Bird Areas (IBA) (MoE/UNDP, 2011). Reforestation and afforestation combined with the implementation of Lebanon's National Strategy for Forest Fire Management (AFDC/MoE, 2009) are some of the main activities that can help in maintaining and increasing Lebanon's forest cover. Pioneer reforestation projects have started during the late 1960s and early 1970s. During the past decade, Lebanon has initiated a number of programs/initiatives to restore forested lands. Such programs/initiatives included: 1) the development of the National Reforestation Plan (NRP) by 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 Lebanon Reforestation Initiative (LRI) in 2012 with the support of the International Program of the United States Forest Service (USFS) to provide needed support in large-scale reforestation activities across the country, 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 Non-Governmental Organizations (NGOs).

3. Gaps and constraints identified by INC and SNC

Lebanon's Initial National Communication (INC) (MoE and UNDP, 1999) and the Second National Communication (SNC) (MoE/UNDP/GEF, 2011) have faced a considerable amount of constraints while developing the national estimates of GHG emissions of the LULUCF sector, especially when it comes to the availability of data required for the estimations. Table 1 represents the gaps and needs identified in the INC and SNC in relation to LULUCF.

Table 1: Gaps and needs for the calculation of GHG emissions identified in the INC and SNC

	Initial National Communication	Second National Communication
Gaps	- Lack of information and records of data changes in forestry and other woody biomass stocks at the institutional level - Lack of comprehensive studies of forests - Lack of studies on annual growth rate for fruit trees - Lack of data related to urban trees - Lack of data on illegal forest and grassland conversion to cropland - Lack of quantitative data on the abandoned terraced lands, and systematic monitoring for ecological indicators - Lack of technology and monitoring equipment - Lack of proper data dissemination - Use of rough estimates for forest and tree species type - Use of rough estimates for the number of urban trees - Consideration of only woodland fires as a reason for carbon dioxide (CO_2) emissions under forest/grassland conversion - Use of inconsistent information for terrestrial observations - Use of data for ecological observations that are specific to projects (limited in time and objectives)	- No national monitoring system - Few studies and reports on forestry - Lack of sufficient funding for research - Lack of required equipment - Lack of consistency in data collection - Deficiencies in technical expertise and cooperation between different research bodies - Overlapping mandates of different agencies - Lack of data management systems - Lack of specific emission factors of greenhouse gases

	Initial National Communication	Second National Communication
Needs	- Equipment including installation of gauging stations, monitoring stations, and maintenance of the existing ones - Data dissemination including building database, standardization of reporting procedures, cooperation between public and private sectors, and the use of monthly bulletins	- Modernization and reorganization of climate monitoring services - More availability and better quality of data - Training for individuals and research institutions - Development of growth models for different forest types - Update of forest map to a scale of 1/20,000 showing distribution per forest type - Improvement of access to data and information - Development of systematic observation systems - Development of legal and institutional status - Integration of private, public sectors and international agencies - Capacity building in climate modeling, data handling, operation and maintenance of equipment used - Identification of key indicators and vulnerable areas - Establishment of monitoring system for snow - Centralization of data management - Organization of standardized inventory systems - Establishment of a specialized scientific coordination body - Enhancing terrestrial and ecological systematic monitoring

4. Methodology

4.1. Adopting the IPCC Good Practice Guidance (GPG) for the LULUCF sector

For the first time in Lebanon, the preparation of the LULUCF section of the inventory followed the 2003 IPCC "Good Practice Guidance for Land Use, Land-Use Change and Forestry" (IPCC GPG for LULUCF), which adopts a land use category-based approach to estimate emissions/removals from all land categories and all relevant GHGs.

Adopting IPCC GPG for LULUCF for GHG inventory involved the following steps (Figure 2):

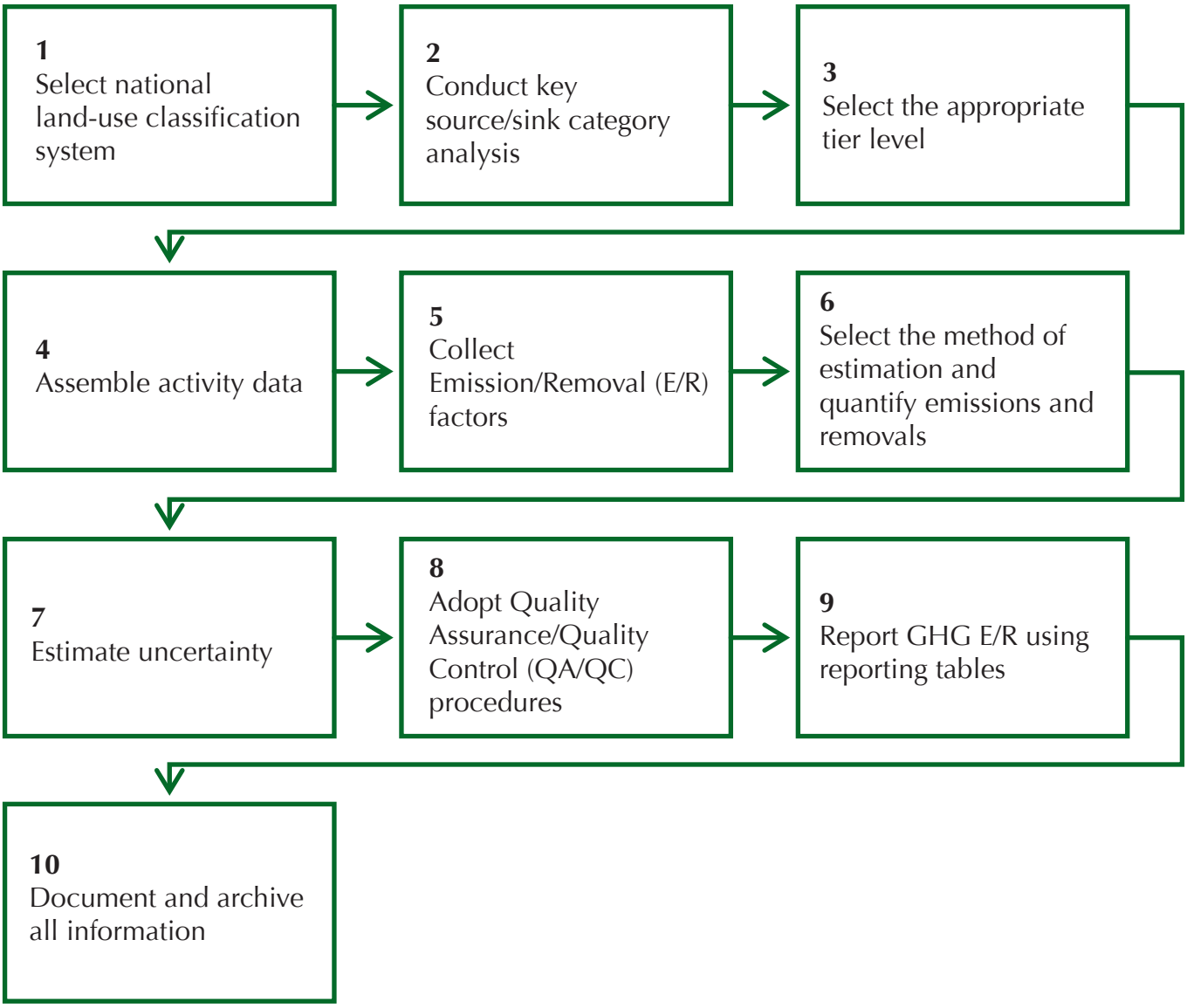


Figure 2: Steps for adopting the IPCC GPG for LULUCF

More specifically, this included the following:

1. The nationally adopted land-use classification system of the land cover/land use map of 1998 was employed for the inventory estimation (Annex I). Each land category was further subdivided into lands remaining in the same land use (for example, forest land remaining forest land) and lands converted into another land-use category (for example, forest land converted into cropland) during the inventory period (IPCC, 2003).

2. The key category analysis recommended by the IPCC GPG for LULUCF is performed to identify those categories that have the greatest contribution to overall inventory uncertainty and thus prioritize efforts to improve their overall estimates. However, this analysis is an iterative process and initial estimates are needed for each subcategory to perform the analysis. Because of the absence of complete and reliable inventory estimation for the LULUCF sector in Lebanon up until now, the analysis was not performed. All the categories and subcategories were accounted for in the inventory estimation depending mainly on the data availability about each land use category (Table 2).

3. Selection of the appropriate tier level for the land categories and subcategories, non-CO_2 gases and carbon pools, was mostly based on the resources available for the inventory process. Tiers correspond to a progression from the use of simple equations with default data to country-specific data in more complex national systems. The tier 1 approach, which employs the basic method and the default emission factors provided in the IPCC guidelines, was typically used in these inventory calculations. Tier 2 uses the same methodological approach as tier 1 but applies emission factors and activity data which are defined by the country. Tier 2 was applied in some cases when country-specific emission factors and activity data were available from literature or through surveys. Tier 3 approach uses higher order methods including models and inventory measurement systems. Tier 3 was only used for the selection of activity data in conjunction with approach 3 when possible.

4. The required activity data were gathered for the inventory years 1994 up until 2012 depending on the tier selected (tier 1, tier 2 or tier 3). The representation of most land-use areas and land conversions however, was done following the approach 3 which is a tier 3 level methodology used in the selection of activity data. It is the most complex, accurate and spatially explicit method, provided by the IPCC GPG for LULUCF, which ensured the consistency of the inventory calculations. The tier levels of the activity data acquired by surveys and personal communications depended on the accuracy and completeness of the nationally available estimates.

5. The sources of emission/removal factors for the years 1994 up until 2012 included regional, national and global databases, forest inventories, national GHG inventory studies and surveys, and use of the Emission Factors Database (EFDB) default values provided by the IPCC.

6. Appropriate equations were used to quantify the emissions and removals, and default worksheets provided in IPCC GPG for LULUCF (IPCC, 2003) were adopted.

7. The uncertainty assessment was conducted by using default uncertainty values from the IPCC GPG for LULUCF and values from published sources for country-specific data.

8. Quality Control (QC) procedures were adopted to ensure data integrity, correctness and completeness, in addition to identifying errors and omissions.

9. GHG emissions and removals were reported using the UNFCCC reporting tables.

10. Documentation and archiving was conducted for all information used to produce the inventory, including all activity data, emission/removal factors, sources of data (Table 3), methods used and QC procedures adopted for different land categories and management systems, and carbon pools and non-CO_2 gases.

Table 2: Land use categories and subcategories, carbon pools and non-CO_2 gases accounted for in the inventory estimation of the LULUCF sector in Lebanon

Categories	Subcategories	Estimations calculated[1]	No activity data available	Estimations not required for calculation[2]
Forest land	Forest land remaining forest land	x		
	Land converted to forest land	x		
Cropland	Cropland remaining cropland	x		
	Land converted to cropland		x	
Grassland	Grassland remaining grassland	x		
	Land converted to grassland		x	
Wetland	Wetland remaining wetland			x
	Land converted to wetland	x		
Settlements	Settlement remaining settlement			x
	Land converted to settlements	x		

[1] Estimations are calculated for the following carbon pools and non-CO_2 gases depending on data availability: Above-Ground Biomass (AGB), Below-Ground Biomass (BGB), Dead Organic Matter (DOM), litter and soil carbon, methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and nitrogen oxides (NO_x).

[2] Lebanon is considered as a Non-Annex I party in the UNFCCC.

4.2. Data collection

Data collection for the inventory years 1994-2012 was conducted using satellite remote sensing and Geographic Information System (GIS) techniques, literature reviews, and surveys. Table 3 represents the type of data sources and databases used in the data collection process.

Table 3: Type of data sources and databases used for data collection

Type of data source	Databases
Online database, global databases	Food and Agriculture Organization Statistics (FAOSTAT), EFDB, Google Earth
Scientific articles and papers	Altas et al. (2007) Aksu et al. (2001) Gerard, J. A. (2009) Mitri et al. (2012) TRAGSA (2012) Darwish, T., and Faour, G. (2008) AFED (2010) Hreiche, A. (2009) IPCC (2003)
National reports	FAO (2005) FAO (2010)
Satellite imagery	5 SPOT imagery (2.5 m) 30 Landsat TM and ETM+ imagery (25 m)
Maps	Land cover/land use map of Lebanon of 1998 Annual rainfall map Fertility and pedology maps of Lebanon (scale 1/200,000) Digital Elevation Model (DEM) of Lebanon (25 m)
Surveys and personal communications	Mr. Elie Chneis (Association for Forest, Development and Conservation (AFDC)) Mr. Jean Stephan (MoA) Dr. Talal Darwish (CNRS) Mr. Joseph Bechara (LRI) Mr. Garo Haroutunian (MoE) Mr. Raymond Khoury (Greenplan)

4.2.1. Activity data

Collection and calculation of the activity data (Annex II) was conducted following three methodologies depending on the availability and type of country-specific data:

- Approach 3 within IPCC GPG
- Surveys and personal communications
- Extrapolations and interpolations

The top-level land categories which were considered in the change detection mapping using approach 3 (based on the IPCC GPG for LULUCF) were the following (IPCC, 2003): forest land (F), cropland (C), grassland (G), wetland (W), settlements (S) and other land (O). The definitions for these categories according to the national classification system based on the land cover/land use map of 1998 are listed in Annex I. The abbreviations FF, GG, CC, WW, SS, OO denoted land-use categories undergoing no conversions; and the abbreviations LF, LG, LC, LW, LS, LO denoted land conversions to these land-use categories:

FF	Forest Land remaining Forest Land	LF	Lands converted to Forest Land
GG	Grassland remaining Grassland	LG	Lands converted to Grassland
CC	Cropland remaining Cropland	LC	Lands converted to Cropland
WW	Wetland remaining Wetland	LW	Lands converted to Wetland
SS	Settlements remaining Settlements	LS	Lands converted to Settlements
OO	Other Land remaining Other Land	LO	Lands converted to Other Land

The approach 3 methodology allowed the generation of data about land use changes such as forest, cropland and grassland conversions to settlements as well as the extent of burned areas in forest, cropland and grassland.

It is to be noted that satellite images from the years 1993, 1994, 1995, 1996, 1997, 2001, and 2009 were not used due to lack of high quality images (e.g. low cloud coverage, non-extensive shaded areas, etc.). The inventory year 1998 was considered a reference year and the areas extracted from the land cover/land use map of 1998 were considered as reference values. It was assumed that no land use changes happened in the year 1998.

As it was not possible to generate all the activity data using approach 3 due to the limited use of satellite data, surveys and personal communications were conducted which revealed a significant data gap in the LULUCF sector in Lebanon. Accordingly, it was only possible to gather data about lands converted to forests through communication with the MoA, the MoE, the Association for Forest Development and Conservation (AFDC), and the LRI (Annex II) for the period 1999-2012.

As there is no data available for the period 1994-1997 using approach 3, the land use Forest Land remaining Forest Land (FF), Grassland remaining Grassland (GG), Cropland remaining Cropland (CC) and land use change, Land converted to Settlements (LS), areas for these inventory years were generated by extrapolation of the trend over time (1999-2012) in order to keep the consistency of the time series. However, the trend was not constant for the burned areas and for the afforestation areas, Land converted to Forest Land (LF); therefore linear extrapolation could not be used for these subcategories. In addition, the lack of surrogate data resulted in gaps for the period 1994-1997 in comparison with the period of 1999-2012. Accordingly, the extent of burned areas and afforested areas were not estimated for the period 1994-1997. Areas of land converted to settlement were interpolated for the years 2001 and 2009 due to lack of good quality satellite imagery on those years.

4.2.2. Emission/Removal (E/R) factors

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

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

A complete list of the E/R factors investigated and reported in the UNFCCC reporting tables for the calculation of GHG emissions and removals from 1994-2012 was provided in Annex III.

E/R factors were collected or calculated (by averages and extrapolations) for each category depending on the disaggregation level required by the GHG emission/removal calculation method and depending on the data availability (Table 4 and Annex III). Detailed calculations, values and sources of all the E/R factors were reported and documented in the UNFCCC reporting tables.

Table 4: Land use categories and required disaggregation levels*

Land use categories	Disaggregation levels
Forest land	- Broadleaf (including shrub lands and woody perennials) - Coniferous - Mixed
Cropland	- Annual - Perennial
Grassland	- Grasses (excluding woody perennials)
Wetland	- Flooded areas (artificial reservoirs and hill lakes)
Settlement	No disaggregation is required
Other land	No disaggregation is required
Burned areas (forest land and grassland)	- Fuel type 1 - Fuel type 2 - Fuel type 3 - Fuel type 4 - Fuel type 5 - Fuel type 6 and 7

* See Annex I

4.3. Uncertainty assessment

This assessment considers source-specific uncertainties relevant to inventory estimates made for each land category. In this work, the following types of uncertainties were identified and combined to estimate the overall uncertainty of the inventory:

- Uncertainties associated with activity data
- Uncertainties associated with emission factors from published references

Results indicated that the overall uncertainty of the LULUCF sector estimations over the inventory period (1994-2012) varied between 47% and 55%.

The uncertainty associated with activity data was derived from the accuracy assessment of the approach 3 methodology. The overall classification accuracy of the change detection mapping between 2003 and 2004 was found to be 85%, while the Kappa Index of Agreement (KIA) was 0.82. As for the classification accuracy of 2007-2008 the overall classification accuracy was found to be 88%, while the KIA was 0.85. It is to be noted that a kappa value closer to 1 indicates better agreement, whereas a kappa closer to 0 indicates agreement closer or equivalent to chance. Overall, the average accuracy of the change detection model was found to be highly accurate (86%). This is equivalent to 14% uncertainty for the activity data generated using approach 3.

The uncertainties of the activity data collected through surveys were associated with the relevant agencies' data quality. As the data have not been already assessed as part of the data collection procedures of these agencies, it was not possible to quantify the uncertainty of this type of data. In addition, extrapolation errors estimation was not accounted for in the IPCC Guidelines. Therefore, those types of uncertainties were not included in the calculation of the uncertainty associated with activity data.

Alternatively, identified uncertainties associated with E/R factors ranged between 2% and 200% depending on the published sources from which they were derived (Annex IV).

Consequently, the overall uncertainty of the LULUCF sector over the inventory period (1994-2012) was improved after the combination of E/R and activity data uncertainties. This improvement is due to the use of approach 3 which is the most precise and accurate method for collection of activity data proposed by the IPCC Guidelines.

5. Results and discussion

5.1. GHG inventory for the years 1994 up to 2012

The summary GHG emissions from the LULUCF sector (Table 5) showed the total CO_2 and non-CO_2 emissions/removals in Gg CO_2 equivalent. The Global Warming Potential (GWP) values were used as provided by the IPCC in its Second Assessment Report (SAR) and based on the effects of greenhouse gases over a 100-year time horizon. Accordingly, the 1995 IPCC GWP values were 1 for CO_2, 21 for CH_4, and 310 for N_2O.

The new available data and more accurate methodology allowed the recalculation of the estimates for the period of 1994-2004. 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 the SNC which used rough estimates from global and national databases and literature reviews.

Table 5: Lebanon's GHG E/R summary from the LULUCF sector for the period 1994-2012

GHG emissions/removals of the LULUCF sector	1994*	1995*	1996*	1997*	1998*	1999	2000	2001	2002	2003
CO_2 (Gg)	-3,450.84	-3,448.44	-3,445.99	-3,443.52	-3,496.71	-3,166.11	-3,221.29	-3,430.78	-3,437.74	-3,335.91
CH_4 (Gg)	NE*	NE	NE	NE	NE	0.10	0.03	0.01	0.01	0.03
CH_4 (Gg CO_2eq.)	NE	NE	NE	NE	NE	2.05	0.57	0.16	0.16	0.54
N_2O (Gg)	NE	NE	NE	NE	NE	0.00	0.00	0.00	0.00	0.00
N_2O (Gg CO_2eq.)	NE	NE	NE	NE	NE	0.38	0.11	0.04	0.04	0.13
NO_x (Gg)	NE	NE	NE	NE	NE	0.01	0.00	0.00	0.00	0.01
CO (Gg)	NE	NE	NE	NE	NE	1.45	0.41	0.14	0.14	0.45
Total emissions (Gg CO_2eq.)	NE	NE	NE	NE	NE	2.43	0.68	0.20	0.20	0.67
Total removals (Gg CO_2)	-3,450.84	-3,448.44	-3,445.99	-3,443.52	-3,496.71	-3,166.11	-3,221.29	-3,430.78	-3,437.74	-3,335.91
Net GHG removals (Gg CO_2eq.)	**-3,450.84**	**-3,448.44**	**-3,445.99**	**-3,443.52**	**-3,496.71**	**-3,163.68**	**-3,220.61**	**-3,430.58**	**-3,437.54**	**-3,335.24**

GHG emissions/removals of the LULUCF sector	2004	2005	2006	2007	2008	2009	2010	2011	2012
CO_2 (Gg)	-3,412.07	-3,303.30	-3,208.47	-3,345.54	-3,305.91	-3,217.35	-3,218.00	-3,200.79	-3,036.90
CH_4 (Gg)	0.01	0.04	0.10	0.06	0.00	0.04	0.04	0.01	0.05
CH_4 (Gg CO_2eq.)	0.12	0.74	2.17	1.19	0.05	0.81	0.81	0.31	1.06
N_2O (Gg)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N_2O (Gg CO_2eq.)	0.03	0.14	0.44	0.24	0.01	0.16	0.16	0.07	0.20
NO_x (Gg)	0.00	0.00	0.02	0.01	0.00	0.01	0.01	0.00	0.01
CO (Gg)	0.10	0.52	1.61	0.82	0.03	0.59	0.59	0.24	0.76
Total emissions (Gg CO_2eq.)	0.15	0.88	2.61	1.43	0.06	0.97	0.97	0.38	1.26
Total removals (Gg CO_2)	-3,412.07	-3,303.30	-3,208.47	-3,345.54	-3,305.91	-3,217.35	-3,218.00	-3,200.79	-3,036.90
Net GHG removals (Gg CO_2eq.)	**-3,411.92**	**-3,302.42**	**-3,205.86**	**-3,344.10**	**-3,305.85**	**-3,216.38**	**-3,217.03**	**-3,200.41**	**-3,035.64**

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

The net CO_2 emissions/removals from the LULUCF sector (Figure 3) shows that forests were important sinks of GHG in Lebanon at the beginning of the inventory period. The changes in forest and vegetation covers at the end of the inventory period (2012) resulted in about 12% (21.8 Gg CO_2eq./year) decrease in CO_2 removals from the LULUCF sector in comparison to the beginning of the inventory period (1994). This decrease is due to an increasing trend in land conversion to settlements equivalent to a decrease in CO_2 removals and to an increasing trend in burned areas equivalent to an increase in CO_2 emissions, given that decrease in removals from fuelwood gathering is quite constant (Figure 4).

Figure 4 shows the CO_2 emissions/removals resulting from the identified changes in the land cover/land use areas and the changes in management activities in the LULUCF sector in Lebanon.

Figure 3: Net CO_2 emissions/removals from LULUCF sector for the period 1994-2012

The changes in land cover/land use resulted in gains and losses in biomass and carbon stocks in soils and litter. The comparison of emissions and removals shows 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) (Figure 4). Although net emissions/removals proved that the LULUCF sector is a major sink, emissions from changes in the LULUCF sector were still high and could not be compensated by the afforestation activities.

GHG emissions and removals reported from the LULUCF sector in Lebanon are respectively caused by biomass losses and increments and by variation in soil carbon stocks from the different land use and land-use change categories which were taken into consideration in this report (Table 6).

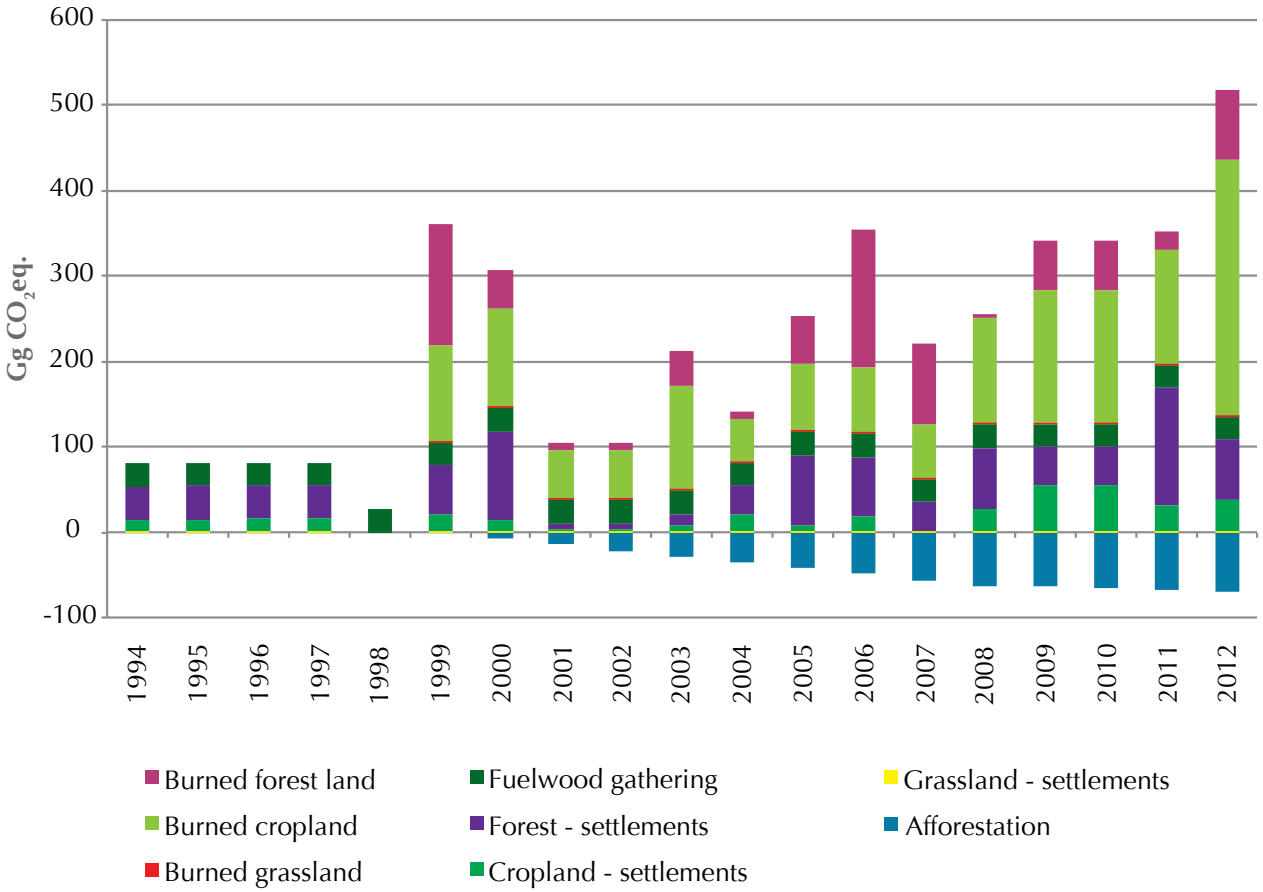


Figure 4: CO_2 emissions/removals from the changes in the LULUCF sector

Table 6: Causes of GHG emissions and removals reported for the LULUCF sector in Lebanon

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

5.2. Changes in CO_2 removals

As previously reported, the land use (FF, GG, CC) and land-use change (LS) areas for the inventory years 1994-1997 were generated by extrapolation of the trend over time (1999-2012) due to lack of data using approach 3.

In general, it was observed that the changes in CO_2 removals over the inventory period (1994-2012) were mainly attributed to the decrease/increase in vegetation cover within forest lands, cropland, and grassland.

For instance, areas of lands converted to settlements varied between 91 ha in 2001 and about 1,200 ha in 2011 (Figure 5). It is important to note that the reported numbers of annual conversion to settlement accounted only for the annual sum of any conversion that is above 90 m^2. This is mainly due to the spatial resolution of the employed satellite imagery. Counting the changes that are below 90 m^2 can slightly increase the total areas of conversion to settlement. In general, variations in areas of land converted to settlement might be related to a number of factors including the active market of the real estate sector, the quality of the image classification results, and the general socio-economic situation, among others. In addition, such types of changes might be related to certain policies and public plans contributing to changes in these lands (e.g. expansion and improvement of the road networks, development of areas of public and private services).

However, it is to be noted that the relatively small area reported in 2001 might be mainly related to underestimation through interpolation (as previously stated the 2001 satellite imagery was not used due to low quality of data). On the other hand, the reported small areas of conversion in 2002 and 2007 might be mainly related to the characteristics and inherent conditions (e.g. shades, sun illumination) of the employed satellite imagery that were acquired on those years.

The spatial distribution per Caza of the total lands converted to settlements between 1998 and 2012 were represented in maps (Annex V). Accordingly, it was observed that the highest rates of forest land conversion to settlement were recorded for the Cazas of Jbeil, Kesrouane, Matn, and Sour (>300 ha), followed by Aaley, Chouf, Aakkar, and Bent Jbeil (between 200 and 300 ha). The highest rates of cropland conversion to settlement were recorded for the Cazas of Baalbeck and Beqaa El Gharbi (750 to 1,500 ha), followed by Zahle (500 to 750 ha). As for grassland, the highest rates of conversion to settlement were attributed to Aakkar and Baalbeck.

It was observed that broadleaf forests were the most affected by this type of conversions (Figure 6). This might be due to the large extent of broadleaf forests in the country and the fact that urbanization most likely occurs more on shrubland (mostly broadleaf vegetation) than on forested areas.

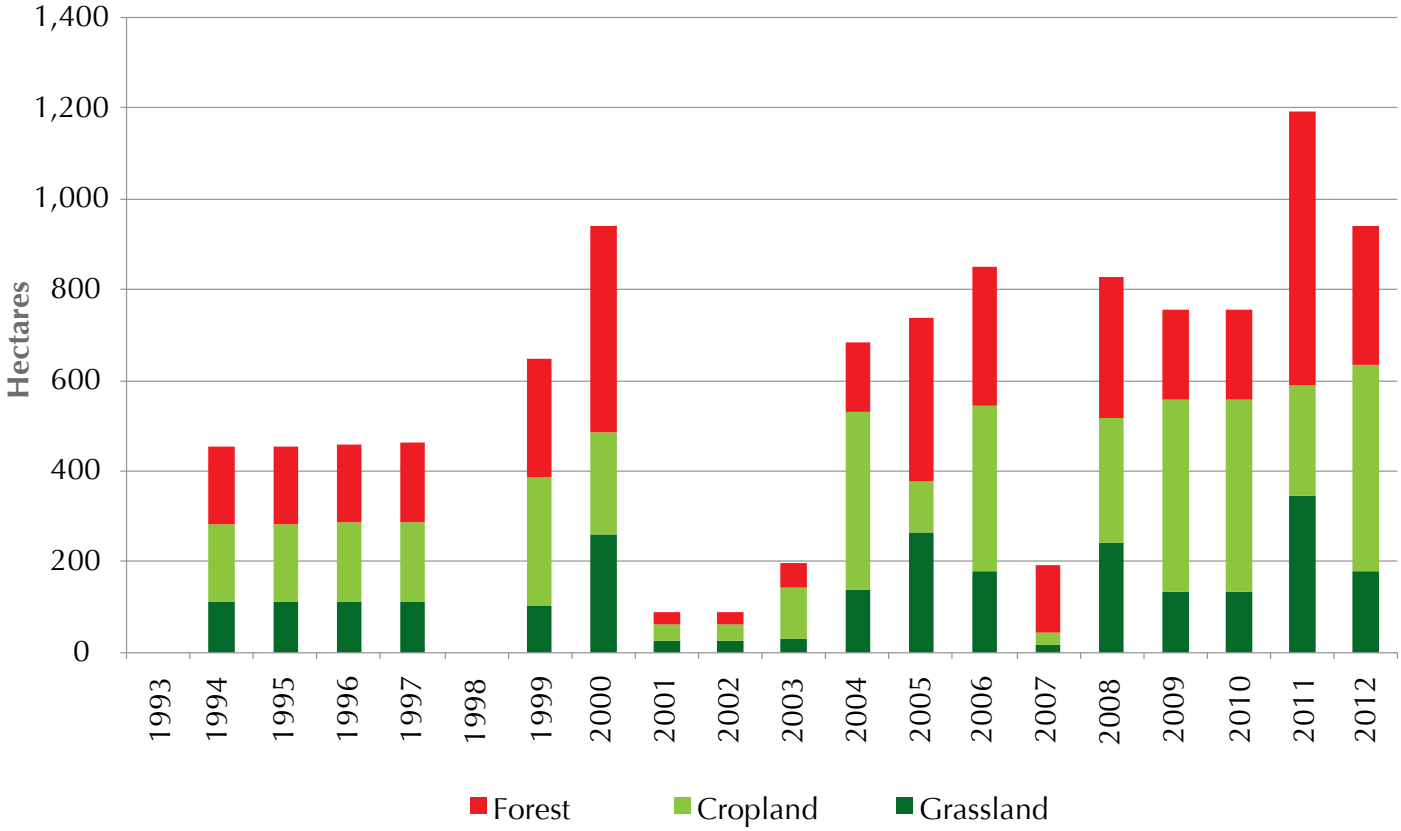


Figure 5: Areas of land categories converted to settlements

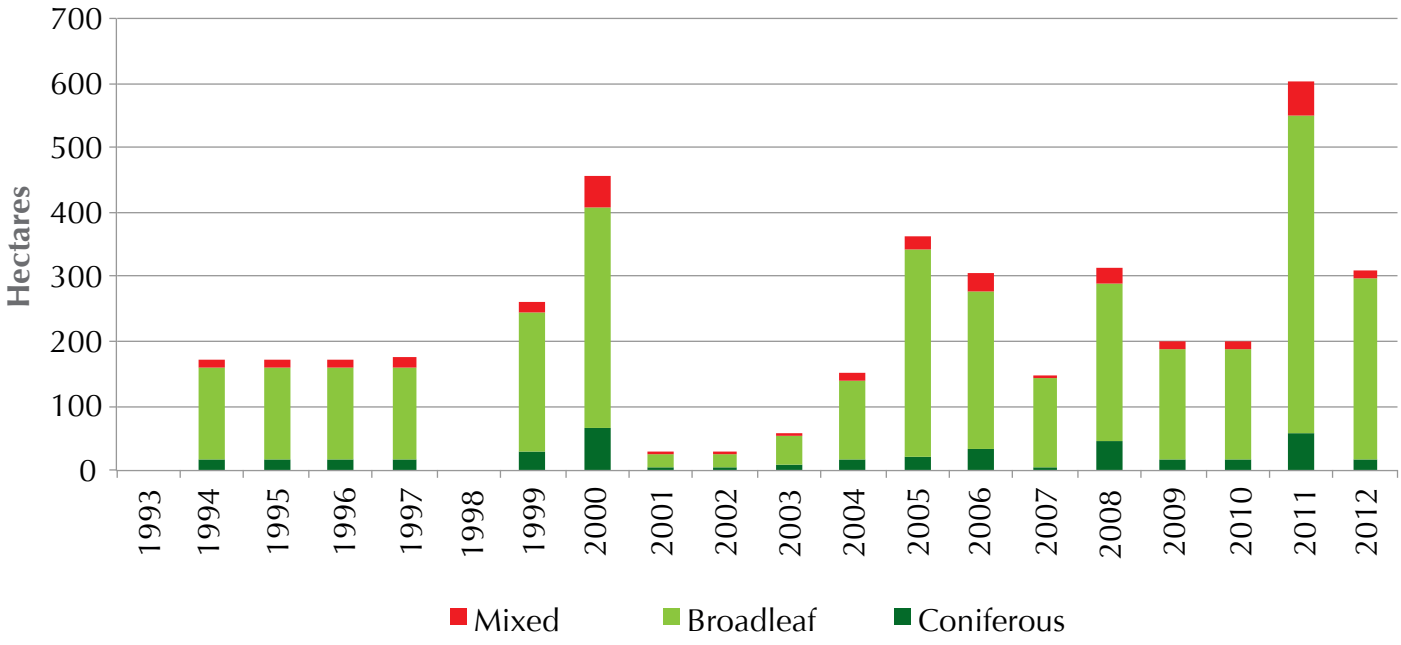


Figure 6: Areas of forest lands converted to settlements by subcategory

Conversions to settlements have also had an increasingly negative effect on cropland and grassland as shown in Figure 7 and Figure 8. It is usually easier and more beneficial to convert annual crops than to remove perennial crops (mainly comprising of fruit trees and orchards). Conversions of cropland and grassland to settlements might be related to the lack of interest of owners in keeping such type of lands (e.g. increase in land prices related to an increasing number of population, increasing demand for development projects), high costs of labors and lack of a market for the agricultural products, and degrading financial situation of citizens (selling agricultural lands and grassland which were eventually converted to urbanized areas). This has been at least confirmed for artificialized cropland on the Lebanese coast (UNEP/MoE, 2013).

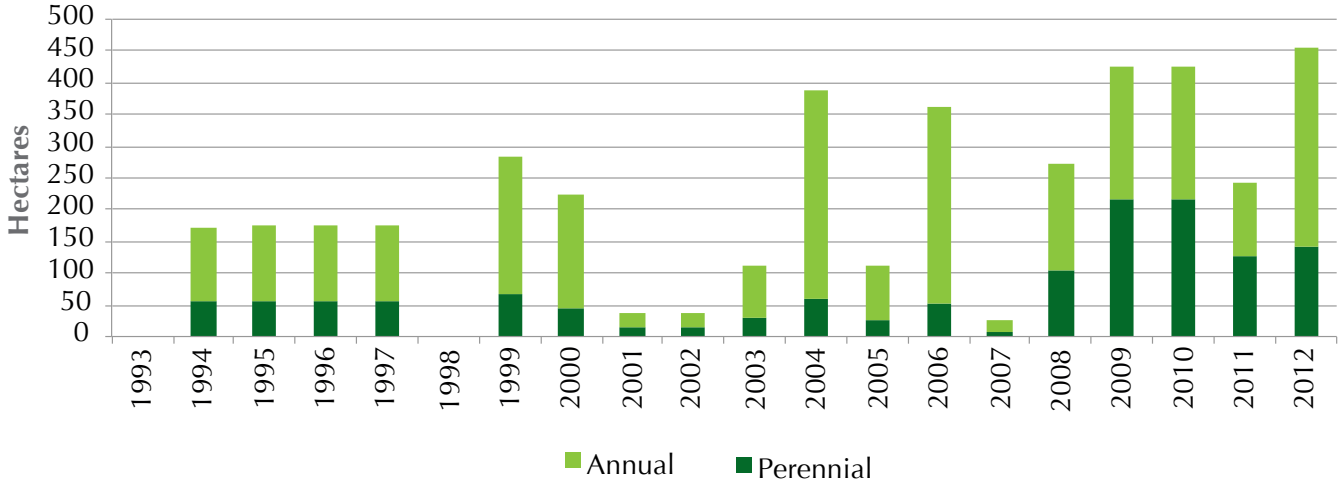


Figure 7: Areas of cropland converted to settlements by subcategory

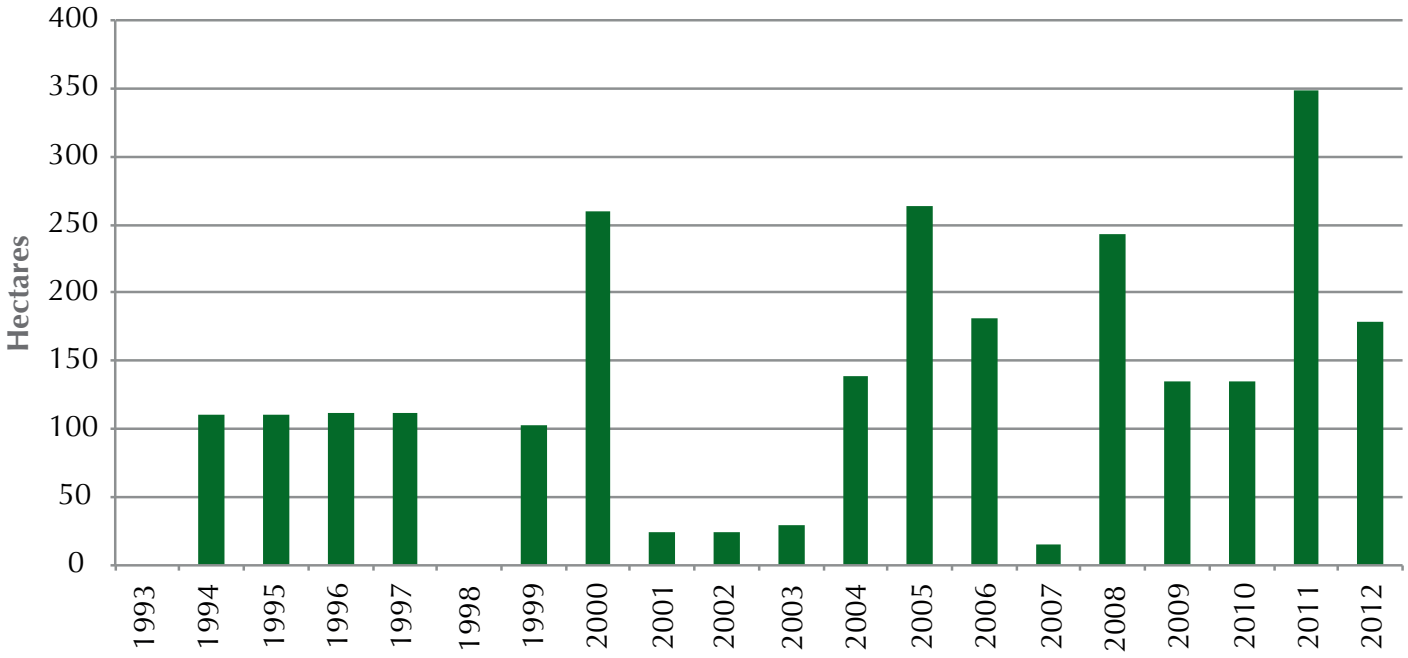


Figure 8: Areas of grassland converted to settlements

Activity data from land conversions

Decrease in CO_2 removals caused by land conversions to settlements nearly doubled between 1994 and 2012. The highest decrease in removals recorded was in 2011 with a total of about 170 Gg/year (Figure 9).

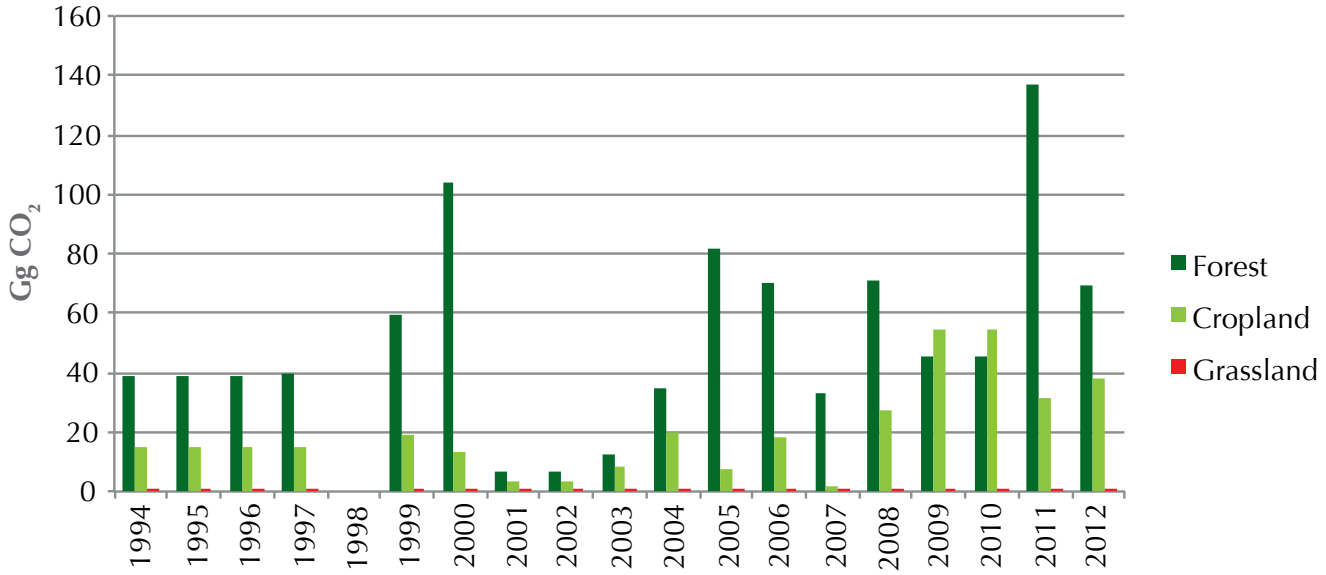


Figure 9: Decrease in CO_2 removals due to biomass losses from lands converted to settlements

Fuelwood gathering is another cause of decrease in vegetation from forest lands. Estimates for fuelwood gathering were quite constant over the inventory time period resulting in an average CO_2 emission of about 27 Gg/year (Figure 10 and Figure 11).

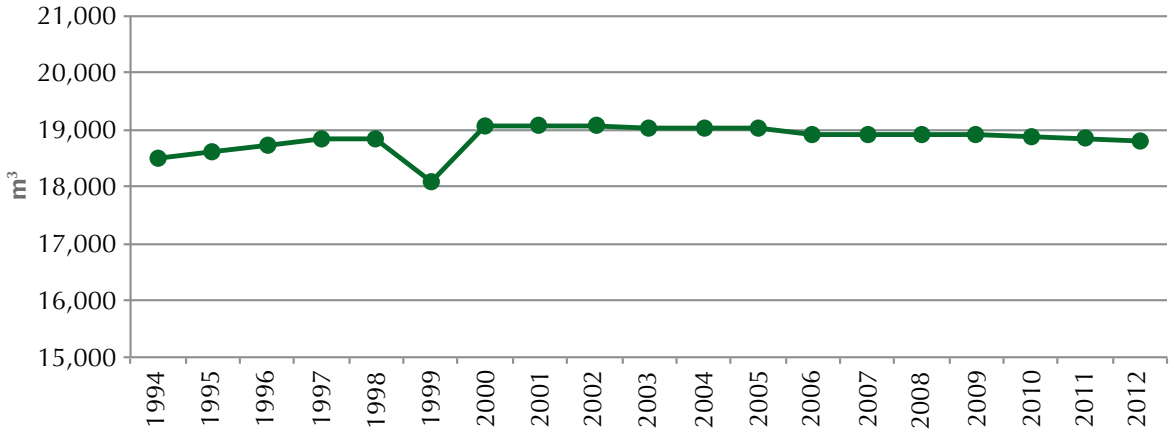


Figure 10: Volumes of fuelwood gathering

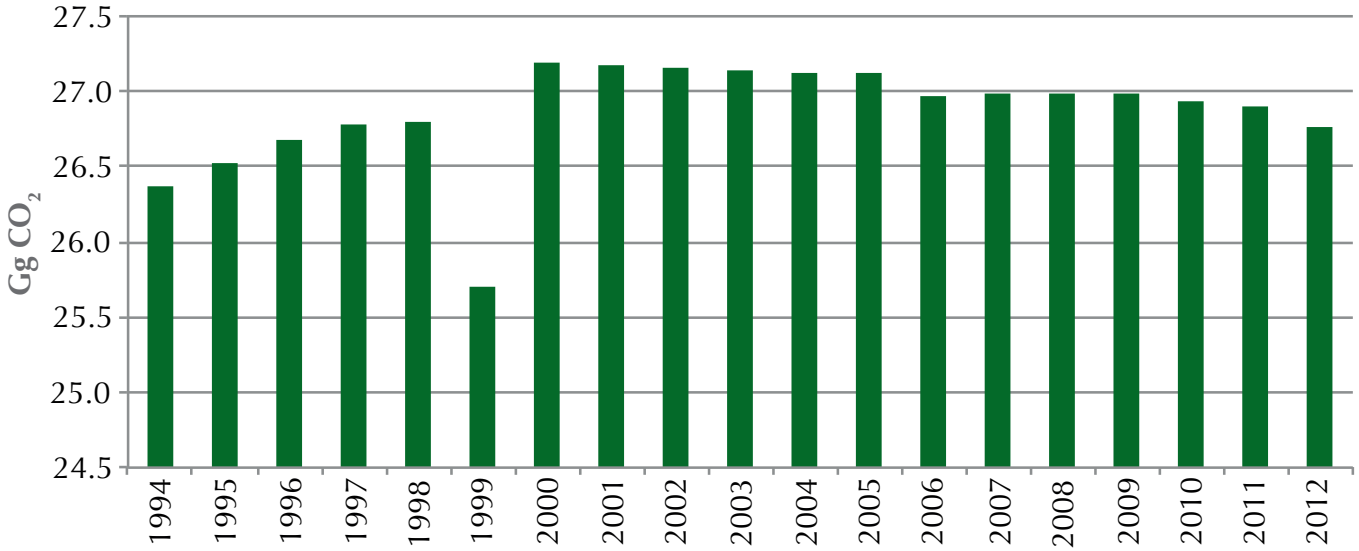


Figure 11: Decrease in CO_2 removals from fuelwood gathering

Moreover, a decrease of about 1.55% in existing forest lands due to urbanization was shown between 1994 and 2012 (Figure 12). These losses in biomass resulted in a decrease in CO_2 removals by 1.95 Gg/year from the forested areas (Figure 13).

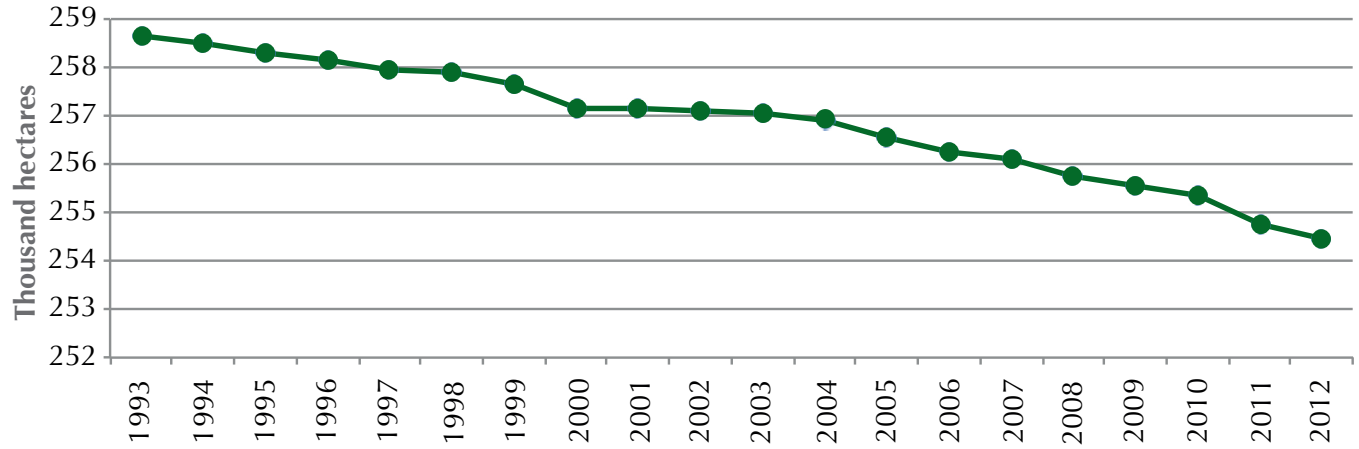


Figure 12: Forest lands remaining forest lands over the inventory period (1994-2012)

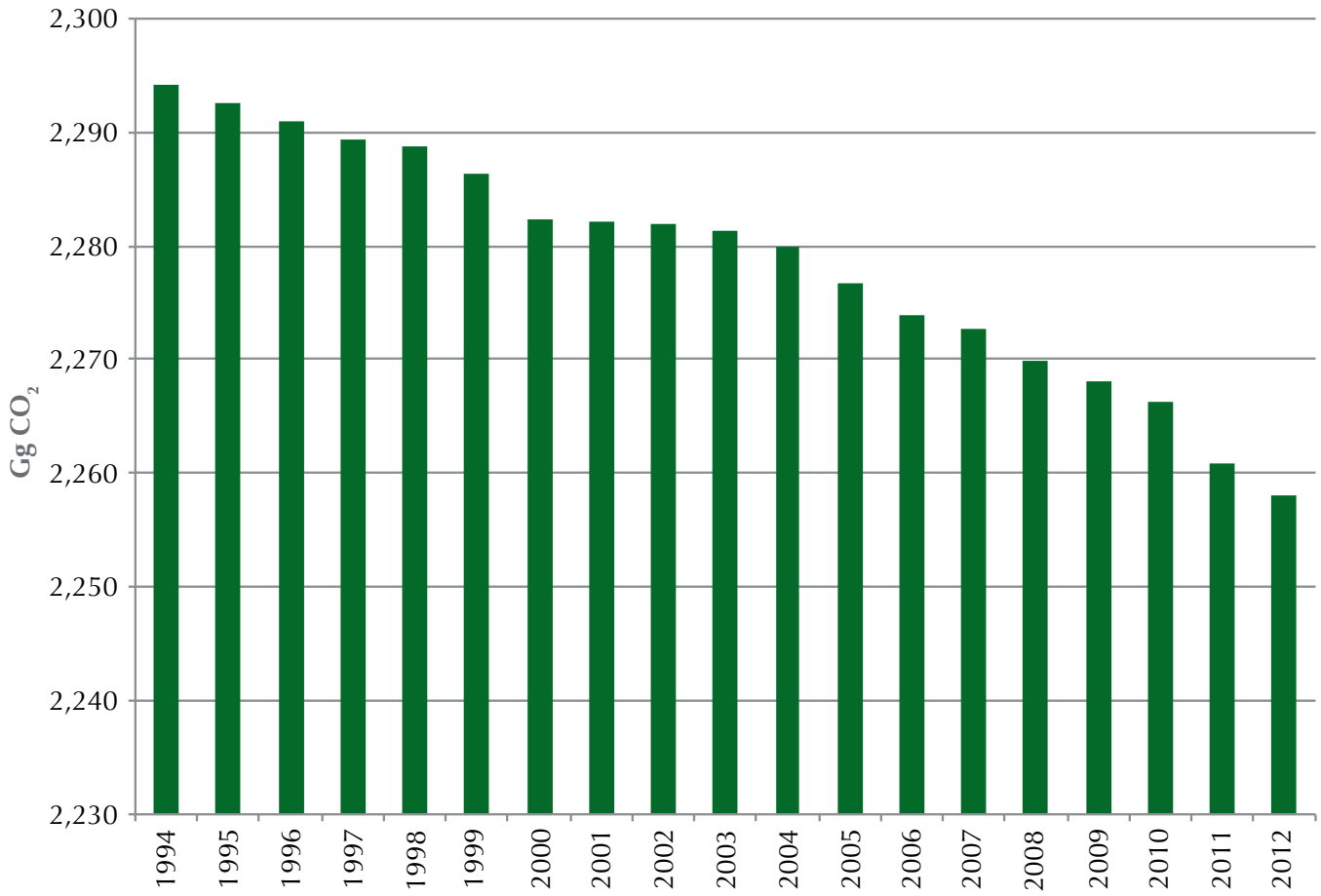


Figure 13: CO_2 removals due to biomass increments from existing forest lands

Also, afforestation activities (Figure 14 and Figure 15) resulted in an average increase in CO_2 removal by 5.11 Gg/year between 1999 and 2012 (Figure 16). The decrease in afforested areas after 2007 might be related to changes in certain reforestation policies especially after the 2007 fires. More efforts have been put to manage wildfire risk (e.g. the development of Lebanon's National Strategy for Forest Fire Management (AFDC/MoE, 2009) and the launching of the operations room at the directorate of the civil defense). Also, many reforestation activities were interrupted after the July 2006 war and reforestation contracts were subsequently terminated. In parallel to a gap of sustained reforestation activities observed between 2008 and 2011, the MoE resumed work on the NRP in 2009 through the project "Safeguarding and Restoring Lebanon's Woodland Resources" and signed in 2010 around 41 reforestation agreements worth USD 1.3 million and covering 185 ha. Also, the United States Forest Service (USFS) launched in 2010 a five-year and USD 12 million Lebanon Reforestation Initiative (LRI). This has possibly contributed to an increase in afforested areas starting 2012.

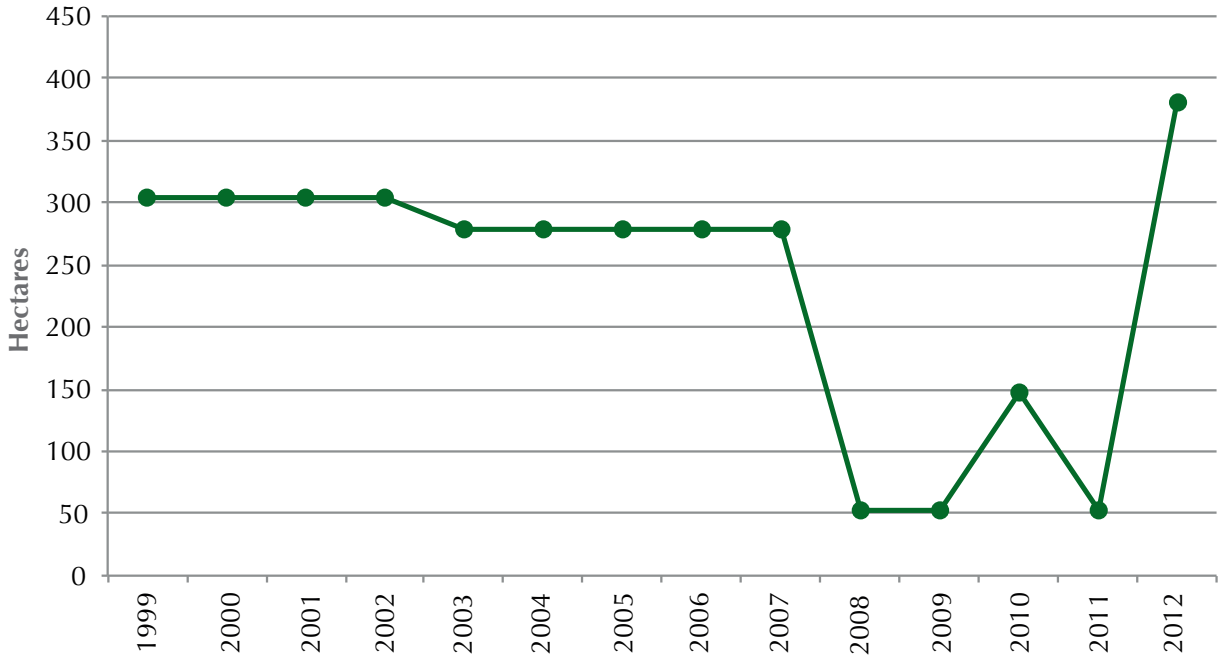


Figure 14: Afforestation areas per year

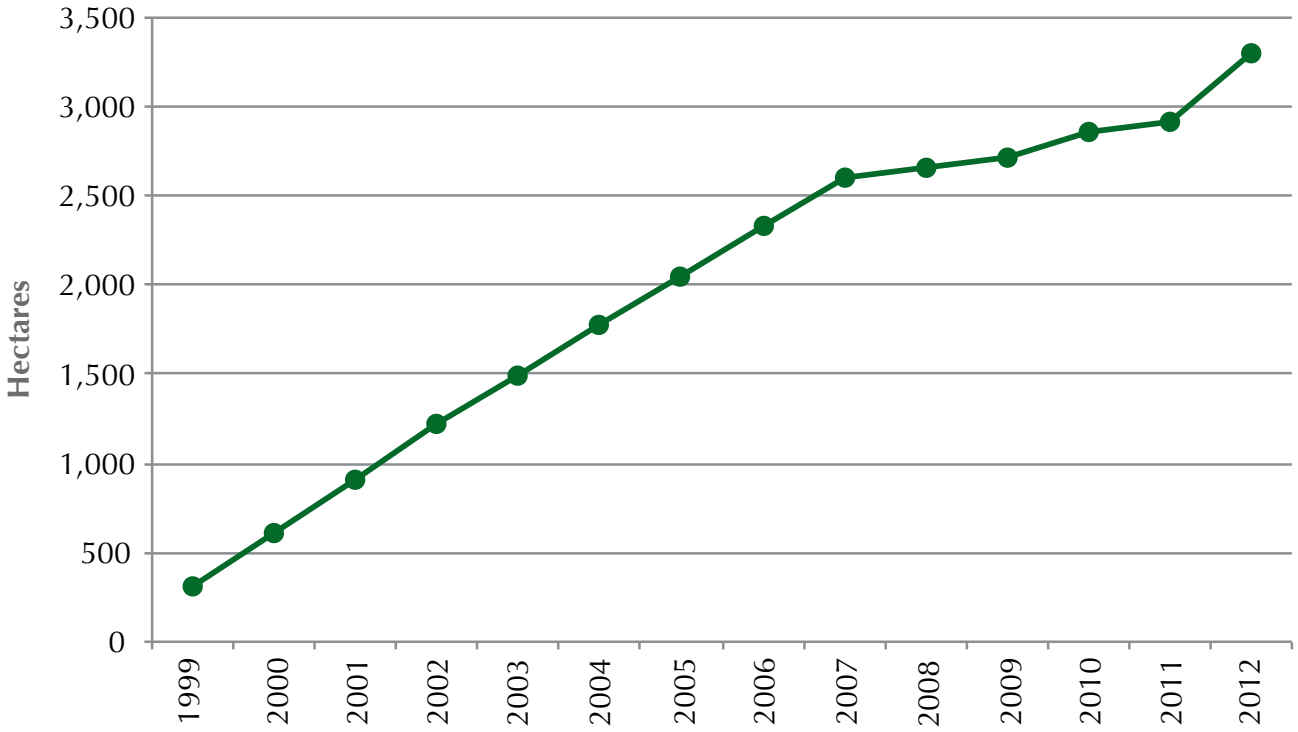


Figure 15: Cumulative lands converted to forests over the inventory period

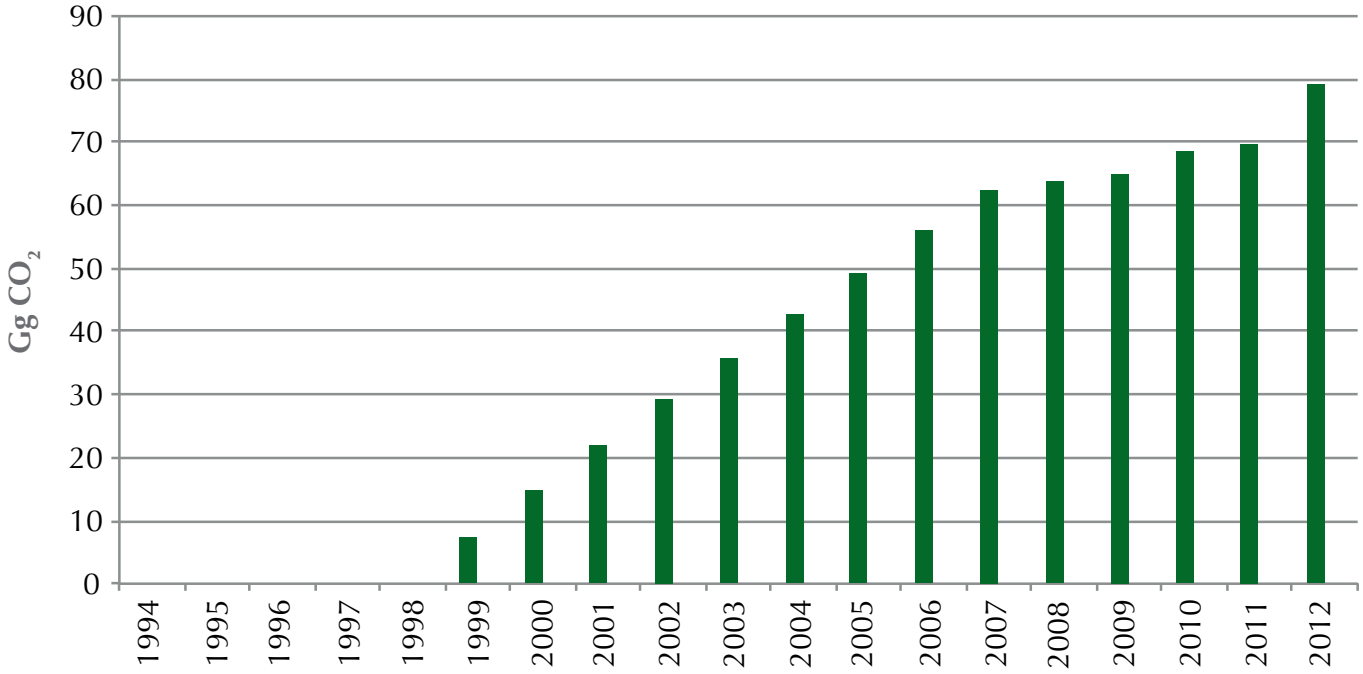


Figure 16: CO_2 removals due to biomass increments and increase in soil carbon stocks from afforestation

Furthermore, the decline in cropland areas covered with perennial woody crops (Figure 17) resulted in the decrease of CO_2 removals by 1.7% from 1994 to 2012 with an average rate of 1.1 Gg/year (Figure 18).

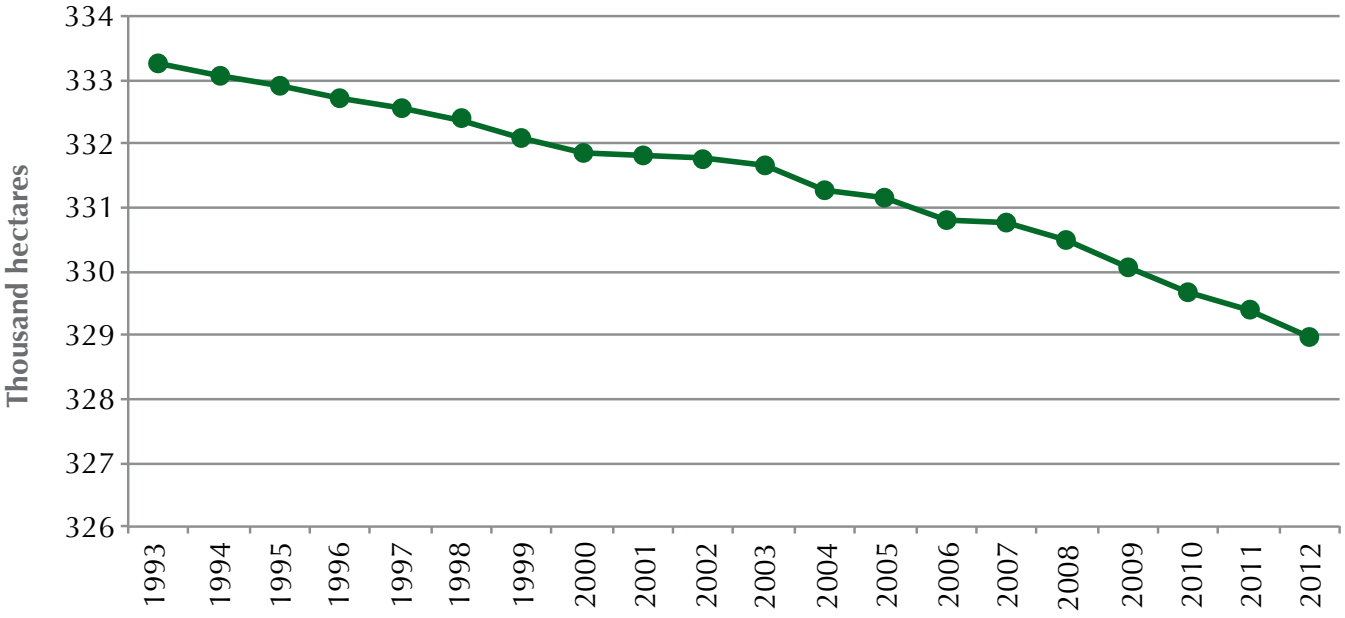


Figure 17: Areas of perennial woody cropland remaining cropland over the inventory period

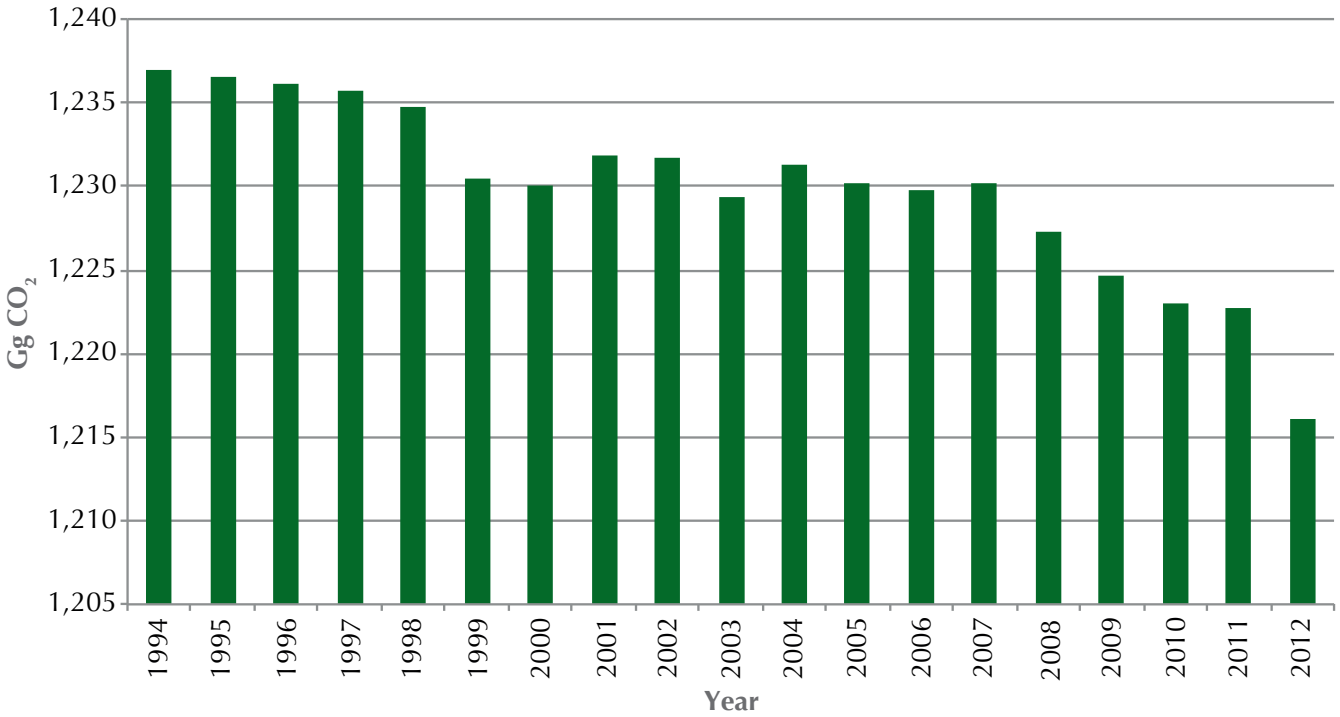


Figure 18: CO_2 removals due to biomass increments from perennial woody crops

5.3. Changes in CO_2 emissions

Again, as previously stated, the lack of data derived from satellite imagery and surrogate data of burned areas for the period 1994-1997 resulted in gaps about emission estimation in comparison with the period of 1999-2012. The main source of GHG emissions are wildfires affecting forest land, cropland and grassland. It can be observed that the fire affected area was highly variable for the last decade. A large trend of inter-annual variability of fire extent was recorded between 1999 and 2012, with three clear peaks in 1999, 2006 and 2012 (Figure 19). More specifically, the largest forest fire affected areas were recorded in 2006 (~1,197 ha), while the largest cropland fire affected areas were recorded in 2012 (~1,305 ha).

The spatial distribution per Caza of the total burned areas between 1998 and 2012 was also represented in maps (Annex V). Accordingly, the highest rates of burned forest land were recorded in the Cazas of Aakkar, Aaley, and Sour (>600 ha), followed by the Cazas of Chouf, Beqaa El Gharbi, and Bent Jbeil (between 400 and 600 ha). In addition, the highest rates of burned perennial cropland were recorded for the Caza of Zahle (> 4,000 ha), followed by the Caza of Beqaa El Gharbi (between 1,500 and 4,000 ha).

The peaks in the extent of fire affected areas might be related to the remarkable extent of drought conditions for those years which significantly contributed to water stress in the vegetation cover. This allows a larger fire spread across the vegetated landscape.

In a recent study conducted by Salloum and Mitri (2013), it was found that the length of the fire season has been increasing on an average of 5.2 days during the past decade. Fire occurrence was positively correlated with mean monthly temperatures, and the length of the fire season was negatively correlated with mean annual precipitation. In addition, an increasing fire occurrence risk was observed in association with high maximum temperatures and long dry seasons.

The 2006 July war might have contributed to increasing the extent of burned areas, especially in South Lebanon. Given that most of the conflict took place before the start of the normal fire season, it is likely that most of the outbreaks were caused by bombing incineration. A review of archive satellite data from NASA's (National Aeronautics and Space Administration) MODIS* Rapid Response System (MRRS) detected only two fire events in southern Lebanon between 12 July and 13 August in 2004 and 2005 respectively, but registered 48 fire events during the same period in 2006. Damages from fires affected olive trees, broadleaf species and maquis scrub vegetation (UNEP, 2007). It is to be noted that broadleaf was found to be more affected by fires mainly due to the large extent of broadleaf vegetation cover.

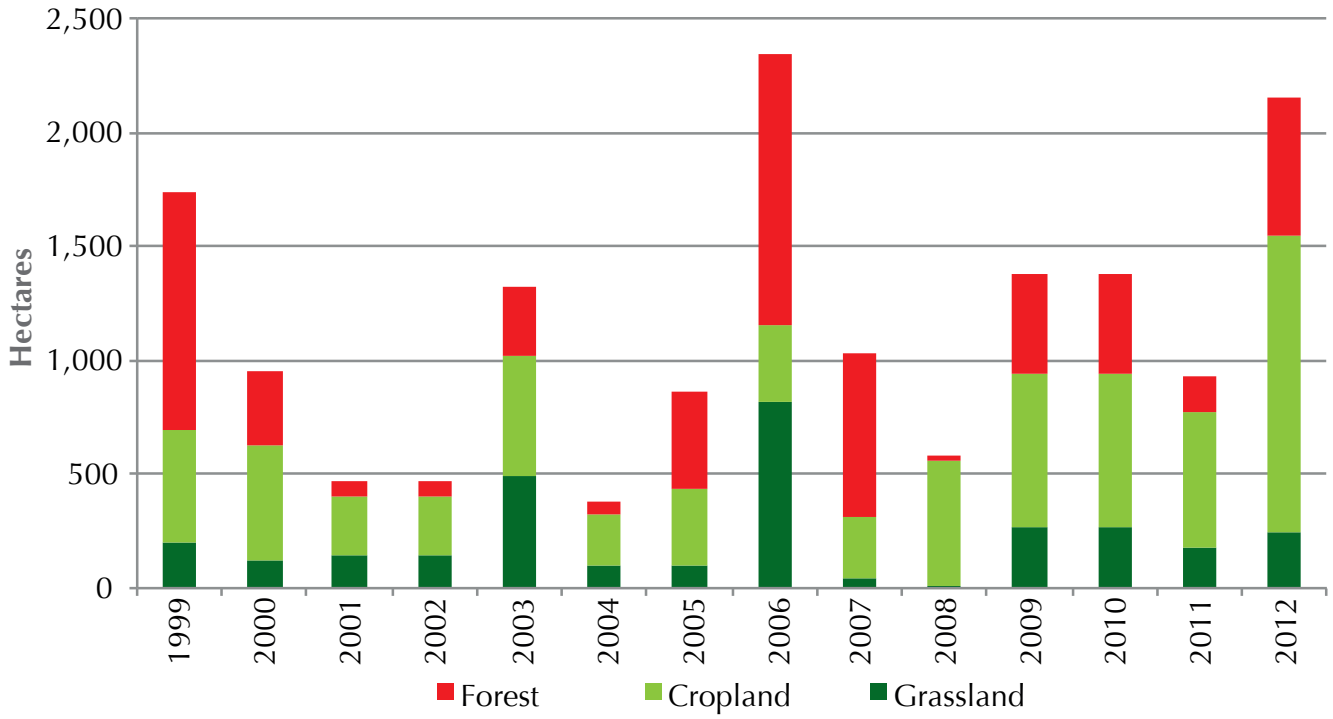


Figure 19: Burned areas

* Moderate Resolution Imaging Spectroradiometer

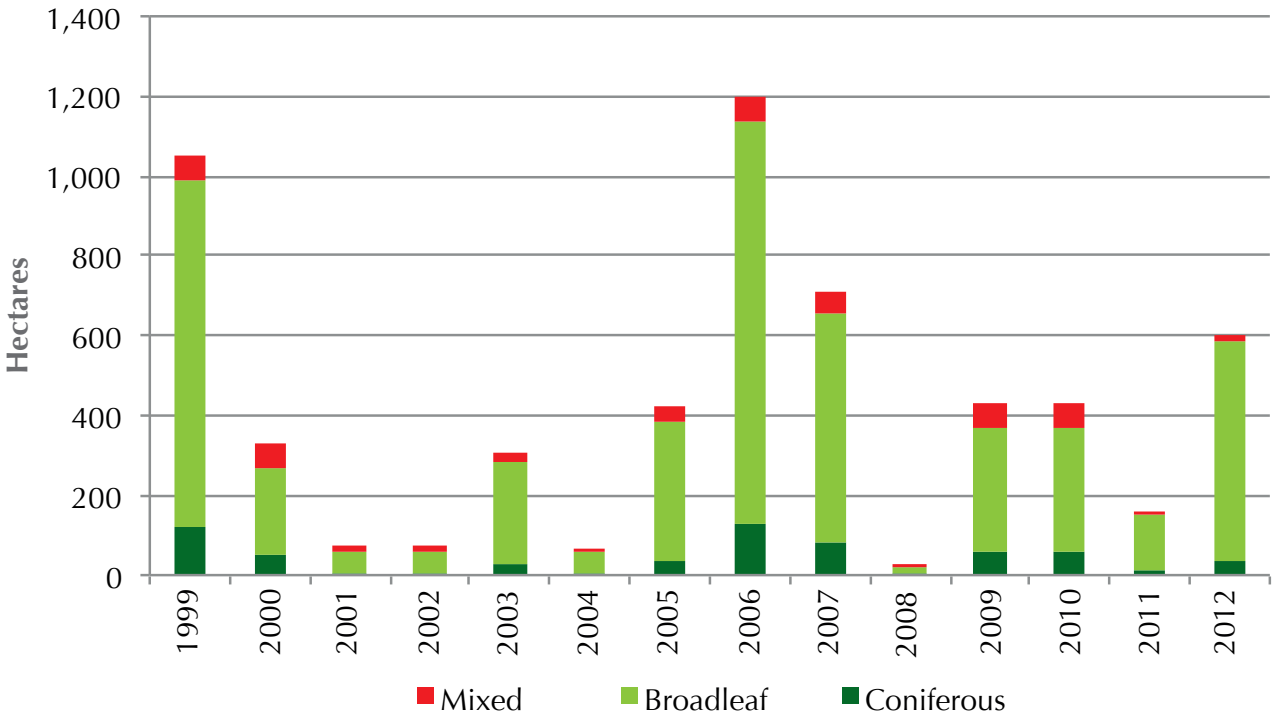


Figure 20: Areas of forest fires by subcategory

Only non-CO_2 emissions (namely CO, CH_4, N_2O, and NO_x) from burned grassland were accounted for in the inventory. CO_2 emissions from burned grassland were not accounted for in tier 1 of the IPCC GPG for LULUCF, since it was assumed that there was a balance in biomass stocks of grassland. Therefore, losses from only burned forests and cropland were the main sources of CO_2 emissions (Figure 21).

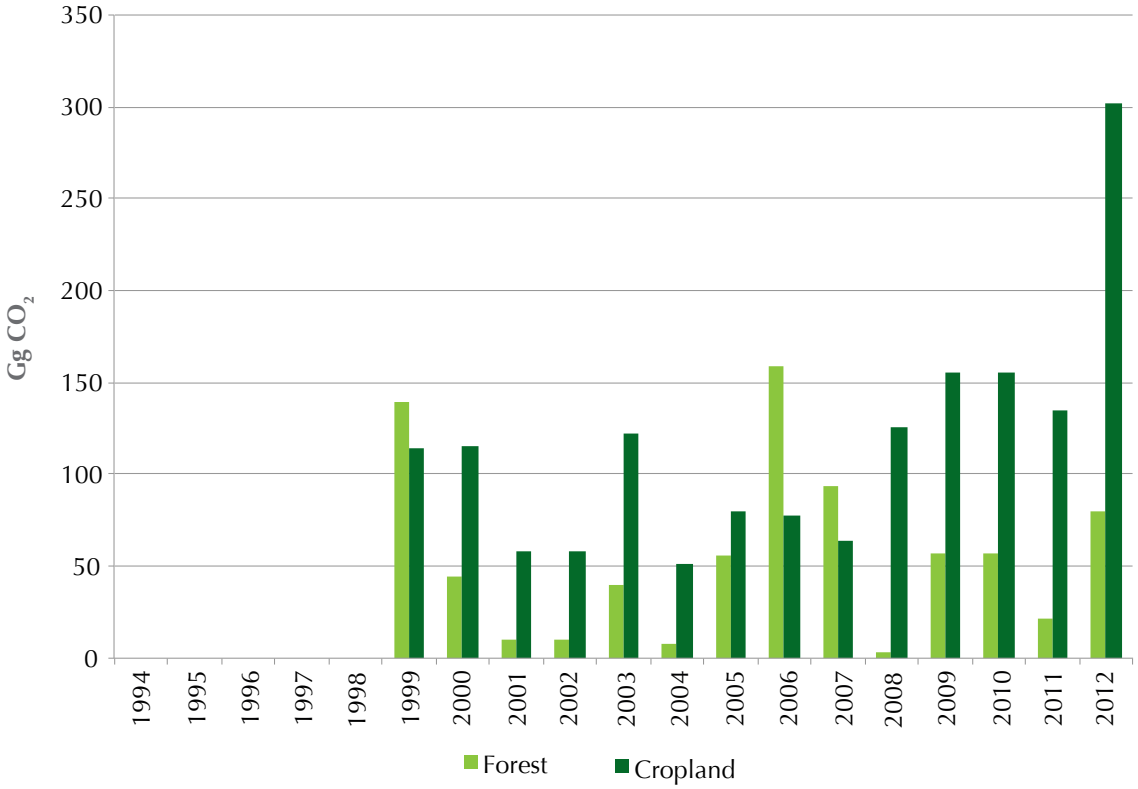


Figure 21: CO_2 emissions from burned areas

The main source of CH_4 and N_2O emissions of the LULUCF sector were forest fires (Figure 22 and Figure 23). CH_4 and N_2O emissions from croplands were not accounted for in the GPG for LULUCF since the source of these types of emissions were mainly agricultural activities (fertilization, livestock, burning, etc…) that happen in croplands. These were included in the agricultural sector rather than in the LULUCF sector.

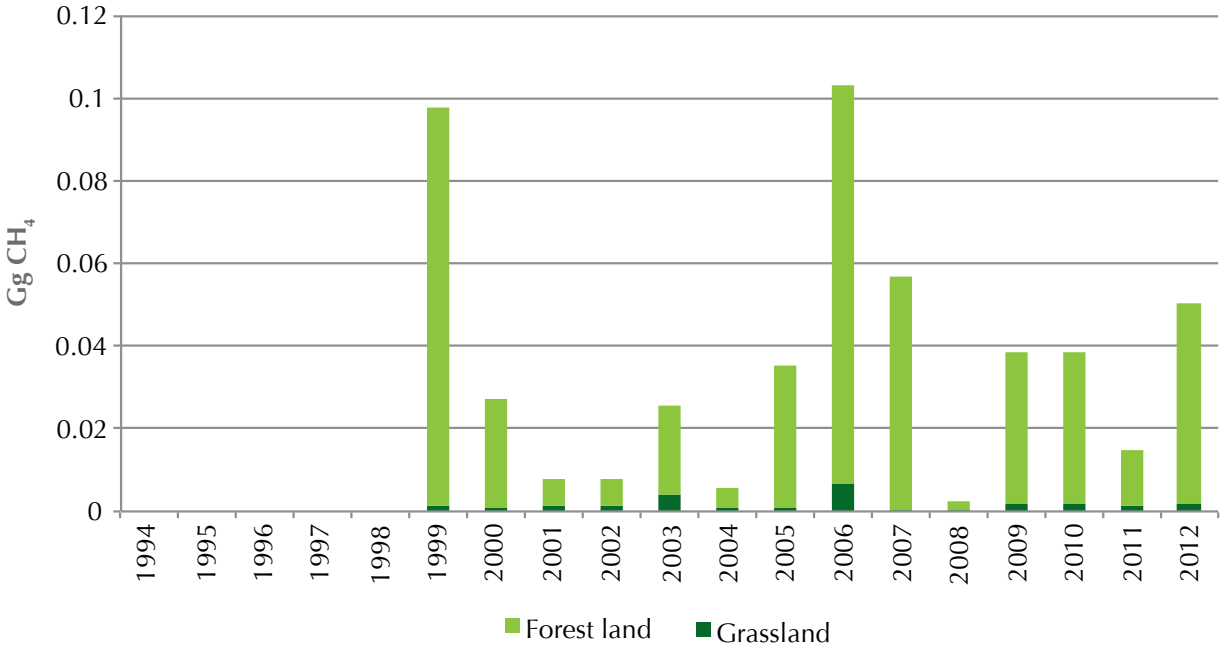


Figure 22: CH_4 emissions by category

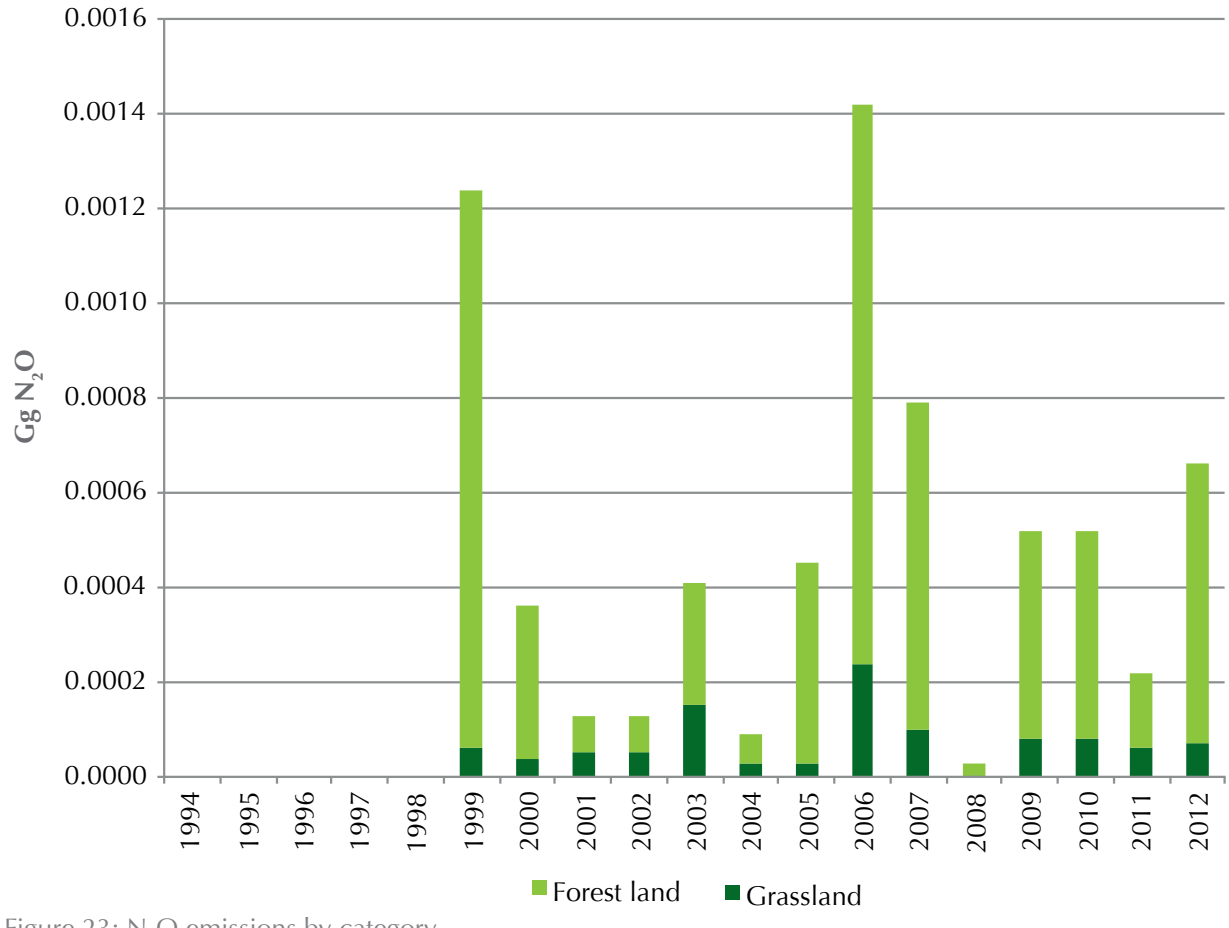


Figure 23: N_2O emissions by category

NO_x and CO emissions were emitted by burned forest areas as well as burned grassland areas with specific emission factors according to the fuel type of each category (Figure 24 and Figure 25). As reported by the SNC, CO emissions from fires exceeded NO_x emissions; however, total estimates differed due to differences in activity data of burned areas which were more accurately assessed in this report through remote sensing techniques.

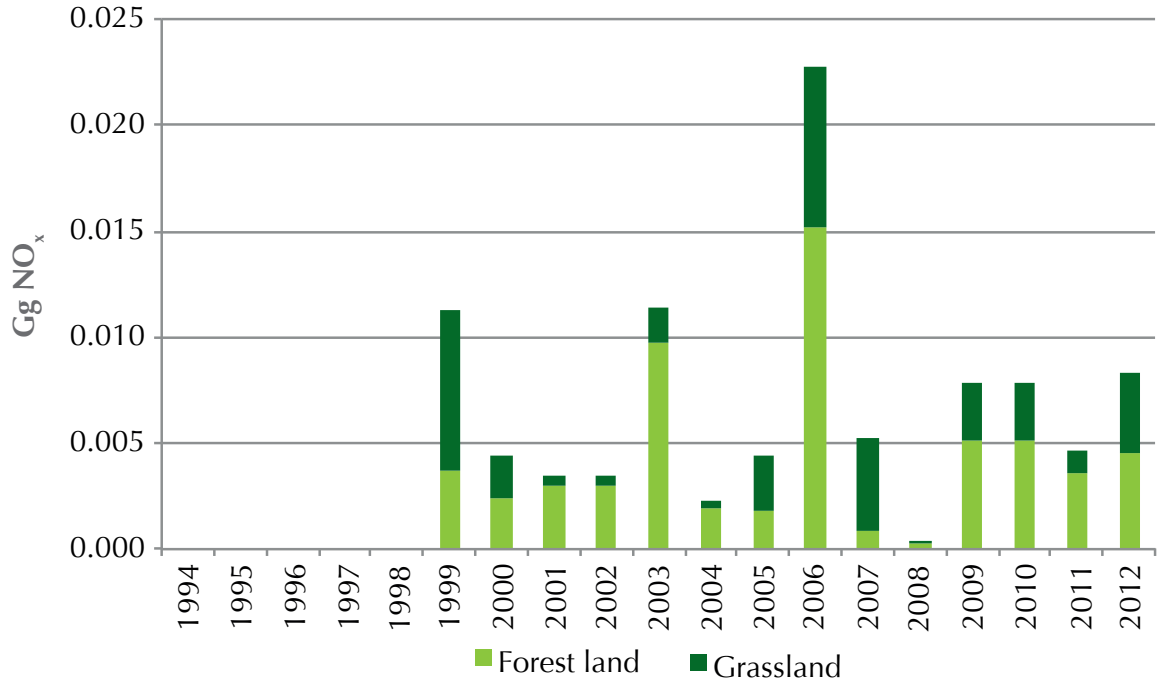


Figure 24: NO_x emissions by category

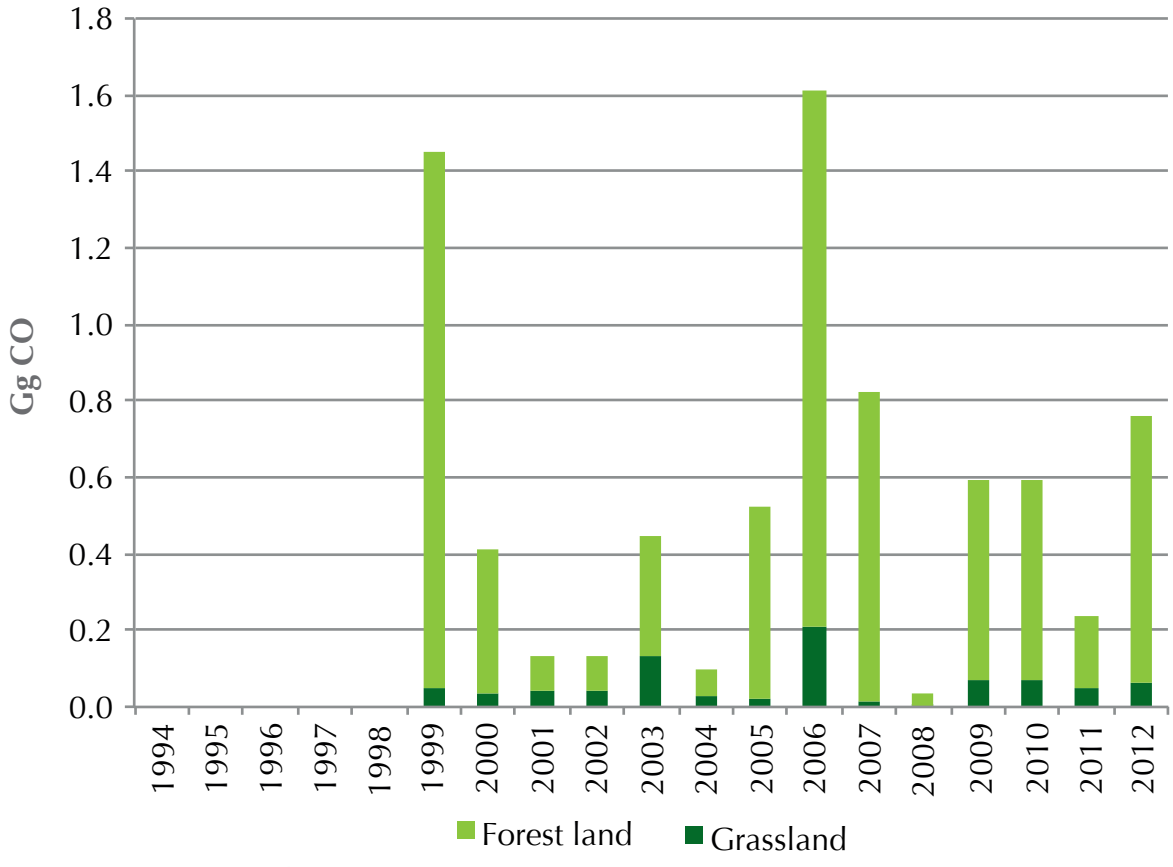


Figure 25: CO emissions by category

5.4. Contribution of categories in GHG emissions/removals

Forests, followed by croplands, have the largest contribution to CO_2 emissions/removals in the LULUCF sector in Lebanon (Figure 26). However, further data (when available) on areas of wetlands (namely hill lakes) and grasslands along with their management systems (e.g. status of grazing) can help in providing new insights on their level of contribution in GHG emissions or removals in the future.

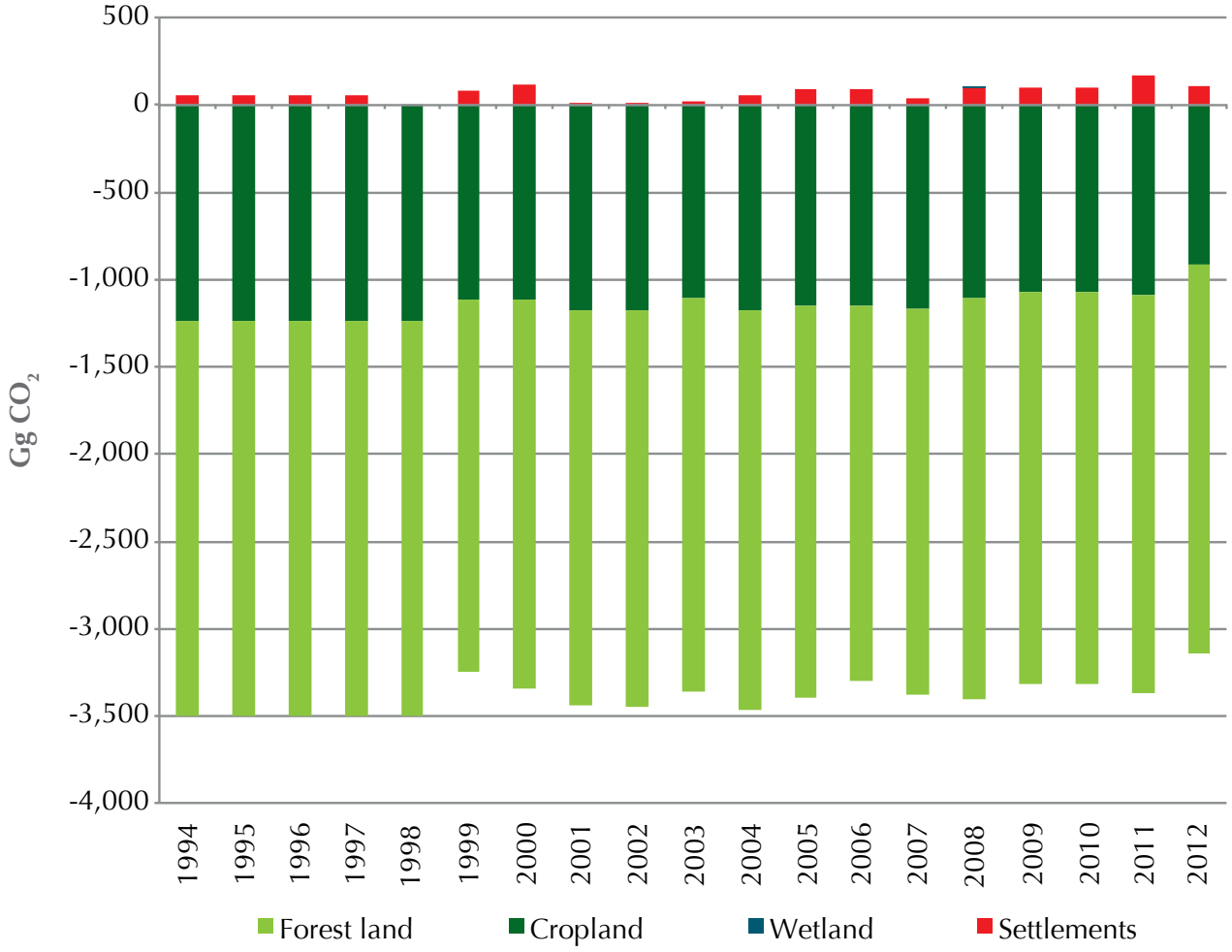


Figure 26: CO_2 emissions/removals by category

5.5. Trend in Lebanon's GHG emissions for the LULUCF sector: 1994-2012

5.5.1. Trend analysis

The GHG emissions/removals for the time series of 1994 up until 2012 was done following the QC procedures recommended by the IPCC GPG for LULUCF to ensure temporal consistency. The consistency of input data for each category of sources and sinks as well as the use of a consistent methodology for the calculations and the recalculations were taken into consideration. Some country-specific data about lands converted to wetland, cropland and grassland were not taken into account, either because they were incomplete or because they were acquired using different methodologies. Their inclusion in the calculations might have resulted in inconsistent time series.

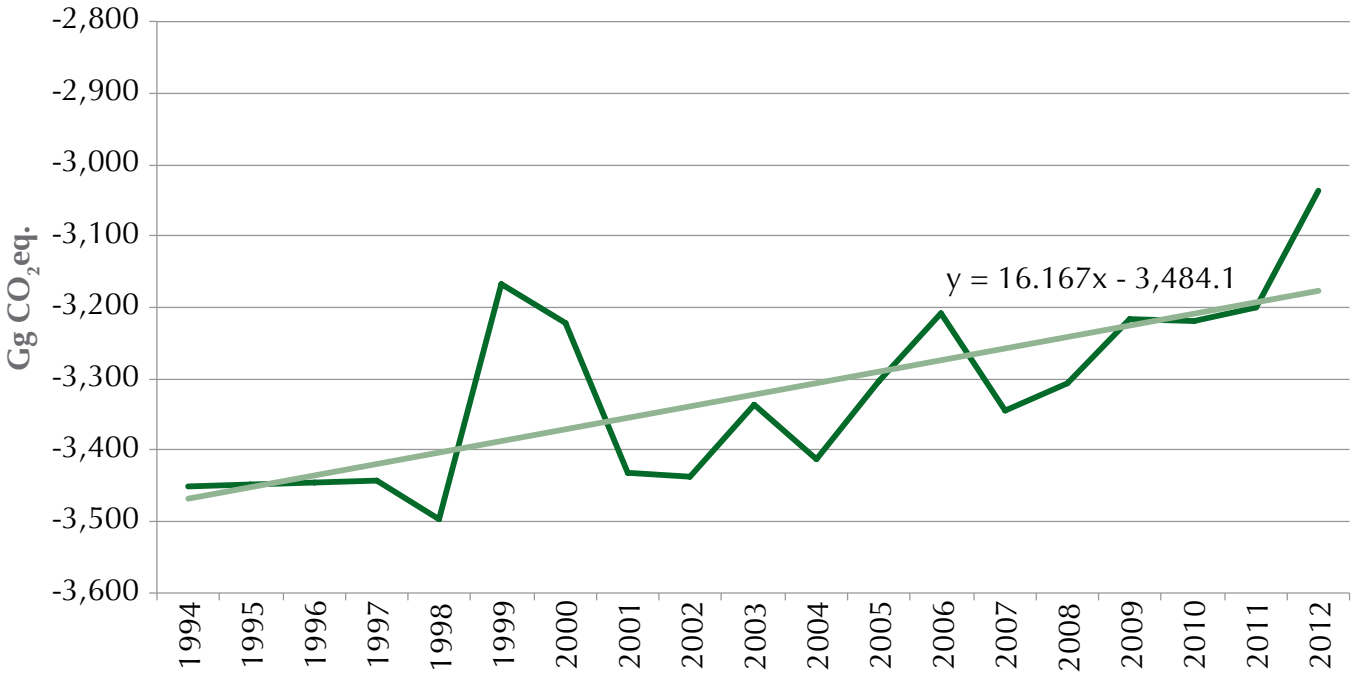


Figure 27: Trend analysis for CO_2 emissions/removals over the inventory period 1994-2012

The analysis of the changes in CO_2 emissions/removals of the LULUCF sector over the last 19 years showed a net decrease in CO_2 removals from the LULUCF mainly due to losses in the vegetation cover that resulted essentially from land conversions to settlements and wildfires, among others (Figure 27).

5.5.2. LULUCF indicators and comparison with Mediterranean countries

In this report, two main indicators of emissions from the LULUCF sector were selected for comparison among Mediterranean countries: 1) net CO_2 emissions due to forest conversions, and 2) change in CO_2 removals from the LULUCF sector. The comparisons involving these two indicators were made possible due to the availability of specific data.

The FAOSTAT emissions land use database provides country-level estimates of GHG emissions based on FAOSTAT activity data using tier 1 computations, following the 2006 IPCC Guidelines for National GHG Inventories. The data consists of the net contribution of CO_2 sources and sinks due to deforestation and reforestation/afforestation activities within countries. FAOSTAT data about Mediterranean countries were compared to the recently collected and calculated data of Lebanon on CO_2 increase/decrease in removals from forest conversion to settlements and lands converted to forests (afforestation). Accordingly, the first indicator (Figure 28) showed the net CO_2 emissions due to forest conversions of Mediterranean forests relative to the period of 1994-2010. Lebanon's net changes in CO_2 removals were relatively low between -30 Gg CO_2 and 90 Gg CO_2 (Figure 29). Net changes in CO_2 removals in Cyprus were the closest to Lebanon's. The largest variation of CO_2 removals betwen 1994 and 2000 were recorded for Morocco.

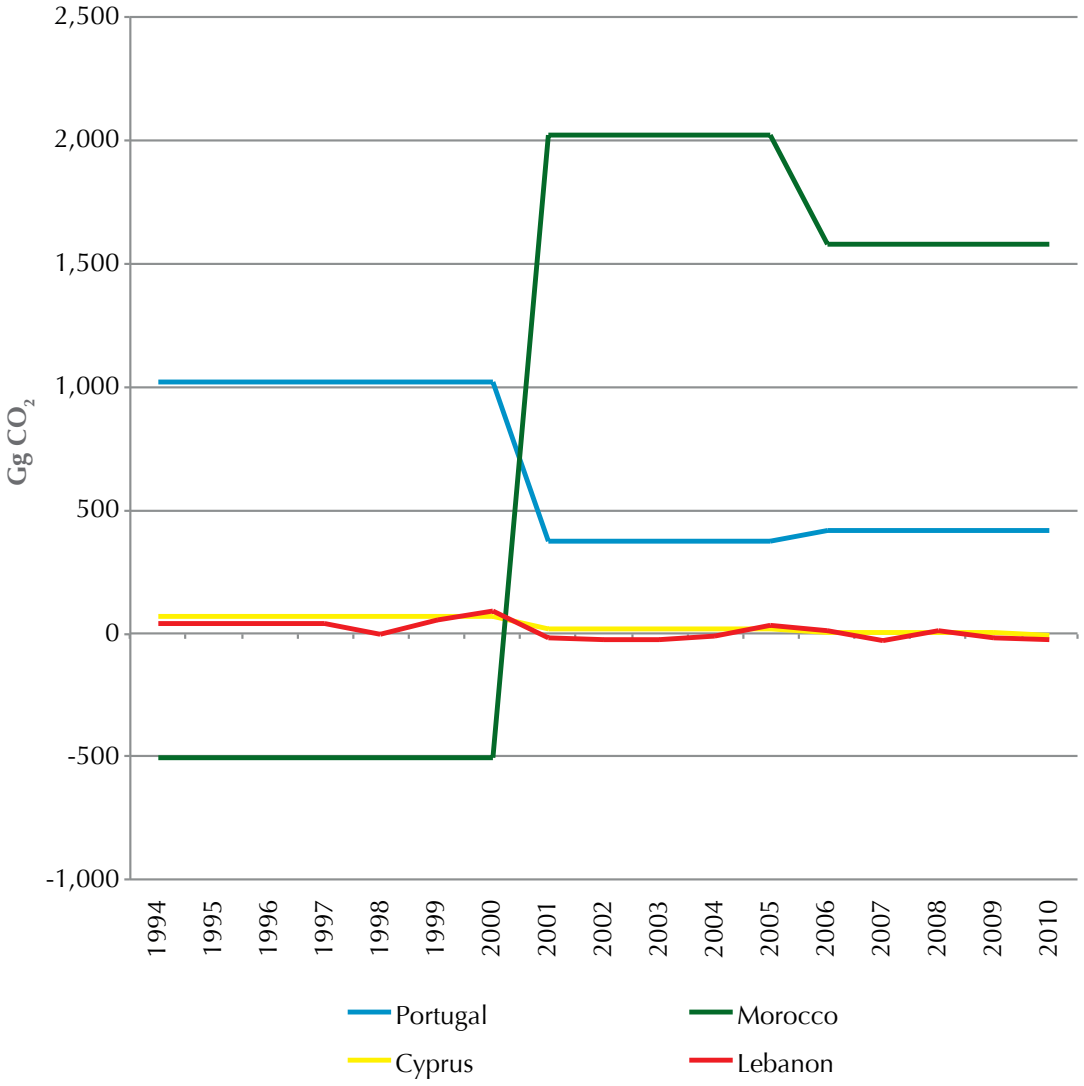


Figure 28: Net changes in CO_2 removals from forest conversions for forests in Mediterranean countries
Source | FAOSTAT, 2013

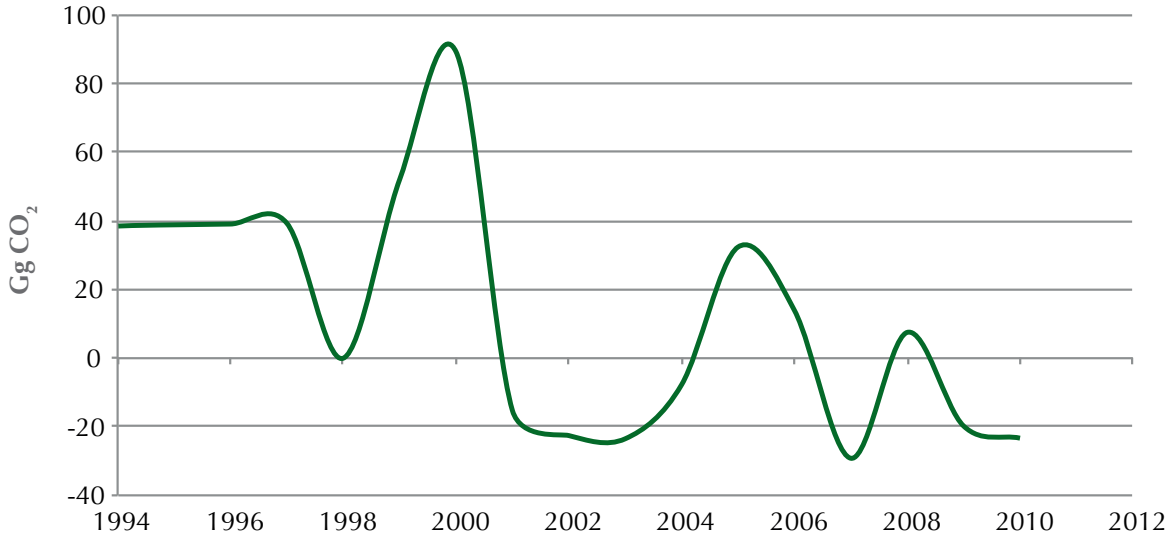


Figure 29: Net changes in CO_2 removals from forest conversions in Lebanon

The second selected indicator was the change in CO_2 removals of the LULUCF sector between 1994 and 2010. Lebanon and Greece showed a decrease in CO_2 removals during this period that might be caused by a decrease in removals or/and an increase in CO_2 emissions (Figure 30). Italy, Turkey and Spain showed increasing CO_2 removals by about 27%, 32% and 48% respectively (UNFCCC, 2013).

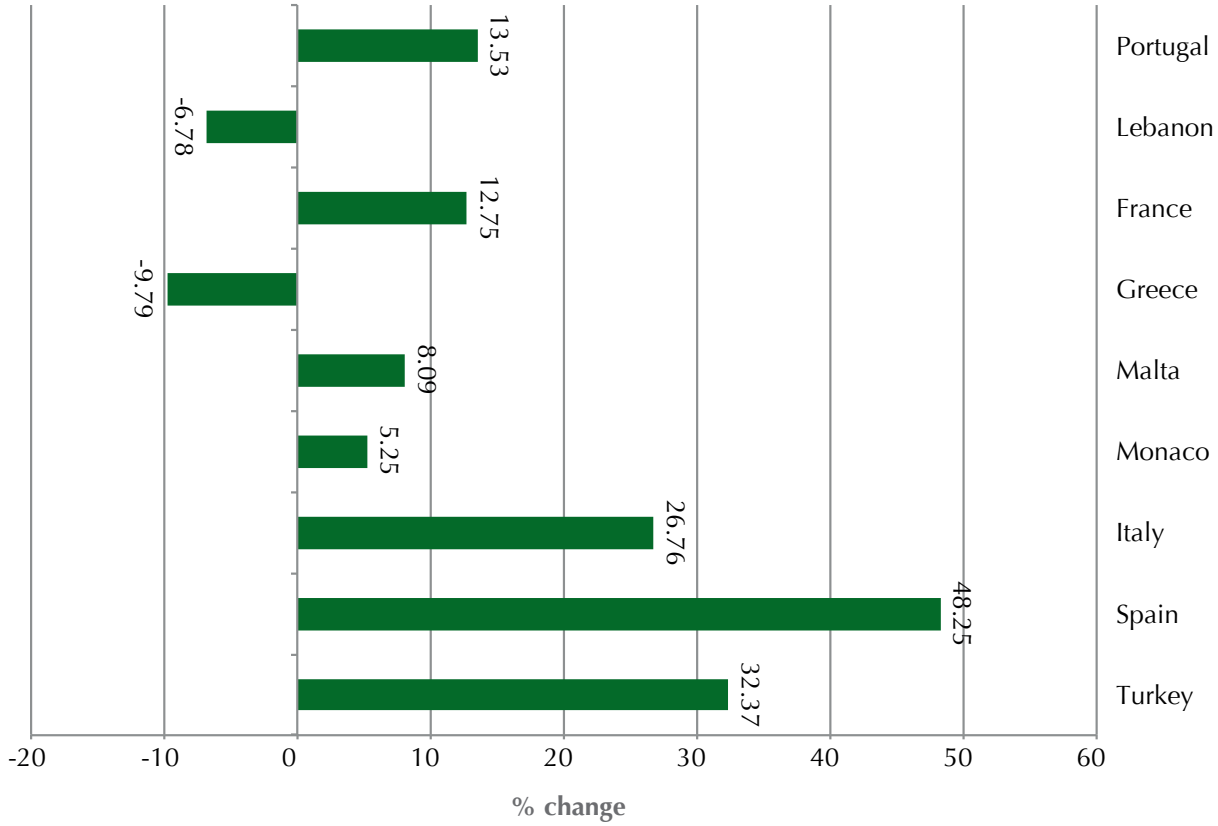


Figure 30: CO_2 removals changes between 1994 and 2010 in some Mediterranean countries
Source | UNFCCC, 2013

6. Conclusions

This work consisted of estimating GHG emissions for the LULUCF sector in Lebanon under the IPCC GPG. The use of a consistent methodology for activity data and emission factors collection and calculation over the inventory period (1994-2012) allowed the development of a consistent time series. The new data allowed the re-calculation of the estimations for the years 1994-2004 and the calculation of the estimations for the years 2005-2012.

More specifically, the use of multi-temporal satellite remote sensing data helped in increasing the accuracy of the activity data and decreasing the uncertainty of the overall estimates. In addition, change detection mapping involving satellite imagery allowed the generation of data about emissions from land-use changes such as forest, cropland and grassland conversions to settlements. These changes proved to be the main sources for CO_2 emissions and decrease in removals in the LULUCF sector in Lebanon. Moreover, the accurate mapping of burned areas allowed the identification of CO_2 as well as non-CO_2 emissions from wildfires. Likewise, the compilation of E/R factors was done following the GPG and taking into consideration the requirements of disaggregation within each of the categories.

The main findings indicated that the LULUCF sector is a major GHG sink highly contributing to the mitigation of the overall national GHG emissions. At the same time, the emissions from forests as well as croplands and grasslands due to land-use changes were estimated to be higher than the removals resulting from afforestation activities.

Overall, the changes in forest and vegetation covers between 1994 and 2012 resulted in about 12% (21.8 Gg CO_2eq./yr) decrease in CO_2 removals from the LULUCF sector. Lebanon was found to have 6.78% decrease in CO_2 removals from the LULUCF sector between 1994 and 2010, whereas CO_2 removals significantly increased (by 5% to 48%) in other Mediterranean countries during this period.

An improved GHG estimation of emissions/removals in the future should include the development of unified national databases, documentation and reporting of national data collection and calculation methodologies, and clear reporting and referencing of information. Such a system will require the collaboration and cooperation among the different national authorities.

Part 2: Mitigation analysis

7. Mitigation actions of the LULUCF sector (2005-2012)

Land Use, Land-Use Change and Forestry (LULUCF) climate mitigation measures can have highly variable 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 comprise the following main categories, among others (Trexler and Gibbons, 1998):

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

This work examined the main mitigation actions conducted in the LULUCF sector between 2005 and 2012. In summary, it was found that previously conducted mitigation actions were almost uniformly distributed over the different Lebanese governorates (Figure 31). The conducted initiatives were categorized under two types of activities, namely, 1) reforestation/afforestation and forest landscape restoration activities, and 2) forest fire management activities. A factsheet was developed for each of the main identified mitigation projects/actions (undertaken between 2005 and 2012 and having a practical or potential contribution in GHG reduction in emissions and/or increase in removals) in the LULUCF sector.

Figure 31: Distribution of main recorded mitigation actions for the LULUCF sector in Lebanon between 2005 and 2012

7.1. Reforestation, afforestation, and forest landscape restoration activities

Table 7: The reforestation initiative of the Ministry of Environment of Lebanon

The reforestation initiative of the Ministry of Environment of Lebanon	
General information: The Ministry of Environment was handled the prerogative of initiating the NRP, aiming at the restoration of the country's green cover loss throughout the years. Accordingly, the Ministry of Environment has executed from 2002 till 2006 (and later on from 2009 to 2014) reforestation activities in all Lebanese regions within the context of the National Reforestation Plan. These activities were achieved through two consecutive phases and have covered the reforestation of approximately 834 hectares of forest lands in all the Lebanese governorates with contributions from NGOs in some places.	
Implementing agency	Ministry of Environment of Lebanon
Geographical coverage	All Lebanese territories
Budget	In 2001, the Government of Lebanon (GoL) allocated in the national budget a LBP 25 billion fund (approximately USD 16.67 million) scheduled over five years for the execution of reforestation projects at the national level.
Timeframe	2002-2014
Source of funding	Government of Lebanon
Goals: To restore the country's green cover loss throughout the years	
Achievements or progress	The reforestation of 834 hectares of forest lands fairly distributed in the five Muhafazat, as follows: **Mount Lebanon:** 60 ha: Faraya and Barouk - 45 ha: Hammana, Damour, Ehmej. **North Lebanon**: 60 ha: Akkar el Atiqa, Ehden, Bcharri, Tannourine - 54 ha: Kousba, Tannourine **Bekaa**: 80 ha: Lala-Baaloul, Khirbet-Anafar, Qaa el Reem, Ras Baalbeck, Chaat, Hermel, Rachaya, Jdita - 104 ha: Tajammoh Baladiyat El –Sahl, Bouday, Chmestar, Al-Qaa, Al-Fakeha-El Jadida, Baalbeck, Rachaya El-Wadi, El-Hermel, Sehmor **South Lebanon**: 50 ha: Jezzine, Al Qraye, Abbassie, Majdelzoun **Nabatieh**: 55 ha: Kfar Rummane, Rmeich, Ebel el Saki, Marjeyoun, Hasbaya - 75 ha: Al-Rihan, Zawtar Esharkieh, El-Merwanieh, Kherbit Selem, Markaba Other reforestation activities for a total of 251 ha involved NGOs. Some of which involved large scale air seeding operations in coordination with the Lebanese army and some NGOs. Airplane seeding of pine and oak seeds over a total area of 80 hectares in the regions of Jran, Jrabta, Kfifan, Rechmaya, Karm Saddeh, Kobeyat, Deir El-Kamar and Andkit was performed. Based on the promising initial results obtained, this operation was followed with similar applications in the regions of Dahr El-Ahmar, Karaoun and Bkifa over another area of 80 hectares.

GHG reduction as of end 2012	11.116 Gg of CO_2
Emission reduction expected by completion of action	Not Available (N/A)
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming an annual average area of 104.25 ha was successfully planted and maintained from 2005 throughout 2012

Table 8: The 40 million forest trees initiative of the Ministry of Agriculture

The 40 million forest trees initiative of the Ministry of Agriculture	
General information: The NRP of the MoA is designed to meet the objectives of the MoA strategy while falling in line with the "Schéma Directeur de l'Aménagement des Territoires Libanais (SDATL)" developed earlier.	
Implementing agency	Ministry of Agriculture
Geographical coverage	All Lebanese governorates
Budget	Approximate cost: USD 350 million assuming USD 10 per tree and 500 trees per ha (i.e. USD 5,000 per hectare) for a total of 70,000 ha
Timeframe	20 years
Source of funding	N/A
Goals: The NRP main objectives are summarized as follows: - Increase the total surface of forests to 20% in a 20 years period of time i.e. an increase of 70,000 hectares of the current area while maintaining their resilience against numerous hazards such as urban encroachment, fire risks, and climate change effects, among others - Protect the biodiversity of the national forests against climate change, overexploitation, and erosion - Enhance and develop the forest economical environmental, social and cultural function	
Achievements or progress	Launching of the European Union (EU) funded forestry actions in Lebanon in 2014 Official launching of the initiative's master plan on 10-12-2014
GHG reduction	N/A
Emission reduction expected by completion of action by 2034	933 Gg CO_2eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that 1) a total of 3,500 ha is planted every year starting the year 2015 and ending the year 2034, and 2) the cumulative planted area is successfully maintained

Table 9: National physical master plan of the Lebanese territory

National physical master plan of the Lebanese territory	
General information: The master plan describes holistically the physical realities impacting land use, future challenges, alternative configurations for land use and development, land use principles, as well as sectoral action plans (transport, tourism, energy, water, environment, education, etc.). The plan presented a vision for national urban planning and critical recommendations for enhancing and harmonizing land uses in Lebanon while protecting the natural and cultural resource base. In 2002, the CoM requested the CDR to prepare a national land use master plan for Lebanon. Following an international tender, CDR contracted the consortium Dar Al Handasah – Institut d'Aménagement et d'Urbanisme de la Région Ile-de-France (DAR-IAURIF)	
Implementing agency	Council for Development and Reconstruction
Geographical coverage	All of Lebanon
Budget	USD 2,970,000
Timeframe	2002-2005
Source of funding	Government of Lebanon
Goals: To propose a unified set of land use categories covering the entire territory, and delineate several protection zones of ecological and patrimonial importance	
Achievements or progress	The final analysis was published in 2004-2005 including a final report, maps, and a geo-database. The Lebanese Council of Ministers approved the master plan (decree 2366 dated 20-06-2009). The master plan is a reference document for several administrations including the Directorate General for Urban Planning (DGUP) (which has to refer back to the master plan when preparing, reviewing or approving new urban master plans) and line ministries (Agriculture, Environment, Public Works and Transport, Water and Energy, Industry, Economy and Trade and Culture including the Directorate General of Antiquities). They should refer to the master plan when making decisions related to urban development, the provision of public services, and environmental heritage conservation.
GHG reduction	In reference to LULUCF, the master plan acknowledges that: - Remarkable sites (mountains, valleys, landscapes and coastline) and natural areas (especially forested zones) constitute in Lebanon a unique asset that must be used for improving the quality of life and the tourism economy. The use of sites, as resources, should prevent their degradation. - The best agricultural lands constitute a national asset that should not be derelict. - There is a need to rationalize the use of land and resources in response to challenges of the future demographic growth and urban sprawl.
Emission reduction expected by completion of action	N/A
Methodology	N/A
Assumptions	N/A

Table 10: Alleviating barriers for quarries rehabilitation

Alleviating Barriers for Quarries Rehabilitation (ABQUAR)	
General information: The ABQUAR project addressed the problem of quarries rehabilitation in Lebanon. Lebanon is spotted with over 1,000 quarries exploited with little consideration to the surrounding environment and its inhabitants thus causing among others: 1) destruction of vegetation and important natural habitats, and 2) permanent loss to biodiversity and natural resources. Decree no. 16456/2006 amended decree no. 8803/2002 where it brought further improvements and restrictions to the quarry sector. For example, the decree bans quarrying inside protected areas. As of 31 December 2010, MoE had 135 bank guarantees on file worth LBP 4.6 billion (or USD 3.07 million). Despite widespread noncompliance by the vast majority of operators, MoE has yet to exercise its public right to deposit bank guarantees and use the money to finance site rehabilitation. Decree no. 1735/2009 also amended decree no. 8803/2002 where it explicitly requires the declaration (statement) that operators must obtain from the Ministry of Energy and Water (Directorate General of Exploitation) to address the potential impacts of the proposed quarry on surface and groundwater and on transmission lines.	
Implementing agency	Ministry of Environment
Geographical	All of Lebanon
Budget	EUR 463,592
Timeframe	2005-2007
Source of funding	The European Commission through life third countries program (EC-LIFE) and the Ministry of Environment (MoE)
Goals: 1) alleviating all legal, technical and financial barriers impeding rehabilitation processes of quarries in Lebanon, and 2) mitigating quarries' environmental and socio-economic impacts	
Achievements or progress	- Reviewing existing institutional and legal frameworks - Developing a GIS-based Decision Support System (DSS) as a tool for prioritization of quarries rehabilitation - Identifying best rehabilitation practices for various kinds of quarries - Developing financial mechanisms and economic incentives for quarry rehabilitation - Strengthening institutional and human capacities through comprehensive training programs tailored to local needs - Drafting a new comprehensive law for quarries - Developing a national rehabilitation program - Increasing public participation and awareness of the benefits of rehabilitation - Communicating and disseminating projects' outcomes and results
GHG reduction	It is believed that this project contributes to an improved understanding in rehabilitation of quarrying sites which in turn can help in reducing GHG when moving to implementation of the national rehabilitation program.
Emission reduction expected by completion of action	N/A
Methodology	N/A
Assumptions	N/A

Table 11: Reforestation on degraded lands

Reforestation on degraded lands	
General information: This project involved reforestation activities on degraded lands in rural areas.	
Implementing agency	Association for Forest Development and Conservation (AFDC) in partnership with the Council for Development and Reconstruction
Geographical coverage	Aley (Il Jurd) and Aiha
Budget	USD 200,000
Timeframe	2006-2007
Source of funding	CDR in Lebanon
Goals: To conduct rural empowerment activities including reforestation of degraded lands	
Achievements or progress	Reforesting a total of 37 ha of degraded lands among other achievements
GHG reduction	0.49 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that an area of 37 ha was successfully planted and maintained

Table 12: Regaining ecological integrity

Regaining ecological integrity of forests	
General information: This project worked towards regaining the ecological integrity needed through supporting rural development activities.	
Implementing agency	AFDC in partnership with the World Wide Fund for Nature (WWF) Italy and the cooperative of beekeepers in the higher Metn and Qornayel
Geographical coverage	Ramlieh and Qornayel (Mount Lebanon)
Budget	USD 300,000
Timeframe	2006-2009
Source of funding	WWF
Goals: To support rural development activities	
Achievements or progress	- Establish a forest center in Qornayel village - Create marketing packages for the rural products in both sites - Complete the reforestation of 4 ha in two sites in Ramlieh and Qornayel villages - Increase the capacity of AFDC units in forest fire fighting and prevention by building capacities and provision of equipment - Other achievements
GHG reduction	0.05 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that an area of 4 ha was successfully planted and maintained

Table 13: Reforestation project in South Lebanon

Restoration and conservation of sensitive forest areas in Lebanon	
General information: This project worked towards restoring sensitive forest areas in South Lebanon after the 2006 war.	
Implementing agency	AFDC in partnership with WWF Italy
Geographical coverage	South-Lebanon
Budget	USD 645,000
Timeframe	2007-2008
Source of funding	Italian Cooperation for Development
Goals: Restore damaged lands among others	
Achievements or progress	- Restoring 50 ha of damaged areas in South Lebanon based on the assessment in cooperation with local authorities and land owners - Providing monitoring equipment to the forest guard, civil defense centers and army, and forest firefighting equipment and tools for AFDC fire fighters local units for early intervention in forest fires - Designing and implementing a training program on forest management and forest fire fighting and control addressing the civil defense, the army and the forest guards - Other achievements
GHG reduction	0.66 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that an area of 50 ha was successfully planted and maintained in 2008

Table 14: Emergency reforestation intervention

Support the national early recovery efforts in restoring a part of the burned Lebanese forests	
General information: This project contributed to the national efforts for early recovery after the 2006 war.	
Implementing agency	AFDC in partnership with the Ministry of Environment
Geographical coverage	Various locations in Lebanon
Budget	EUR 200,000
Timeframe	2007-2008
Source of funding	Italian Cooperation for Development
Goals: To support the national early recovery efforts in restoring a part of the burned Lebanese Forests	

Achievements or progress	- 20 hectares of lands reforested - One tree nursery established - A tree nurseries' assessment report produced
GHG reduction	0.266 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained

Table 15: Forest for peace

Forest for peace project	
General information: This project responded to the need for improving the quality of life of the rural population in South Lebanon.	
Implementing agency	AFDC in partnership with the Norwegian Agency for Development Cooperation (NORAD), Friendship Organization Norway - Lebanon
Geographical coverage	Aarkoub-South Lebanon
Budget	USD 25,000
Timeframe	2008-2009
Source of funding	NORAD
Goals: To contribute to improving the quality of life of the rural population in South Lebanon	
Achievements or progress	- Reforestation of 0.25 hectares of pine - Reforestation of 20 hectares in Fardis, South Lebanon - Other achievements
GHG reduction	0.269 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained

Table 16: Development of a community forest

Reforestation: development of a community forest	
General information: This project recognized the need to involve the local communities in forest development.	
Implementing agency	AFDC in partnership with Lebanese Dutch Business Association
Geographical coverage	Aley, Mount Lebanon Jezzine, South Lebanon
Budget	EUR 47,000
Timeframe	2008
Source of funding	Embassy of the Netherlands
Goals: Support the national early recovery efforts in restoring a part of deforested lands and in increasing the percentage of forest cover in Lebanon	
Achievements or progress	- 4 hectares of land in the village of Jesr Elkadi (Aley, Mount Lebanon) were reforested with 2,000 seedlings of stone pine. - 2 hectares of land in the village of Qaitouly (Jezzine, South Lebanon) were reforested with 1,000 seedlings of stone pine. - 1 hectare of land in the village of Bkaseen (Jezzine, South Lebanon) was reforested with 500 seedlings of stone pine.
GHG reduction	0.093 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained

Table 17: Management and sustainable development of forest areas

Management and sustainable development of forest areas	
General information: This project worked towards the management and sustainable development of forest areas in Andket-Akkar in North Lebanon.	
Implementing agency	AFDC
Geographical coverage	Andket-Akkar
Budget	EUR 449,000
Timeframe	2008-2009
Source of funding	Italian Cooperation for Development
Goals: To manage forest areas in Andket-Akkar in the north of Lebanon	

Achievements or progress	- Pilot forest areas in North Lebanon restored (10 ha) - Establishment of a forest center for multiple uses - Stronger and updated human and technical capacities on sustainable forest and agriculture management are available - Fire prevention measures are implemented
GHG reduction	0.133 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained

Table 18: Reforestation within an integrated forest fire management

Reforestation within an integrated forest fire management	
General information: This project addressed forest and forest fire management issues in Lebanon in an integrated approach.	
Implementing agency	AFDC, Ministry of Environment, and FAO
Geographical coverage	Various locations in Lebanon
Budget	USD 2,600,000
Timeframe	2008-2011
Source of funding	Lebanon Recovery Fund
Goals: To improve forest fire management in Lebanon through prevention, intervention, and restoration	
Achievements or progress	- Identification of the forest sensitive areas to be targeted and the kind of intervention needed in each site - Installation of a new tree nursery - Rehabilitation of infrastructure for combating fires and establishment of fire breaks, water ponds, and water outlets - Reforestation of 100 ha of degraded lands - Conduct training sessions on fire management and control to the Civil Defense, Lebanese Army, forests guards and volunteers - Implement national public awareness campaign on forests and fire prevention - Produce awareness materials for dissemination to the public on fire prevention, targeting local communities
GHG reduction	1.332 Gg of CO_2
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained

Table 19: Reforestation and afforestation activities conducted by Jouzour Loubnan

Jouzour Loubnan's reforestation and afforestation activities	
General information: Reforestation/afforestation activities were conducted between 2008 and 2014. Local community groups were involved in reforestation activities which involved the use of native tree species.	
Implementing agency	Jouzour Loubnan
Geographical coverage	Chabrouh, Ehmej, Ainata, Harf Shlifa and Btedi in the Bekaa valley, Ibl Es Saki, Ehden, and Kfardebiane
Budget	USD 946,659 (assuming an average cost of USD 7 per seedling)
Timeframe	2008-2014
Source of funding	Different sources of funding including the EU, the private sector, and United States Agency for International Development (USAID) through Lebanon Reforestation Initiative
Goals: 1) to intervene mainly in arid mountainous regions as, on one hand, they are very often dismissed in forestation programs and, on the other hand, the benefits of such forestation are tremendous, 2) to empower local communities, and 3) to promote environmental awareness	
Achievements or progress	A total of 135,237 seedlings were planted.
GHG reduction	1.37 Gg of CO_2
Emission reduction expected by completion of action	2.57 Gg of CO_2
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that 1) the seedlings were successfully planted and maintained, 2) each ha of planted land comprised 700 seedlings, and 3) the cumulative plantations consisted of 185 seedlings (in 2008), 5,680 seedlings (in 2010), 11,795 seedlings (in 2010), 22,009 seedlings in (2011), 32,358 seedlings (in 2012), 39,155 seedlings (in 2013), and 24,055 seedlings (in 2014)

Table 20: Safeguarding and restoring Lebanon's woodland resources

Safeguarding and restoring Lebanon's woodland resources	
General information: This project works towards creating an enabling environment and capacity for sustainable land management as a contribution to greater ecosystem stability and reduced soil erosion.	
Implementing agency	UNDP (United Nations Development Programme) Lebanon in partnership with the Ministry of Environment
Geographical coverage	All Lebanese territories
Budget	USD 980,000 (assuming an average cost of USD 7 per seedling)
Timeframe	2009-2014
Source of funding	Global Environment Facility
Goals: 1) development of a strategy for the safeguarding and restoration of Lebanon's woodland resources, developed and under implementation through capacity building and execution of appropriate Sustainable Land Management (SLM) policies and practices, 2) strengthening the capacity of the Ministry of Environment in the field of reforestation, 3) support the Ministry of Environment in the implementation of the National Reforestation Plan, 4) raising of funds for the implementation of reforestation activities in Lebanon, 5) Implementation of a set of innovative technologies and instruments for the rehabilitation of forests and woodlands, and their subsequent sustainable management	
Achievements or progress	- Strengthening the capacity of local forest seedlings production nurseries through the introduction of modern technologies for the production of seedlings with good quality and low cost in coordination with foreign experts - Reducing the cost of reforestation in Lebanon through the adoption of modern techniques tested by the project and found sound and viable - Assisting the Ministry of Environment in the development of a new concept of direct contracting with municipalities, which was put in practice for the first time in Lebanon - Launching a new reforestation project in coordination with USAID with a budget of USD 12 million for the development of forest nurseries and the introduction of some modern techniques of reforestation in Lebanon - Reforesting a total of 30 ha of land during the lifetime of the project - Helping the Ministry of Environment in reforesting a total of 191.5 ha during the third phase of the reforestation plan
GHG reduction	N/A
Emission reduction expected by completion of action	0.39 Gg of CO_2
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the seedlings were successfully planted and maintained The 191.5 ha reforested with the help of the project were accounted for in the reforestation plan of the Ministry of Environment.

Table 21: Lebanon Reforestation Initiative (LRI)

Lebanon reforestation initiative	
General information: The Lebanon Reforestation Initiative, funded by the USAID and implemented by the USFS, works towards providing a successful framework for longer-term technical and financial assistance to expand and protect Lebanon's forests for a sustainable future. The project favors a decentralized approach to engaging communities at the municipal level and focuses on 1) assisting native tree nurseries with technical improvements and enhanced business planning, 2) developing comprehensive forest mapping, 3) promoting the importance of reforestation and biodiversity through community-led activities that foster local ownership and forest sustainability, 4) supporting the planting of quality native seedlings, and 5) strengthening capacities to prevent respond to wildfires.	
Implementing agency	Lebanon Reforestation Initiative in partnership with local community groups
Geographical coverage	Tannourine, Bcharreh, Kfarzabad, Aanjar, Rashaya, El Qlaiaa, Ainata, Rmadyeh, and Maqne
Budget	USD 2,734,109 (assuming an average cost of USD 7 per seedling)
Timeframe	2011-2014
Source of funding	USAID
Goals: The Lebanon Reforestation Initiative aims to restore Lebanon's native forests and to install commitment to reforestation and wildfire prevention and response through capacity building of local communities and organizations.	
Achievements or progress	A total of 390,587 seedlings were planted.
GHG reduction	3.87 Gg of CO_2
Emission reduction expected by completion of action	7.43 Gg of CO_2
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that: 1) the seedlings were successfully planted and maintained, 2) each ha of planted land comprised 700 seedlings, and 3) the cumulative plantations consisted of 76,087 seedlings (in 2011), 127,536 seedlings (in 2012), 127,536 seedlings (in 2013), and 59,428 seedlings (in 2014)

7.2. Forest fire management activities

Table 22: Developing Lebanon's National Strategy for Forest Fire Management

Developing Lebanon's National Strategy for Forest Fire Management	
General information: After the disastrous fire of 2007 there was a need to develop a national plan for forest fire management at the national level.	
Implementing agency	AFDC in partnership with the Ministry of Environment
Geographical coverage	All of Lebanon
Budget	EUR 350,000
Timeframe	2007-2008
Source of funding	EU
Goals: - Develop a national protocol of cooperation in forest fire management and control and reach a Memorandum of Understanding (MoU) among the Ministries of Environment, Agriculture, Interior and Defense. - Provide basic tools and equipment for forest guards and Civil Defense centers in sensitive forest areas for early intervention in fire fighting. - Produce and document uniform information and make it available to the Lebanese Army for training its individuals, and upgrade the technical skills of officials from the Civil Defense, the forest guards, and the Internal Security Forces about forest fire management and forensic fire investigations.	
Achievements or progress	- Lebanon's National Strategy For Forest Fire Management (decision no. 52/2009) - Operations room at a national scale for forest fire prevention and control - Effective tools and equipment for forest fire control provided and used by the forest guards and the Civil Defense - Professional and skilled forest fire fighters and improved forensic fire investigations conducted by Lebanese Internal Security Forces
GHG reduction	484 Gg of CO_2eq.
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the strategy succeeded in suppressing 50% of the fires (out of the 5,828 ha that burned between 2009 and 2012) within the first 20 minutes from fire occurrence

Source | AFDC/MoE, 2009

Table 23: Strengthening Lebanese capabilities in forest fire control operations

Strengthening Lebanese capabilities in forest fire control operations	
General information: This project recognized the importance of strengthening the capabilities of Lebanese fire fighters in improved forest fire control operations.	
Implementing agency	Ministry of Interior and Municipalities (MoIM) – Lebanon, Lebanese Civil Defense, TRAGSA, and AFDC
Geographical coverage	Different locations in Lebanon
Budget	USD 144,100
Timeframe	2010
Source of funding	Spanish Government
Goals: - To increase the human capacities and technical means of forest fire brigades, adapting their capacities to work efficiently in the forest. - To provide advanced technical assistance for the concerned institutions, the team of national fire operations room, fire brigades and land users. - To enhance the functionality and the managerial capacities and technological preparedness of the national operation room.	
Achievements or progress	- The human capacities and technical means of forest fire brigades have been increased and adapted to work efficiently in the forest. - The technical forest fire managerial capacities of the concerned institutions and national forest fire groups are adapted and further strengthened. - The managerial capacities and technological preparedness of the national operation room are strengthened.
GHG reduction	150.66 Gg of CO_2eq.
Emission reduction expected by completion of action	N/A
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the action succeeded in suppressing 20% of the fires (out of the 4,454 ha that burned between 2010 and 2012) within the first 20 minutes from fire occurrence

Table 24: RISICO (RISchio Incendi e COordinamento) system for forest fire forecasting

RISICO system for forest fire forecasting	
General information: This project was initially entitled: "Risk Prevention and Management of the Chouf Cedar Reserve" worked at transferring and testing in Lebanon the Italian system RISICO forest fire forecasting	
Implementing agency	Italian National Civil Protection Department, CIMA (International Center on Environmental Monitoring) Research Foundation, Lebanese General Directorate of Civil Defense – MoIM in collaboration with: Al-Shouf Cedar Nature Reserve, LARI (Lebanese Agricultural Research Institute) and AFDC
Geographical coverage	All of Lebanon
Budget	EUR 890,000
Timeframe	2010-2011
Source of funding	Ministry of Foreign Affairs with technical support from the Italian Embassy in Lebanon and the Italian Cooperation for Development office in Beirut
Goals: One of the main fire-related activities of the project aimed at transferring to Lebanon the system RISICO used by the Department of Civil Protection for predicting forest and rural fire risk at the national scale.	
Achievements or progress	- Transfer of the operating system RISICO at the headquarters of the Lebanese Civil Defense - Issue of a daily bulletin for prediction and prevention of forest and rural fires - Realization of different training sessions aimed at the general understanding of the system - Full-scale exercise that allowed to test the chain of command and control starting from the issue of the bulletin, the activation of the prevention activities (patrolling, monitoring and preparedness and forest fires fighting activities)
GHG reduction	N/A
Emission reduction expected by completion of action	75.33 Gg of CO_2eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the action succeeded in suppressing 10% of the fires (out of the 4,454 ha that burned between 2010 and 2012) within the first 20 minutes from fire occurrence

Table 25: Managing wildfire risk in the Wildland-Urban Interface (WUI)

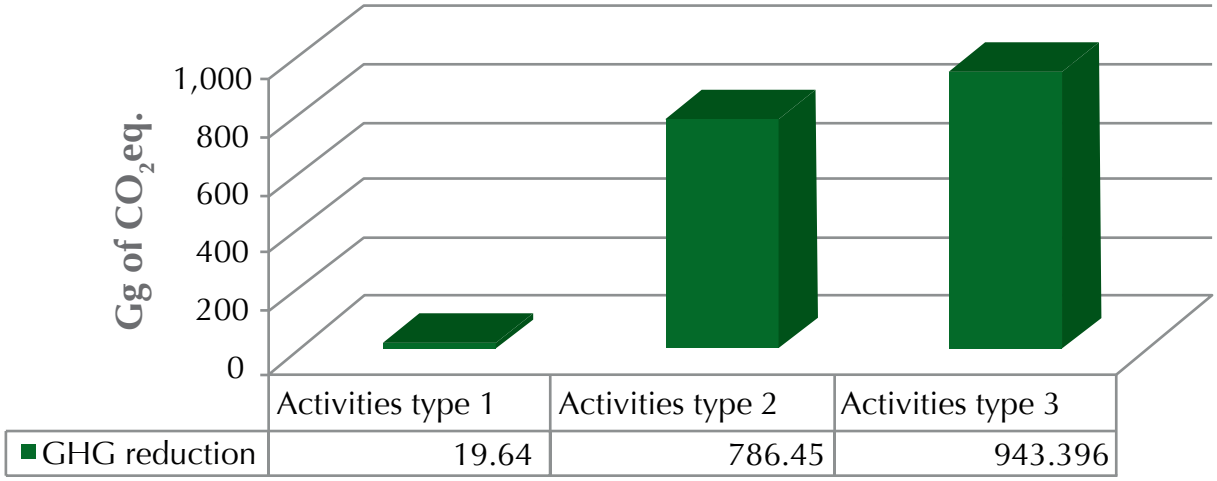
Managing wildfire risk in the Wildland-Urban Interface	
General information: This project worked towards a better assessment and management of wildfire risk in the wildland-urban interface through gaining from the US experience.	
Implementing agency	University of Balamand
Geographical coverage	All of Lebanon
Budget	USD 104,635
Timeframe	2012-2014
Source of funding	USAID-PEER (Partnerships for Enhanced Engagement in Research)
Goals: To develop the capacity of stakeholders in Lebanon to assess and manage wildfire risk in Lebanon's WUI (Wildland-Urban Interface) in light of future climate change and human development in wildland areas and improve knowledge and understanding among university students, local community groups, and municipalities about the nature and risks of wildfire in Lebanon's WUI	
Achievements or progress	- Development of a wildfire-climate model and maps for Lebanon - Incorporation of wildfire risk assessment and management in educational materials - Development of a web-application for improved decision making in forest fire risk management
GHG reduction	N/A
Emission reduction expected by completion of action	38.23 Gg of CO_2eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the action succeeded in suppressing 10% of the fires (out of the 2,151 ha that burned in 2012) within the first 20 minutes from fire occurrence

Table 26: Partnership for protection of forests in Lebanon

Partnership for protection of forests in Lebanon	
General information: This project established a partnership with Lebanon Reforestation Initiative and the United States Forest Service for improved protection of forests in Lebanon especially against wild-fires.	
Implementing agency	AFDC in partnership with Lebanon Reforestation Initiative and United States Forest Service
Geographical coverage	Different locations in Lebanon
Budget	N/A
Timeframe	2012-2014
Source of funding	USAID
Goals: To provide training and equipment for forest fire control	
Achievements or progress	- Training of 60 volunteers from different forest areas on forest fire fighting tools and techniques - Equipping the trained volunteers with equipment for early forest fire intervention - Training of trainers for 120 members of the Lebanese Army Forces (LAF) forces on forest fire fighting - Equipping the trained LAF forces with equipment for early forest fire intervention
GHG reduction	N/A
Emission reduction expected by completion of action	38.23 Gg of CO_2eq.
Methodology	IPCC GPG for LULUCF 2003
Assumptions	Assuming that the action succeeded in suppressing 10% of the fires (out of the 2,151 ha that burned in 2012) within the first 20 minutes from fire occurrence

7.3. Summary of GHG mitigation measures from LULUCF

Overall, the total GHG reduction from reforestation/afforestation activities conducted between 2005 and 2012 is 19.64 Gg of CO_2 equivalent. The total GHG reduction from forest fire management activities within the same time frame is 786.45 Gg of CO_2eq. (taking into account all presented assumptions). Finally the total emission reduction expected by completion of the presented actions is 943.396 Gg of CO_2eq. (Figure 32).



Activities type 1: Reforestation/afforestation
Activities type 2: Fire management
Activities type 3: Expected reduction of uncompleted actions

Figure 32: Summary statistics of GHG reduction from mitigation actions of the land use, land-use change and forestry sector in Lebanon between 2005 and 2012

8. Mitigation options

Mitigation scenarios are proposed plans and projects that have a potential for sectorial emission reduction or sink enhancing. Furthermore, mitigation options should be selected and analyzed mainly according to their direct and indirect economic impact, consistency with national development goals, and economic feasibility.

The SNC previously suggested the following mitigation options in the forestry sector:

- Scenario 1: Maintaining and conserving existing forest carbon sinks
- Scenario 2: Afforestation and reforestation including agroforestry and sylvo-pastoral systems
- Scenario 3: Substituting fossil fuels by forest-based biofuels

Several measures through which these mitigation options can be implemented have been proposed (Table 27):

Table 27: Measures for achieving mitigation scenarios proposed in the SNC

Mitigation scenario 1
- Adopting sustainable forest management practices (grazing, Non-Woody Forest Product (NWFP)) and harvesting of wood in forests and Other Wooded Land (OWL) to address the possible threats to these ecosystems and improve their status - Preventing forest degradation and habitat fragmentation through sustainable management, land use management, insect and pest management and forest fire fighting strategies, which will provide stability for ecosystems to permit the establishment of ecological equilibrium, and therefore the reduction of habitat loss and degradation - Rehabilitating abandoned lands and degraded zones to ensure natural or assisted forest regeneration and development Additional activities for forest protection, management and monitoring: - Clipping of wood and pruning of trees, including transportation of pruning residues - Clearing of grass and weeds along the borders of all roads surrounding forests and OWL on a yearly basis for the purpose of fire protection - Equipping vehicles with water tanks and pumps for patrolling all forest and OWL areas - Charging forest guards with monitoring a specific region to prevent fires and control grazing and deforestation of newly reforested areas. Violations would be dealt with in coordination with the Internal Security Forces, and setting up a communication system between guards - Managing pests in forests and OWL by spraying pesticides by plane
Mitigation scenario 2
- Implementation of the NRP, which stipulated the use of native species in each site according to the ecological criteria, the climate and soil characteristics in the related ecosystem and which has banned the introduction of non-native species - Conservation and implementation of a management strategy for the forest genetic resources conservation, including the management of seeds provenances - Including efforts of agroforestry or even urban greening (recreation areas, urban parks, etc.), linking forests and OWL through corridors and creating contiguous forest lands to reduce habitat fragmentation
Mitigation scenario 3
OWL can serve as the main source of biofuel from wood clipping and sylviculture practices. The density of forests and OWL can also be reduced to provide biofuel while also reducing the fire risk.

Source | MoE/UNDP/GEF, 2011

New and improved data and methodology were used in the TNC to estimate and report the greenhouse gas emissions resulting from changes in the LULUCF sector in Lebanon for the period of 1994-2012. Most importantly, the adopted method involved the use of up-to-date remote sensing techniques as part of the approach 3 in the "Good Practice Guidance" adopted by the IPCC (2003), which allowed more precise estimation of land-use and land-cover change areas. The LULUCF sector proved to be a major sink for GHGs with an average of 3,321 Gg/year of

CO_2eq. sequestrated over the inventory period of 1994 to 2012. A 12% net decrease in CO_2 removals from the LULUCF sector was recorded between 1994 and 2012. This was 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.

In this context, there was a need to design and develop mitigation actions that could help in maintaining and/or increasing carbon removals from this sector, especially by targeting the forest cover which is one of the main sources of GHG emissions and removals of the sector. Accordingly, proper mitigation needed to be identified and analyzed along with their potential economic instruments.

The purpose of this work was to propose certain measures to reduce GHG emissions and enhance carbon sinks in the country based on the findings of the most recent LULUCF National GHG Inventory and taking into account what has been achieved in the Second National Communication (MoE/UNDP/GEF, 2011). The work involved extensive literature review about 1) economic instruments for environmental protection, 2) the economic perspective of forest development, and 3) policy instruments for environmental and natural resource management (an application for forestry and LULUCF in general).

9. Background information

9.1. Facts about the forest sector in Lebanon

The review of previously developed Forest Resources Assessment (FRA) reports in addition to other reports and documents addressing the forest sector in Lebanon highlighted some important facts (FAO, 2005, FAO, 2010, Mitri and El Hajj, 2008 and MoE/UNDP/GEF, 2011):

- The majority of forests and other wooded land are privately owned (60.4% and 80% respectively) (FAO, 2005).
- 97.4% of forests are production forests (FAO, 2005).
- 85.1% of forests are somehow disturbed by human activity (FAO, 2005).
- Fuelwood collection represents the main activity undertaken in these forests followed by plant food collection. Several other products such as honey, pine, oregano, sumac are collected from the forests.
- Main threats to the forest cover include: fire, insects, diseases, urban expansion, changes in land-use, quarries and armed conflict.
- There are gaps in Lebanese legislation/policies on forestry:

    a) Lack of a forest policy statement
    b) Lack of management rights of public forests
    c) Lack of a national forest program (there is one under development at the Ministry of Agriculture)

d) Overlapping responsibilities among the Ministry of Agriculture, the Ministry of Environment, the Ministry of Interior and Municipalities and the Council for Development and Reconstruction

e) Lack of efficiency, coordination, and resources in undertaking reforestation and afforestation activities

In this context, the establishment of a National Forest Authority was previously recommended (Mitri and El Hajj, 2008). In addition, Lebanon's National Strategy for Forest Fire Management was endorsed in 2009 (decision no. 52/2009) (AFDC/MoE, 2009).

9.2. Lebanon's National Strategy for Forest Fire Management

Lebanon's National Strategy for Forest Fire Management (AFDC/MoE, 2009) aimed at reducing the risk of intense and frequent forest fires whilst allowing for fire regimes that are socially, economically and ecologically sustainable. It highlighted the importance of fire management in Lebanon within a risk-management framework, known as the 5Rs (Table 28): 1) research, information and analysis; 2) risk modification, including fire vulnerability reduction and prevention of harmful fires; 3) readiness, covering all provisions intended to improve interventions and safety in the event of fire; 4) response, including all means of intervention for fire suppression; and 5) recovery, including the rehabilitation and ecological restoration of healthy forest conditions, and the support to individuals and communities in the short and medium term aftermath of the fire.

Table 28: The five components for the implementation of Lebanon's National Strategy for Forest Fire Management

Component 1: research, information and analysis	To support and promote the improvement, know-how sharing, monitoring and dissemination of knowledge on fire ecology, fire management and post-fire vegetation dynamics among all relevant actors (science/research, policy makers, land managers, grassroots' groups), bridging science and traditional knowledge
Component 2: risk modification	To develop effective measures intending to reduce fire vulnerability, increase ecological and social resilience to fire, and prevent the occurrence of harmful fires and unsustainable fire regimes. Minimizing the risk of fire and preventing harmful fires has four main elements: a) The adoption of spatial planning processes to ensure that natural and built assets are identified in relation to fire risk and to agree on landscapes with more resilient types of land uses and spatial distribution of uses and infrastructures within territorial units b) The adoption of management practices within the landscape to help minimize the risk of damage to: life, the natural environment, and built assets c) The establishment of policies and economic instruments to support land owners, users and managers in the adoption of risk reduction management practices and land uses d) The reduction of the frequency of ignitions from arson and carelessness

Component 3: readiness	To undertake all possible provisions by individuals, communities and fire and land management agencies so they are prepared before a fire event occurs, and improve interventions and safety by monitoring the probability of fire and detecting the event of fire.
Component 4: response	To suppress the fires within the first 20 minutes after they start and limit the extension of fires; this is done through the development of procedures, methods and techniques coupled with appropriate material and very well trained personnel. The highest levels of preparedness should be observed during high fire risk periods. Activities should be undertaken in close collaboration among all concerned stakeholders; they include: a) Building the capacities of the Civil Defense and empowering them to fight forest fires b) Training other stakeholders to suppress fires by organizing common training activities so they are able to assist the Civil Defense and to interfere at the early stages of the fire, thus preventing its expansion c) Developing the capabilities of air firefighting through helicopters d) Developing an appropriate legal framework and empowering law enforcement agencies to better prosecute those in charge of voluntary or non-voluntary (accidental) fires e) Developing and implementing an appropriate legal framework for the establishment of a common forest-fire operations room or another arrangement that would ensure the coordination of fire suppression activities and implement the most appropriate coordination mechanism among all concerned stakeholders f) Providing firefighting personnel, including NGOs and CBOs (Community-Based Organizations) with the most adapted and most appropriate equipment, based on their level of intervention as a stakeholder g) Monitoring fires after suppression to prevent them from restarting h) Improving the role of municipalities in fire suppression

Component 5: recovery	To provide support for individuals and communities in the immediate aftermath of the fire as well as in the medium and long term efforts of community and economic renewal, and restore healthy ecological conditions of the burned forest land to facilitate the natural recovery of vegetation and increase forest resilience against future fires. Activities to be undertaken in close collaboration among all concerned stakeholders include: a) Analyzing the post-fire emergency needs of individuals and communities and establishing a 'Solidarity Fund' that gives them adequate support b) Mapping fire affected areas and assessing the impact of fire on different vegetation types c) Prohibiting grazing in burned forests (forest law prohibits grazing for the 10 years following a destructive forest fire) and prohibiting land-use change of a burned forest for the 10 years following a fire d) Implementing activities aiming at the reduction of soil erosion when the winter starts, as erosion is one of the most severe fire consequences e) Developing post-fire active restoration/rehabilitation protocols and activities (forest landscape restoration), facilitating natural forest regeneration and undertaking reforestation activities in areas where regeneration is not possible f) Supporting ecological restoration actions undertaken by the department of forests and natural resources to recover resilient vegetation types for reducing fire risk and assisting the natural regeneration by protecting the burned ones g) Developing post-fire snags and woody debris management guidelines for the Lebanese forest ecosystems and forest areas, and modifying the existing legislation that prohibits the removal of burned trees accordingly h) Develop a national reporting system, based on statistics as well as the common post-fire identity cards and expand a national data base on forest fires, their occurrence, the ecosystems where they emerge and the exact climatic conditions at the time of emergence; this would substantively contribute to better manage the forest fires in the future i) Involving the local communities in the different activities related to post-fire management in addition to identifying socio-economic opportunities to link forest restoration and local development

9.3. Reforestation initiatives in Lebanon

Pioneer reforestation projects have started during the late 1960s and early 1970s. During the past decade, Lebanon has initiated a number of programs/initiatives to restore forested lands. Such programs/initiatives included: 1) the development of the NRP by 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, and 4) the launching of the project "planting four million forest trees" by the MoA in 2012.

The national reforestation initiatives have been complemented by the simultaneous implementation of several other initiatives undertaken by local NGOs including, among others: 1) the LRI launched in 2012 with the support of the international program of the USFS and USAID to provide needed support in large-scale reforestation activities across the country, 2) the AFDC established in 1993 to achieve sustainable community-based conservation of forests and natural resources, raise awareness and build capacities to contribute to the national efforts for better environmental management, and 3) Jouzour Loubnan founded in 2008 and whose mission is to participate in the restoration of Lebanese woodland and promote sustainable reforestation mainly in arid regions.

9.4. National reforestation fund

Lebanon lacks active and properly operational financial instruments to sustain large-scale reforestation/afforestation initiatives in the country. One of the main identified potential financial instruments comprised the "Reforestation Fund" (so-called Sandouk al Tahrij) which was stipulated by the forest law of 1949 (article 98). The "Reforestation Fund" stipulates that the fines, belonging to the state, levied for forest infractions and the fines levied for violation of the provisions of the agricultural laws and regulations are paid to the Treasury Fund on behalf of the MoA to be allocated for public afforestation activities after the approval of the Commission provided for in article 89. It is to be noted that the "Reforestation Fund" has been inactive for a long period of time without the presence of any significant initiative to re-activate it.

10. Proposed mitigation scenarios, instruments and expert evaluation

10.1. Baseline scenario

The baseline scenario was developed based on the trend data from 1999 to 2012. Forest lands were specifically targeted in this scenario since they have one of the largest contributions to the changes in emissions and removals from the LULUCF sector. 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 forest lands by afforestation between 1999 and 2012 were added to the forest land area after 20 years of their conversion.

10.2. Mitigation options

Two mitigation scenarios were proposed. Each of the mitigation scenarios has addressed the emissions and removals from changes in the LULUCF sector so as to reduce emissions and increase removals.

Mitigation scenario 1: maintaining the current extent of Lebanon's forest and other wooded land cover

Scenario 1 involved maintaining the current extent of Lebanon's forest and other wooded land cover (Table 29) through the reduction of new losses in the forest cover due to urbanization and through the compensation of losses to urbanization by afforestation/reforestation activities.

Table 29: Scenario 1 factsheet

Sector: LULUCF	
Subsector: forestry	
Description	
Title	Maintaining the current extent of Lebanon's forest and other wooded land cover
Introduction (brief description on the strategy/policy/project)	Lebanon's forests and other wooded land cover are proved to be a major carbon sink compared to other sectors as they largely contribute to removing CO_2 emissions from the atmosphere. This cover is majorly affected by: 1) annual loss of vegetation due to urbanization, and 2) intense and relatively large wildfires. Accordingly, this scenario suggests maintaining the extent of the current forest and other wooded land cover by: 1) Reducing the extent of new losses in the cover due to urbanization 2) Compensating the annual loss to urbanization through afforestation/ reforestation activities 3) 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) 4) 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)

GHG reduction	
Baseline	Calculations are based on trend data of 1999-2012. The following cumulative averages were taken into account: 1) Cumulative annual average (1999-2012) decrease in forest areas to urbanization from 2012 to 2030 2) Cumulative annual average (1999-2012) afforestation areas from 2012 to 2030 3) Cumulative annual average (1999-2012) forest fire areas from 2012 to 2030 Based on the above: - The total net cumulative removals from the LULUCF sector until 2030 are 5,5547.14 Gg CO_2eq. - The total net cumulative emissions from the changes in the LULUCF sector until 2030 are 6,760.5 Gg CO_2eq.
Reduction potential	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_2eq. (approx. 0.57%). 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_2eq. (approx. 12%). Total cumulative reduction potential of mitigation scenario 1 is equal to 852 Gg CO_2eq. (approx. 12.57%). It should be noted that the prevention of large and intense wildfires contributes to 95.42% of the emission reduction of the mitigation scenario.
Timeframe for implementation	Short to medium

Mitigation scenario 2: increasing the current extent of Lebanon's forest and other wooded land cover 7% by 2030

Scenario 2 involved increasing the current extent of Lebanon's forest and other wooded land cover 7% by 2030 (Table 30) through afforestation/reforestation activities in line with the national programs, initiatives, and previously identified principles (Box 1) to restore forested lands.

Table 30: Scenario 2 factsheet

Sector: LULUCF	
Subsector: forestry	
Description	
Title	Increasing the current extent of Lebanon's forest and other wooded land cover 7% by 2030
Introduction (brief description on the strategy/policy/project)	The current cover of forests and other wooded land is 24.3%. This scenario suggests: 1) Increasing the current extent of Lebanon's forest and other wooded land cover up to 31.3% through afforestation 2) Facilitating the natural post-fire recovery of vegetation (fifth component of the national fire management strategy decision no. 52/2009) 3) 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 (244.78 ha/year). Therefore, the total area for afforestation is around 4,309 ha/year.
GHG reduction	
Baseline	Calculations are based on trend data of 1999-2012. The following cumulative averages were taken into account: 1) Cumulative annual average (1999-2012) decrease in forest areas to urbanization from 2012 to 2030 2) Cumulative annual average (1999-2012) afforestation areas from 2012 to 2030 3) Cumulative annual average (1999-2012) forest fire areas from 2012 to 2030 Based on the above: - The total net cumulative removals from the LULUCF sector until 2030 are 5,5547.14 Gg CO_2eq. - The total net cumulative emissions from the changes in the LULUCF sector until 2030 are 6,760.5 Gg CO_2eq.

Reduction potential	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_2eq. (approximately 26.5%). Preventing large and intense wildfires: the cumulative reduction potential from 2013 to 2030 is equal to: 813 Gg CO_2eq. (approximately 12%). Total cumulative reduction potential of mitigation scenario 2 is equal to 2,605 Gg CO_2eq. (approximatly 38.5%). It should be noted that the prevention of large and intense wildfires contributes to 31.2% of the emissions reduction of the mitigation scenario.
Timeframe for implementation	Medium to long

Box 1: Principles for forest landscape restoration in Lebanon

A recent publication in Lebanon comprised a numbers of measures that can help managers in forest landscape restoration activities (Navarrete Poyatos et al., 2011):

- Prioritize soil conservation and water regulation: loss of fertile soil remains the main reason for land degradation

- Use native species: non-native species often lack natural control mechanisms like pests or competition and can become invasive thereby threatening local biodiversity

- Conserve and support biodiversity: restoration must safeguard the biological diversity of species at all scales

- Promote diversity and heterogeneity at the landscape scale: varied patches of vegetation at landscape level reduce vulnerability to perturbations and increase resilience

- Design reforestation activities according to forest-fire prevention principles: although restoration techniques very often imitate the successional stages of the vegetation, intermediate stages with highly flammable components must be avoided

- Promote forest multi-functionality and productivity: strike a balance between traditional goods and services, such as timber products, and new values demanded by society including recreation and carbon sequestration

Available tools to achieve the above principles included:

- The implementation of Lebanon's strategy for forest fires management (AFDC/MoE, 2009)

- The establishment of native forest trees' nurseries: when planting trees, it is always best to utilize native tree and shrub seedlings from a locally adapted seed source because they are better adapted to Lebanon's extremes in weather and to regional planting sites. They are less likely to be stressed than non-native plants and they are more resistant to insect and disease attacks (AFDC, 2008). Accordingly, a handbook was provided that covers all the technical aspects of restoration from seed collection through seedling production in the nursery, to planting out in the field. (Navarrete Poyatos et al., 2011).

Box 1: Principles for forest landscape restoration in Lebanon

- The use of mapping tools: one of the recent mapping tools is "The Reforestation Web-Mapping Platform of Lebanon" (www.lri-lb.org), developed by Lebanon Reforestation Initiative (LRI). It is a user-friendly mapping database that will serve as an online reference center for sustainable reforestation in Lebanon. The new reforestation mapping platform delivers cutting-edge online interactive maps that are accessible and easily used by reforestation practitioners to identify priority sites for reforestation, monitor forest tracks, anticipate appropriate native tree species and consider forest fire threats – all at a high community-level resolution. Maps include an updated digital vegetation map of Lebanon, environmentally suitable reforestation sites nationwide including their biophysical characteristics, and recommended native tree species to be planted. Also, maps about fuel type, fire hazard, and burned areas were developed by the Biodiversity Program - Institute of the Environment at the University of Balamand (BP-IOE-UOB) and were integrated in the mapping tool to provide updated and detailed online mapping information about wildland fire risks by locality.

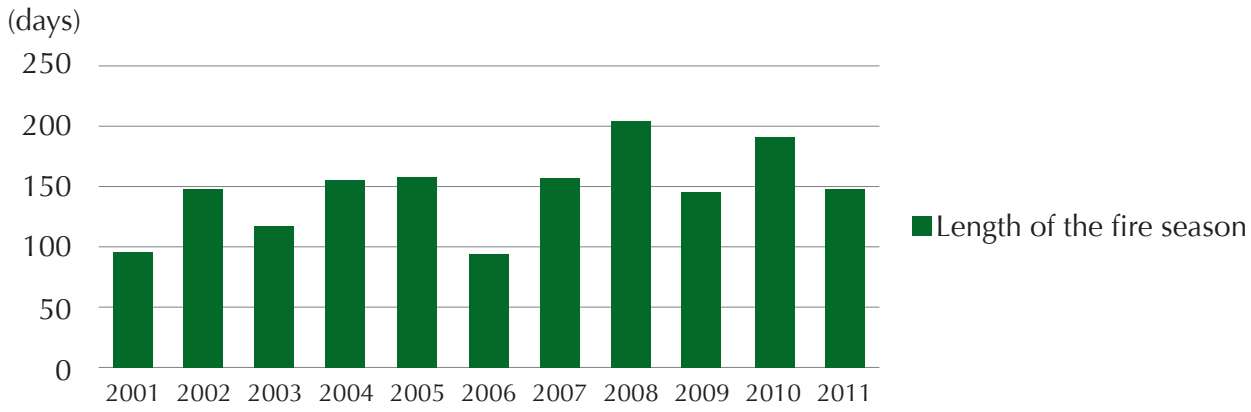
10.3. Forest fire considerations

Both scenarios involved the implementation of Lebanon's National Strategy for Forest Fire Management (AFDC/MoE, 2009). More specifically, the two scenarios involve mainly the adoption of the second, fourth and fifth components of the strategy. Box 2 included the most recent research findings in assessing and managing wildfire risk in Lebanon under a climate and socio-economic change scenario in Lebanon undertaken within ongoing research at the BP-IOE-UOB and especially within the framework of the USAID funded project "towards a better assessment and management of wildfire risk in the WUI in Lebanon: gaining from the US experience". The primary objective of the project was to use models to identify areas most vulnerable to wildfire risk due to changing fuel conditions, land-use and climate warming. This project was managed by BP-IO-UOB and funded by the USAID in agreement with the US National Academies of Science (NAS).

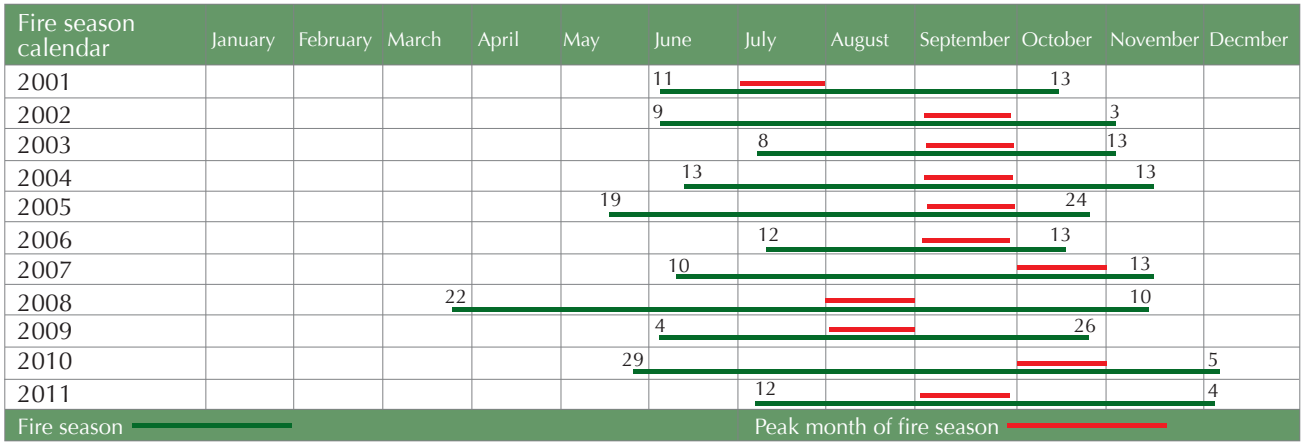
Box 2: Towards an improved fire risk assessment and management in Lebanon

Salloum and Mitri (2013) investigated the yearly temporal pattern of fire activity and its relationship to weather in Lebanon during the past decade. The results showed that the length of the fire season has been increasing on an average of 5.2 days during the past decade. Also, it was found that the average start date of the fire season was 14 June, while the average end date of the fire season was 12 November, and the average peak month was September.

Fire occurrence was positively correlated with mean monthly temperatures, and the length of the fire season was negatively correlated with mean annual precipitation. In addition, an increasing fire occurrence risk was observed in association with high maximum temperatures and long dry seasons.

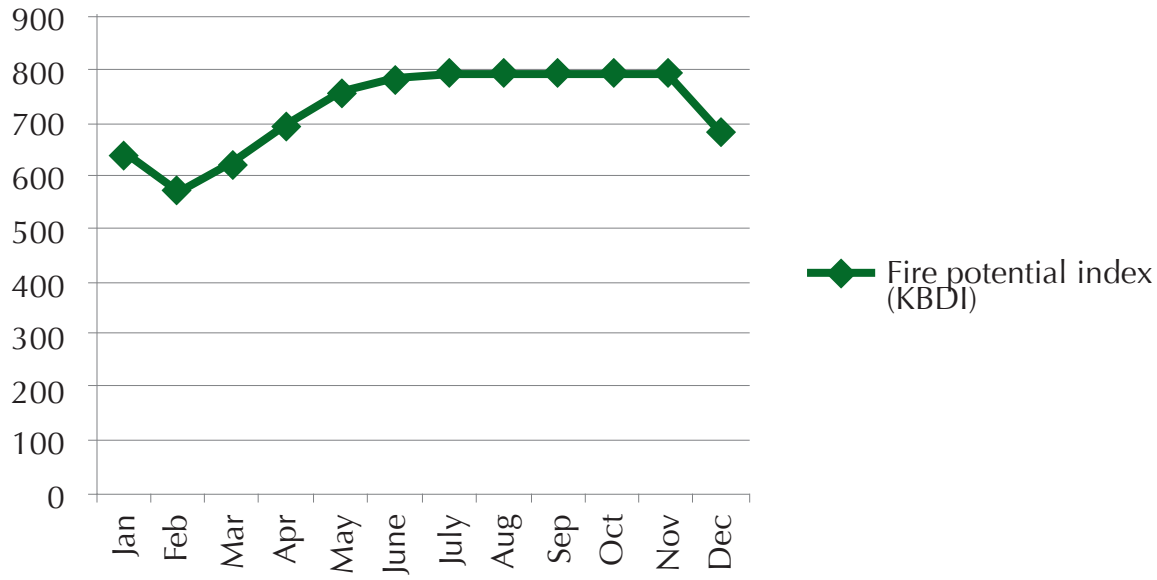


Temporal variation in the length of the fire season.



Fire calendar of 2001 throughout 2011

Mitri et al. (2013) evaluated wildfire potential by measuring the Keetch-Byram Drought Index (KBDI). It is an index used to determining forest fire potential. The drought index is based on a daily water balance, where a drought factor is balanced with precipitation and soil moisture. The drought index ranges from 0 to 800, where a drought index of 0 represents saturated soil (no moisture depletion), and an index of 800 represents absolutely dry conditions. In addition, a number of fire risk related maps (e.g. Lebanon's wildfire hazard in the wildland-urban interface map, Lebanon's overall wildfire risk map as a product of biophysical and socio-economic risks, and Lebanon's biophysical-based wildfire risk map as a product of wildfire hazard and vulnerability) were made available on the project's webpage. (home.balamand.edu.lb/wildfire)



Variation of KBDI throughout the year for current climatic conditions of a location in North Lebanon at an elevation of 195 m

10.4. Reduction potentials

The results of the mitigation scenarios (Figure 33) indicate a 12.57% reduction potential for scenario 1 and 38.5% reduction potential for scenario 2 in comparison to the baseline scenario.

Scenario 1 reduction potential is due to two mitigation actions: 1) reducing and compensating losses due to urbanization by afforestation (0.57% reduction potential) and 2) preventing intense and large wildfires (12% reduction potential). Scenario 2 reduction potential is due to the following mitigation actions: 1) increasing the forest cover by afforestation including the compensation of losses due to urbanization (26.5% reduction potential) and 2) preventing intense and large wildfires (12% reduction potential).

It was found that preventing forest fires was the most effective action in reducing GHG emissions in scenario 1 (95.42% contribution); whereas afforestation activities have the largest effect in reducing GHG emissions in scenario 2 (68.8% contribution). Generally, fire prevention would involve short to medium-term activities, while afforestation would involve medium-to long term activities.

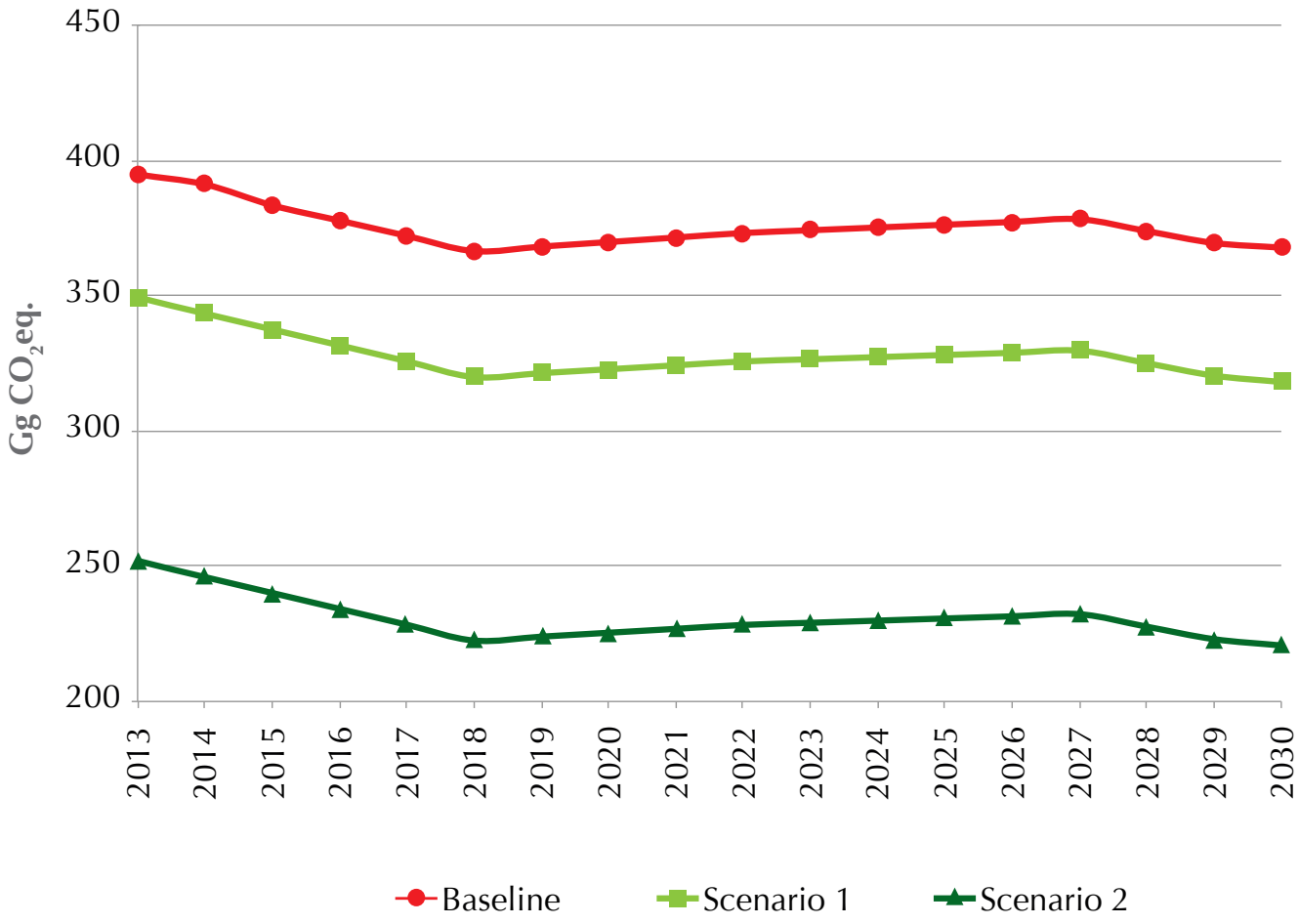


Figure 33: Net emissions from the changes in the LULUCF sector: baseline versus mitigation scenarios

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 (as shown in Figure 33).

10.5. Economic instruments

A number of economic instruments for maintaining and increasing the forest cover were investigated. Their definitions as well as examples of their implementation are presented in the below factsheets (Table 31, Table 32, Table 33 and Table 34).

Table 31: Payment for environmental services

Instrument name	Payment for Environmental Services (PES)
Instrument definition	"A voluntary transaction where a well-defined Environmental Service (ES) (or a land-use likely to secure that service) is being 'bought' by an ES buyer (minimum one) from an ES provider (minimum one) if and only if the ES provider secures ES provision (conditionality)" (Wunder, 2005).
Instrument applicability	Carbon sequestration and storage, protection of biodiversity, protection of watershed and landscape beauty
Case studies around the world	Costa Rica: - Instrument applicable to several services provided by forests: water, biodiversity, carbon sequestration, landscape - Landowners present a sustainable forest management plan prepared by a licensed forester. They receive payment if the plan is approved. - Forest conservation contracts payments reached USD 64 /ha/year. - Duration of contract: 5 years - Bulk of the financing of the program: fuel tax - Impact: 270,000 ha enrolled by end of 2005 Colombia: - Compensation to landowners for the cost of conservation of undisturbed forest ecosystems - Incentive was defined by government and NGOs.
Sources	Pagiola, 2006 and Gaviria, 1996

Table 32: Subsidies

Instrument name	Subsidy for reforestation
Instrument definition	"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. The subsidy is usually given to remove some type of burden and is often considered to be in the interest of the public".
Case studies around the world	Colombia: Certificate for Forestry Incentive which subsidized 50% of the cost of reforestation with exotic species and 75% of the cost of reforestation with native species. This subsidy was directed towards medium-sized owners. In addition to this program, the government promotes reforestation via subsidies financed by international organizations.
Sources	Gaviria, 1996

Table 33: Conservation payment programs for land conversion

Instrument name	Conservation payment programs for land conversion
Instrument definition	Establishment of a payments system for farmers to convert agricultural land to other uses, including forests or agroforestry. However, one must be careful because afforestation seems to be a by-product of these programs and not an end by itself.
Case studies around the world	Conservation Reserve Program (USA): - Main objective: reducing soil erosion due to agriculture with secondary objectives such as habitat creation, better water quality, and income transfer to farmers - Enrolled farmers receive payments for converting erodible or sensitive cropland to grass and/or trees through a 10-year contract. - End of 2005: 35.9 acres enrolled at a cost of USD 1.8 billion Permanent Cover Program (Canada): - Objective: conserve and improve soil productivity by retiring crop land suffering from soil damage - 1.3 million acres of cropland converted to forests. - Payments made to farmers: USD 15 and 22 per acre for 10 year contracts and USD 36 and 47 per acre for 21 year contract for pasture and forest Europe (EU): - Afforestation scheme which pays for afforestation of agricultural land to reduce wood shortage - Farmers receive payment for afforestation and for conservation. - By 1997, this scheme had converted 930,000 ha of land for a cost of USD 2.6 billion.
Sources	Chen et al., 2009

Table 34: Community forests

Instrument name	Establishment of community forests
Instrument definition	According to FAO "community forestry" was initially defined as "any situation which intimately involves local people in a forestry activity. It embraces a spectrum of situations ranging from woodlots – in areas which are short of wood and other forest products for local needs, through the growing of trees at the farm level to provide cash crops and the processing of forest products at the household, artisan or small industry level to generate income – to the activities of forest dwelling communities". "The fundamental concept of community forestry is to establish community-based organizations through which forest users are given collective management responsibility (but not ownership for the local forests on which they depend for product flows" (Springate-Baginski et al., 2003).
Case studies around the world	England: - Established more than 10,000 hectares of new woodland - Brought more than 27,000 hectares of exiting woodland under management - Created or improved 12,000 hectares of other habitats - Planted or restored 1,200 km of hedgerows - Opened up 16,000 ha of woods and green-space for recreation and leisure - Restored/created more than 4,000 km of footpaths and cycle routes - Engaged and involved hundreds of thousands of people in finding out about and improving their local areas - Secured investment of over GBP 175 million to improve people's quality of life Nepal: - Emergence of community forests through a series of steps between 1975 and 1993 after nationalization of private forests - Initially adopted for improved resource management but also evolved into improved livelihoods - Formation of Forest User Groups (FUG); three types of users identified: regular forest users, occasional forest users and future forest users - Over 12,000 FUGs formed to date of article, managing 15% of forest land. Most FUGs found to be "diligently protecting their forests and regulating product extraction. The previous trend of widespread forest degradation has generally been reversed and communities are beginning to benefit from improved forest product flow".
Sources	communityforest.org.uk Springate-Baginski et al., 2003

10.6. Discussion and evaluation

The proposed economic instruments were evaluated based on expert judgment (expert meeting conducted on 09-09-2013 at the MoE, Annex VI). First, the main problems of the forestry sector in Lebanon were identified. Second, the most important laws/rules/regulations being applied to the forestry sector, their efficiency and the main issues facing their implementation were discussed (Table 35). Third, the proposed economic instruments were evaluated accordingly.

Table 35: Main problems of the forestry sector in Lebanon as identified by national experts

1) Land tenure rules/law enforcement: low control on forest activities conducted in privately owned forests under the decision no. 1/433 dated 30-08-2010

2) Absence of law enforcement and weakness in the policy implementation

3) Lack of awareness among the public about the importance of the forest cover

4) Urbanization: there is a need for collaboration with the DGUP, MoA and other entities such as the Order of Engineers and Architects (OEA) in order to coordinate an improved land zoning for the benefit of a reduced impact on the forest cover from urban expansion. The forest law 1949 (article 93) imposes on those who cut conifer trees to reforest/afforest an area of 2,000 m^2 for every 50 trees of the cut tree species. In contrast, more recent decrees related to the conservation of forest resources (no. 141-1977, no. 43 dated 17-03-1983, and no. 85 dated 07-09-1991) excluded some licensed or future construction projects and public works from the implementation of the above mentioned law.

5) Increasing problem of intense and large forest fires in the last decades

6) Poor land management: lack of enforcement of zoning decrees; in this respect the joint responsibility of municipalities and the DGUP should be emphasized.

7) Land classification problems: in some cases, the forest cover exists on what used to be abandoned agricultural land that evolved into forests. In that case, the owner is able to prove that the land is classified as agricultural. This enables the landowners to cut existing trees.

8) Absence of a monetary valuation of forestry services

9) Absence of sustainable forest management: this is mainly caused by the ongoing lack of national policies and programs.

10) Continuous decrease in the forest area due to urbanization, severe forest fires, illegal clear cutting and uncontrolled fuelwood gathering

11) Limited financial resources for reforestation activities that are a major obstacle for the restoration of the forest cover

12) Weak law enforcement concerning the controlled grazing in the newly reforested lands (law 1949, article 88)

13) Law 558 for the conservation of forests (nature reserves and others) is relatively well implemented. However, there are also special provisions in that law concerning buffer zones around the reserves where in principle the land owner does not have the right to exploit the land as wished (article 8).

14) Lack of implementation of the national land use master plan: "Schéma d'Aménagement du Territoire Libanais" (SDATL). The SDATL was endorsed in June 2009 (decree no. 2366 dated 20-06-2009). The master plan is a reference document for several administrations including the DGUP.

15) Legislative framework lacks an integrated approach and should be accompanied by a national policy or strategy for forest management.

The framework for evaluating the four proposed economic instruments was inspired by the Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis. Accordingly, the following have been identified for each instrument:

- Advantages (strengths)
- Disadvantages (weaknesses)
- External facilitating factors for the adoption of the instrument (opportunities)
- External hindering factors for the adoption of the instrument (threats)

"Payment for Environmental Services"

The fragmentation of land ownership in Lebanon and the increase in the value of built estate is a major obstacle for the implementation of PES. Local populations are usually not very interested in the realization of forest-based community activities especially given that most of them are small land owners and the income from environmental services of the forests cannot compensate that of real estate projects. However, PES might be more efficient with large land owners such as religious endowments. Nevertheless, many land owners can be motivated by the increasing need for a natural landscape, which in turn, positively affects property prices (increasing demand of having a property in areas where forests are dominant).

In addition, the acknowledgement of the long term economic services of forests might provide a solution to limit the problem of expanding quarries and stimulate the protection of forests with the provision of incentives, especially in communal lands. More specifically, the applicability of PES in areas where people are already harvesting non-wood forest products is increasing since payments for forest management activities would present an additional income (e.g. the successful cases of large stone pine forests in Jezzine and Metn).

In general, the successful implementation of PES would initially require a detailed environmental valuation of the services provided by forests. This would help in realizing the real value of a forest and, therefore, the importance of its protection.

"Subsidies for reforestation"

This instrument is similar to the existing "Reforestation Certificate" (namely, Ifedet El Tehrij) which is currently not properly implemented mainly due to a lack of incentives. The "Reforestation Certificate" was devised in the 1940s to help local communities planting forest land with a given right to harvest the forest in 20 years. This can be assimilated to subsidizing forestry management. It requires a sustained commitment from the community to maintain the new plantations. In this context, local community groups might ensure longer sustainability of the planted sites than temporarily elected municipal councils.

Subsidy for reforestation on private lands might mainly attract landowners with interest in planting their lands. Many native species are economically exploitable and can be planted on abandoned private land. It is however better applied on large privately owned lands. Similarly to the PES, a good economic valuation of the forests will provide incentives for conservation as well as a good basis for the calculation of the subsidy. When the subsidy takes the form of a tax reduction the implementation of the instrument becomes problematic due to an improper implementation of a tax payment system in Lebanon.

"Land conversion"

The most applicable land conversion in this context is the conversion of cropland to agroforestry which still provides the economic opportunities of agricultural products. However, the long-term investment of 20 years for a forest to become fully productive can be an issue of concern. Therefore, farm owners can be encouraged to start creating forest corridors around their agricultural land.

The implementation of such an 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 which can in turn be complementary to agriculture (e.g. wind breaks, and use of wood products in the production of wooden boxes for harvested crops, among others).

Other cases where land conversion could be applied involve unsuitable lands for agriculture such as steep slopes and rocky terrain. In addition, the introduction of trees into cities and residential areas could be a complementary alternative given the fact that urban sprawl is one of the main problems for the decreasing forest cover.

"Community forests"

A similar existing setting to community forests is being implemented in Lebanon by the forest law of 1949 (especially through what is called communal lands or "Mouchaa" by law – articles 54 to 63). In this case the municipality or the land committee rents municipal land to users and uses the income for developmental projects within the community. It also provides a source of income for communities through bidding for grazing and pruning for charcoal production (decree no. 1576 dated 05-04-1950).

The successful implementation of community forests requires a well-defined land management plan developed with cooperation among all residents of the community and involved public entities in order to agree on a specific land use (examples of such settings existed in Metn, Baabda, Aakkar, Anjar, and Sour regions).

It is to be noted that the absence of a detailed plan and monitoring system may result in the overexploitation of forest resources (e.g. overgrazing, uncontrolled pruning and fuelwood gathering, among others), in addition to possible managerial conflicts within the committees in charge of the land.

Table 36 provides a classification for the instruments according to the SWOT framework and summarizes the main points pertaining to the above mentioned instruments.

Table 36: SWOT analysis

Instrument	Strengths	Weaknesses	Opportunities	Threats
PES	- Contribution to maintaining the forest cover - Possibility of being a good alternative for limiting the expansion of quarries	- Implementation requires large public funds - Calculation of the payment might be problematic	- Need for natural landscape - Good economic valuation of the forest will make it possible to realize the value of the forest and the importance of its protection	- Mentality/culture - Limited applicability to certain regions/ large land - Fragmentation of land - Increase in the value of built estate
Subsidies	- Possibility to build on a similar existing instrument the "Reforestation Certificate"	-Difficulty in applicability to owners of small lands - Improper implementation of a tax payment system in Lebanon impeding the implementation of tax reduction	- Good economic valuation of the forest is a requirement	- Mentality/culture
Land conversion	- Applicability in regions where land doesn't have a very high value (e.g. steep slopes)	-	- Creation of agroforestry corridors around agricultural land	- Long time frame for conversion/ investment
Community forests	- Source of income for communities	-	- Need for a land management plan	- Risk of overexploitation of rented land - Conflict within the land committees

Table 37: Implementation framework of scenarios

Scenario	Objective	Economic instruments	Activities	Target group	Public authorities in charge
Mitigation scenario 1	Maintaining the current extent of Lebanon's forest and other wooded land cover	- Payment for Environmental Services (PES) - Conservation payment programs for land conversion - Establishment of community forests	Reducing the extent of new losses in the cover due to urbanization	- Land owners - Municipalities - Local communities	- DGUP - MoA - MoE - MoIM - CDR
			Compensating the annual loss to urbanization through afforestation/ reforestation* activities	- NGOs - Municipalities - Local communities - Land owners - Farmers - Volunteers - Tree nursery owners - Research institutions - Private institutions	- MoA - MoE - CDR - MoIM - Ministry of Public Works and Transport (MoPWT) - CNRS
			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)	- National and regional research institutions - NGOs - Municipalities - Universities - Land managers (agriculture agents, rangers, etc.) - Land owners - Land users - Regional development offices (agriculture forestry) - Private enterprises - Residents and tourists in areas of risk - School children - Civil works managers - Local authorities - Regional/local governmental institutions - Local communities - Hunter associations - Forest guards	- MoA - MoE - Ministry of Education (MoEd) - Ministry of Defense (MoD) - MoIM - CNRS - CDR - Ministry of Economy and Trade (MoET) - Ministry of Energy and Water (MoEW) - Ministry of Justice (MoJ) - MoPWT

			Preventing large and intense wildfires by adopting the strategic objective from the fourth component (response) of Lebanon's National Strategy for Forest Fire Management (decision no. 52/2009)	- Forestry and natural resources department - Research institutions - NGOs - Municipalities - Decision makers from all relevant governmental departments - Forest guards - Volunteers - Fire brigade at the Civil Defense - Forest guards - Fire fighters - Fire fighters at the Lebanese air forces - Local community fire units - Local communities	- MoEd - MoE - MoA - MoIM - Directorate of Civil Defense - Lebanese Army - MoIM - MoJ
Mitigation scenario 2	Increasing the current extent of Lebanon's forest and other wooded land cover by 7% by 2030	- Subsidy for reforestation* - Conservation payment programs for land conversion - Establishment of community forests	Increasing the current extent of Lebanon's forest and other wooded land cover up to 31.3% through afforestation*	- NGOs - Municipalities - Local communities - Land owners - Farmers - Volunteers - Tree nursery owners - Research institutions - Private institutions	- MoA - MoE - CDR - MoIM - MoPWT - CNRS

Scenario	Objective	Economic instruments	Activities	Target group	Public authorities in charge
Mitigation scenario 2	Increasing the current extent of Lebanon's forest and other wooded land cover by 7% by 2030	- Subsidy for reforestation* - Conservation payment programs for land conversion - Establishment of community forests	Facilitating the natural post-fire recovery of vegetation (fifth component of the National Strategy for Forest Fire Management decision no. 52/2009)	- Municipalities - NGOs - Local communities - National research institutions - Universities - Forest guards - Land owners - Land managers and users	- MoIM - Directorate of Civil Defense - MoET - MoA - MoE - MoEd - CNRS - MoJ
			Preventing large and intense wildfires by adopting the strategic objective from the fourth component (response) of Lebanon's National Strategy for Forest Fire Management (decision no. 52/2009)	- Forestry and natural resources department - Research institutions - NGOs - Municipalities - Decision makers from all relevant governmental departments - Forest guards - Volunteers - Fire brigade at the Civil Defense - Forest guards - Fire fighters - Fire fighters at the Lebanese air forces - Local community fire units - Local communities	- MoEd - MoE - MoA - MoIM - Directorate of Civil Defense - Lebanese Army - MoJ
***Afforestation's potential funding sources and estimated costs**					
Funding agencies	- National: GoL (reforestation fund, national environmental fund, MoF-BDL (Ministry of Finance-Banque du Liban)), municipalities (revenues from forest investments), private sector - International: EU, FAO, International Union for Conservation of Nature (IUCN), UNDP (Global Environmental Facility (GEF)), USAID (USFS)				
Estimated build-up costs	- USD 15 per tree - USD 7,700 per hectare (for a total 4,309 ha/year) - Approximate cost: USD 33,180,000 per year (over 20 years)				

10.7. The scenarios' implementation framework

The implementation framework (Table 37) for the application of the proposed scenarios through the use of the appropriate economic instruments was formulated as per the experts' recommendations and the interpretation of the SWOT analysis results. It was found that "PES" could be mainly applied to scenario 1, while "subsidy" could be mainly applied to scenario 2, "land conversion" and "community forestry" could be applied to both scenarios.

10.8. Sources for funding and technical support

The need for a fund to finance the above mentioned instruments was emphasized. In this context, the "Reforestation Fund" (so-called Sandouk al Tahrij) stipulated by the forest law of 1949 (article 98) is the principal source of funding. However, the law needs reactivation and improved management through the responsible commission (article 89) consisting of the Minister of Agriculture as president, and the Ministry's Director General and the Chairman of the forestry department as members. Once reactivated, the "Reforestation Fund" can help in funding the implementation of the previously discussed instruments. It is needless to say that the reactivation of this fund might help in getting better access to international funds in the form of grants and loans, among others.

Also, the forest law of 1949 mentioned that municipalities and villages are required to keep the third of the net revenues from forestry products and forest investments as reserved funds for later afforestation/reforestation activities within the municipalities' lands. This resource can be used in the implementation of community forests as part of the mitigation actions.

Investigation of other potential sources for funding and possible financial support identified the following:

- The NRP: In 2001, the GoL allocated a fund of LBP 25 billion issued through the national budget law no. 326 date 28-06-2001. The MoE has handled the prerogative of initiating the NRP, aiming for the restoration of the country's green cover loss throughout the years. In 2009 the MoE resumed work on the NRP with supplemental funding of GEF and implemented by UNDP.

- The MoE drafted a decree to setup the National Environmental Fund (NEF) pursuant to law 444/2002. Accordingly, the fund would have a legal identity, financial and administrative autonomy, and would be under the mandate of the Ministry of Environment. Funding and fund replenishment would come from several sources including provisions in the Government of Lebanon's annual budget, environmental fees, grants, fines, and compensations, and interest on deposits. The final application decrees of the NEF are however not in place yet, and the fund is not functional until present.

- The MoF, through the central bank of Lebanon, Banque du Liban, introduced in 2001 a subsidized interest loan to support investment in three key economic sectors (industry, agriculture and tourism) - BDL circular 7743/2001. In June of 2009, BDL also introduced a

new policy to facilitate loans for environmentally-friendly projects (new projects as well as retrofits) –BDL circular 197/2009.

- In November 2010, the BDL further introduced new loan incentives to finance environmental projects in energy (renewable energy, energy efficiency, and green buildings) and non-energy – BDL circular 236/2010. The underlying pillars of BDL's policy to support green projects are longer loan maturity, lower interest rates, and no ceiling on loan amounts.

- The private sector is a very important partner that can financially help in conducting reforestation activities. The private sector proved to be an important partner in funding reforestation activities, especially after the fire events of 2007.

- Other international initiatives might also contribute to provide additional technical and financial support for reforestation activities. The US Forest Service (USFS) launched in 2010 a five-year and USD 12 million LRI.

All of these initiatives emphasize the opportunities which can be grasped in order to pool resources into a national fund with sustainable sources of income that will not only allow the implementation of forest-protection programs, but also allow for the funding of the proposed instruments.

11. Conclusions

The main objective of this work was to identify proper mitigation measures which would help in reducing GHG emissions and maintaining/increasing removals from the LULUCF sector in Lebanon. Accordingly, the following mitigation scenarios along with their economic instruments have been identified:

- Mitigation scenario 1: Maintaining the current extent of Lebanon's forest and other wooded land cover (while preventing large and intense wildfires considerations) with a reduction potential of 12.57% and time frame for implementation of short to medium-term. The relevant economic instruments for implementation comprised: PES, land conversion and community forests.

- Mitigation scenario 2: Increasing the current extent of Lebanon's forest and other wooded land cover by 7% by 2030 (while preventing large and intense wildfires considerations) with a reduction potential of 38.5% and a time frame for implementation of medium to long-term. The associated economic instruments for implementation comprised: subsidy, land conversion and community forests.

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" (so-called Sandouk al Tahrij) stipulated by the forest law of 1949 (article 98) represents a promising source for funding.

12. References

AFDC/MoE, (2009). Lebanon's National Forest Fire Management Strategy. Mitri G. (Ed.), Beirut, Lebanon.

AFDC, (2008). Forest Tree Nurseries. Assessment: Lebanon-2008. Mitri G. (Ed.), Beirut, Lebanon.

AFED, (2010). Arab Environment: Sustainable Management of a Scarce Resource. Chapter 2: Water Resources and Climate Change. 2010 Report of the Arab Forum for Environment and Development (AFED). Technical Publications and Environment and Development magazine, Beirut, Lebanon.

Aksu, B., As, N., Atik, C., Doğu, D., Erdinler, S., and Koç, H., (2001). Türkiye'de Yetişen Endüstriyel Öneme Sahip Ağaçların Anatomik, Fiziksel, Mekanik ve Kimyasal Özellikleri. İ.Ü. Orman Fakültesi Dergisi, 51, 71-88.

Altaş, M., Baygüven, B., Can, A., Katircioğlu, R., Koçer, Ü., Küsek, G., Ünal, E., (2007). Turkish National Inventory Report 2005 – submitted under the United Nations Convention on Climate Change. National Inventory Report, Ankara.

Chen X., Lupi F., He, G., Ouyang Z. and Liu J., (2009). Factors Affecting Land Reconversion Plans Following a Payment for Ecosystem Service Program. Biological Conservation, 142: 1740 – 1747.

England's Community Forests. (n.d.). Retrieved November 2014, from http://www.communityforest.org.uk/

Darwish, T., and Faour, G., (2008). Rangeland Degradation in Two Watersheds of Lebanon. Lebanese Science Journal, 9, 71-80.

FAO, (2005). National Forest and Tree Resources Assessment 2003-05 (TCP/LEB/2903). Working paper 95, Forest Resources Assessment, Forestry, Beirut.

FAO, (2010). Global Forest Resources Assessment 2010. Country Report: Lebanon, Forestry Department, Rome.

FAO, (2011). Country Pasture/Forage Resource Profiles - Lebanon, Asmar, F., Rome, Italy.

FAOSTAT, (2013). Browse Data. Retrieved May 22, 2013, from FAOSTAT: http://faostat3.fao.org/home/index.html#VISUALIZE_BY_DOMAIN

Gaviria D., (1996). Economic and Financial Instruments for Sustainable Forestry in Colombia. www.fao.org/docrep/w3247e/w3247e08.htm

Gerard, J. A., (2009). Manual Procedure: Forestry and Other Land Use.

Hreiche, A., (2009). Integrated Water Resources Management Planning in the Republic of Lebanon-Irrigation Needs and Management, EUWI MED.

IPCC, (2000). Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Hayama, Kanagawa, Japan: Institute for Global Environmental Strategies (IGES).

IPCC, (2003). Good Practice Guidance for Land Use, Land-Use Change and Forestry. Hayama, Kanagawa, Japan: Institute for Global Environmental Strategies (IGES).

Lebanon Reforestation Initiative, (n.d.). Retrieved November 2014, from http://www.lri-lb.org

Liu, Y., Jimenez, E., Okten, G., and Goodrick, S., (2013). Parametric Uncertainty Quantification in the Rothermel Model with Randomized Quasi-Monte Carlo Methods, International Journal of Wildland Fire.

Mitri, G. and El Hajj, R., (2008). State of Lebanon's Forests 2007. Mitri, G. (Editor) A publication of the Association for Forests, Development and Conservation (AFDC), the Italian Cooperation, WWF-Italy, UNDP, and the International Union for Conservation of Nature (IUCN).

Mitri, G., Salloum, L., and Nader, M., (2012). Forest Fuel Type Mapping in Lebanon. 18th International science meeting. 22-24 March 2013. Lebanon.

Mitri, G., Jazi, M, and McWethy, D., (2013). Spatial Modeling of Wildfire-Climate Risk in the Eastern Mediterranean – a research conducted within the project towards a better assessment and management of wildfire risk in the Wild-Urban Interface in Lebanon: gaining from the US experience (Mitri, G. PI).

MoE, (2012). Lebanon's National Report to the United Nations Conference on Sustainable Development - RIO+20. Lebanon: Wide Expertise Group.

MoE/UNDP/GEF, (2011). Lebanon's Second National Communication to the United Nations Framework Convention on Climate Change. Beirut. Lebanon.

MoE and UNDP, (1999). Lebanon's Initial National Communication under the United Nations Framework Convention on Climate Change. Beirut, Lebanon.

MoE/UNDP, (2011). State and Trends of the Lebanese Environment (SOER) 2010.

Navarrete Poyatos, M.A., Navarro Cerrillo, R., Palacios Rodríguez, G., Chnais, E. and Salman, H., (2011). Forest Nurseries in Lebanon for Native Species Production. Gland, Switzerland and Malaga, Spain: IUCN, Cordoba, Spain: University of Cordoba-IDAF, and Beyrouth, Lebanon: Association for Forest, Development and Conservation. viii + 120 pp. ISBN: 978 - 2 - 8317 - 1398 – 4

Pagiola S., (2006). Payments for Environmental Services in Costa Rica, Revised version of a paper presented at the ZEF-CIFOR workshop on payments for environmental services: methods and design in developing and developed countries, Titisee, Germany, June 15-18, 2005, http://siteresources.worldbank.org/

Salloum, L. and Mitri, G., (2013). Assessing the Temporal Pattern of Fire Activity and Weather Variability in Lebanon (In review).

Springate-Baginski O., Prakash Dev O., Prasad Yadav N. and Soussan J., (2003). Community Forest Management in the Middle Hills of Nepal: the Changing Context. Journal of Forest and Livelihood, 3(1): 5 – 20.

TRAGSA, (2012). General Protection Plan Against Forest Fires in Lebanon.

Trexler, M. and Gibbons, R., (1998). Land-Use Change and Forestry under the Kyoto Protocol. Linkages, 3(4).

Turner, B.L., Skole, D.L., Sanderson, S., Fischer, G., Fresco, L. and Leemans, R., (1995): Land-Use and Land-Cover Change: Science/Research Plan. IGBP Report No. 35 and HDP Report No. 7, International Geosphere-Biosphere Programme and Human Dimensions of Global Environmental Change Programme, Stockholm, Sweden, 132 pp.

UNEP (United Nations Environmental Programme), (2007). Lebanon Post-Conflict Environmental Assessment. ISBN: 978-92-807-2794-4

UNEP/MoE, (2013). Environmental Resources Monitoring in Lebanon project, Analysis of the Current Land Use and Socio-Economic Activities in the Coastal Zone (to be published).

UNFCCC, (2013). United Nations Framework Convention on Climate change. Official Website. http://unfccc.int/2860.php

Wildfire Risk Management Project, University of Balamand, (n.d.). Retrieved November 2014, from http://home.balamand.edu.lb/

Wunder S., (2005). Payments for Environmental Services: Some Nuts and Bolts. Occasional Paper No. 42. CIFOR, Bogor.

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
Settlements	This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions.	This category includes all developed land, including transportation infrastructure and human settlements.	Dense urban area	No disaggregation needed
			Unorganized dense urban area	
			Moderately dense urban area	
			Moderately dense unorganized urban area	
			Low density urban area	
			Low density unorganized urban area	
			Tourist resort	
			Archeological site	
			Large equipment	
			Industrial or commercial zone	
			Harbor zone	
			Airport	
			Train station	
			Highway	
			Other type of road	
			Farm building	
			Farm building with field crops	
			Farm building with deciduous fruit trees	
			Quarry	
			Dump	
			Sea filling	
			Urban sprawl and/or construction site	
			Vacant urban land	
			Green urban space	
			Large sport or leisure equipment	

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
Cropland	This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the threshold used for the forest land category, consistent with the selection of national definitions.	This category includes arable and tillage land. More specifically, the following classes were considered under this category: crops, olive groves, vineyards, deciduous fruit trees, bananas, citrus trees, and greenhouse cultivations.	Field crops in a large area	Annual
			Field crops combined with olive	Annual
			Field crops combined with vines	Annual
			Field crops combined with deciduous fruit trees	Annual
			Field crops combined with citrus trees	Annual
			Field crops combined with greenhouses	Annual
			Field crops in small plots or terraces	Annual
			Urban sprawl on field crops	Annual
			Olives	Perennial
			Olives combined with field crops	Perennial
			Olives combined with vines	Perennial
			Olives combined with deciduous fruit trees	Perennial
			Olives combined with citrus trees	Perennial
			Olives combined with intensive field crops	Perennial
			Olives combined with greenhouses	Perennial
			Vineyards	Perennial
			Vineyards combined with field crops	Perennial
			Vineyards combined with olives	Perennial
			Vineyards combined with deciduous fruit trees	Perennial
			Vineyards combined with intensive field crops	Perennial
			Vineyards combined with greenhouses	Perennial
			Deciduous fruit trees	Perennial
			Deciduous fruit trees combined with field crops	Perennial
			Deciduous fruit trees combined with olives	Perennial

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
			Deciduous fruit trees combined with vines	Perennial
			Deciduous fruit trees combined with citrus trees	Perennial
			Deciduous fruit trees combined with banana trees	Perennial
			Deciduous fruit trees combined with intensive field crops	Perennial
			Deciduous fruit trees combined with greenhouses	Perennial
			Citrus trees	Perennial
			Citrus trees combined with field crops	Perennial
			Citrus trees combined with olives	Perennial
			Citrus trees combined with deciduous fruit trees	Perennial
			Citrus trees combined with banana trees	Perennial
			Citrus trees combined with intensive field crops	Perennial
			Citrus trees combined with greenhouses	Perennial
			Banana trees	Perennial
			Banana trees combined with deciduous fruit trees	Perennial
			Banana trees combined with citrus trees	Perennial
			Banana trees combined with intensive field crops	Perennial
			Banana trees combined with greenhouses	Perennial
			Urban sprawl on orchard	Perennial
			Intensive filed crops	Annual
			Intensive filed crops combined with olives	Annual
			Intensive filed crops combined with deciduous fruit trees	Annual
			Intensive filed crops combined with citrus trees	Annual
			Intensive filed crops combined with greenhouses	Annual
			Greenhouses	Annual

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
			Greenhouses combined with field crops	Annual
			Greenhouses combined with vines	Annual
			Greenhouses combined with deciduous fruit trees	Annual
			Greenhouses combined with citrus trees	Annual
			Greenhouses combined with banana trees	Annual
			Greenhouses combined with intensive field crops	Annual
			Urban sprawl on greenhouses	Annual

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
Forest land	This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided at the national level into managed and unmanaged and also by ecosystem type as specified in the IPCC Guidelines. It also includes systems with vegetation that currently falls below, but is expected to exceed, the threshold of the forest land category. Managed forest: all forests subject to some kind of human interactions (notably commercial management, harvest of industrial round-wood (logs) and fuelwood, production and use of wood commodities, and forest managed for amenity value or environmental protection if specified by the country), with defined geographical boundaries.		Dense pine forests (mainly Pinus brutia and Pinus pinea)	Coniferous
			Dense cedar forests (Cedrus libani)	Coniferous
			Dense fir forests (Abies cilicia)	Coniferous
			Dense cypress forests (Cupressus ssp.)	Coniferous
			Dense oak forests (Quercus ssp.)	Broadleaf
			Dense broadleaves forests (Platanus, Populus, Salix)	Broadleaf
			Mixed dense forests	Mixed
			Urban sprawl on dense forest	Mixed
			Low density pine forests (Pinus brutia and Pinus pinea)	Coniferous
			Low density cedar forests (Cedrus libani)	Coniferous
			Low density juniper forests (Juniperus ssp.)	Coniferous
			Low density fir forests (Abies, Cilicia)	Coniferous
			Low density cypress forests (Cupressus ssp.)	Coniferous
			Low density oak forests (Quercus ssp.)	Broadleaf
			Low density broadleaves forests (Platanus, Populus, Salix)	Broadleaf
			Low density mixed forests	Mixed
			Urban sprawl on low density forest	Mixed
			Shrubland	Broadleaf
			Shrubland with dispersed trees	Broadleaf
			Urban sprawl on shrubland	Broadleaf

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
Grassland	This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used in the forest land category and is not expected to exceed, without human intervention, the thresholds used in the forest land category. This category also includes all grassland from wild lands to recreational areas as well as agricultural and silvo-pastural systems, subdivided into managed and unmanaged, consistent with national definitions.	This category includes rangelands and pasture land that is not considered as cropland. More specifically, it included moderately dense herbaceous vegetation, and highly dense herbaceous vegetation.	Moderately dense herbaceous vegetation	Annual grasses
			Low density herbaceous vegetation	Annual grasses

	Definition according to IPCC GPG for LULUCF (2003)	Definition according to the national classification system	Disaggregation adopted according to the national classification system (land use map of 1998)	Disaggregation as per the IPCC GPG for LULUCF (2003) recommendations
Wetland	This category includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. This category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.	This category includes land that is covered or saturated by water for all or part of the year. More specifically, it included the following classes: surface water bodies, lakes, rivers, and reservoirs.	Continental humid zone	Flooded areas (artificial reservoirs and hill lakes)
			Marine humid zone	
			Water plane (reservoir)	
			Hill lake	
			Stream or river	
			Harbor basin	
Other land	This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.	This category included bare soil, rock, ice, and recently burned forested lands.	Bare rock	No need for disaggregation
			Urban sprawl on bare rock	
			Bare soil	
			Beach	
			Sand dune	
			Burned area	

*ssp. = subspecies

Annex II: List of activity data

	Only for calc. purposes	Extrapolation			
	1993	1994	1995	1996	1997
FF-Total	258,646.65	258,475.95	258,304.34	258,131.73	257,957.98
Coniferous	35,274.24	35,257.05	35,239.76	35,222.37	35,204.87
Broadleaf	196,658.18	196,517.58	196,376.23	196,234.06	196,090.95
Mixed	26,714.23	26,701.32	26,688.35	26,675.30	26,662.16
GG-Total	318,130.90	318,023.29	317,915.11	317,806.28	317,696.75
CC-Total	333,242.83	333,069.80	332,895.87	332,720.90	332,544.79
Perennial	160,701.36	160,646.49	160,591.33	160,535.84	160,479.98
Annual	172,541.46	172,423.32	172,304.54	172,185.07	172,064.81
FO		NE*	NE	NE	NE
Coniferous		NE	NE	NE	NE
Broadleaf		NE	NE	NE	NE
Mixed		NE	NE	NE	NE
FO		NE	NE	NE	NE
Fuel type 3		NE	NE	NE	NE
Fuel type 4		NE	NE	NE	NE
Fuel type 5		NE	NE	NE	NE
Fuel types 6 and 7		NE	NE	NE	NE
GO		NE	NE	NE	NE
Fuel type 1		NE	NE	NE	NE
Fuel type 2		NE	NE	NE	NE
CO		NE	NE	NE	NE
LS-Total		451.34	453.73	456.40	459.40
FS		170.70	171.60	172.61	173.75
Coniferous		17.19	17.28	17.39	17.50
Broadleaf		140.60	141.34	142.18	143.11
Mixed		12.91	12.98	13.05	13.14
GS		107.61	108.18	108.82	109.54
CS		173.02	173.94	174.96	176.11
Perennial		54.87	55.16	55.49	55.85
Annual		118.15	118.77	119.47	120.26
LF-Total		NE	NE	NE	NE
FAO, 2010 and MoE, 2013		NE	NE	NE	NE
AFDC		NO**	NO	NO	NO
LRI		NO	NO	NO	NO
Lands converted to Wetland (LW)-Total		NE	NE	NE	NE
OW		NE	NE	NE	NE

	Baseline	Interpolation			
	1998	1999	2000	2001	2002
FF-Total	257,890.00	257,628.13	257,172.00	257,142.81	257,113.63
Coniferous	35,216.00	35,187.56	35,121.00	35,116.50	35,112.00
Broadleaf	196,008.00	195,792.44	195,451.75	195,431.06	195,410.38
Mixed	26,666.00	26,648.13	26,599.25	26,595.25	26,591.25
GG-Total	317,600.00	317,497.13	317,237.13	317,212.41	317,187.69
CC-Total	332,364.00	332,082.13	331,856.69	331,819.22	331,781.75
Perennial	160,354.00	160,287.75	160,243.25	160,230.06	160,216.88
Annual	172,010.00	171,794.38	171,613.44	171,589.16	171,564.88
FO	0.00	1,048.63	330.00	73.19	73.19
Coniferous	0.00	122.88	54.25	6.47	6.47
Broadleaf	0.00	870.00	217.06	53.66	53.66
Mixed	0.00	55.75	58.69	13.06	13.06
FO	0.00	1,048.63	330.00	73.19	73.19
Fuel type 3	0.00	280.50	98.63	5.94	5.94
Fuel type 4	0.00	482.69	97.63	31.38	31.38
Fuel type 5	0.00	6.94	14.75	5.34	5.34
Fuel types 6 and 7	0.00	278.50	119.00	30.53	30.53
GO	0.00	198.38	125.50	148.47	148.47
Fuel type 1	0.00	148.13	78.50	76.44	76.44
Fuel type 2	0.00	50.25	47.00	72.03	72.03
CO	0.00	493.56	501.75	250.94	250.94
LS-Total	0.00	646.62	941.56	91.38	91.38
FS	0.00	261.87	456.13	29.19	29.19
Coniferous	0.00	28.44	66.56	4.50	4.50
Broadleaf	0.00	215.56	340.69	20.69	20.69
Mixed	0.00	17.88	48.88	4.00	4.00
GS	0.00	102.88	260.00	24.72	24.72
CS	0.00	281.88	225.44	37.47	37.47
Perennial	0.00	66.25	44.50	13.19	13.19
Annual	0.00	215.63	180.94	24.28	24.28
LF-Total	0.00	305.00	305.00	305.00	305.00
FAO, 2010 and MoE, 2013	0.00	305.00	305.00	305.00	305.00
AFDC	0.00	0.00	0.00	0.00	0.00
LRI	0.00	0.00	0.00	0.00	0.00
Lands converted to Wetland (LW)-Total	0.00	NE	NE	NE	NE
OW	0.00	NE	NE	NE	NE

	Interpolation				
	2003	2004	2005	2006	2007
FF-Total	257,059.19	256,905.94	256,543.94	256,236.63	256,088.25
Coniferous	35,102.81	35,083.69	35,063.13	35,028.06	35,022.31
Broadleaf	195,366.69	195,244.75	194,924.19	194,682.31	194,544.06
Mixed	26,589.69	26,577.50	26,556.63	26,526.25	26,521.88
GG-Total	317,158.00	317,018.88	316,755.56	316,573.94	316,558.25
CC-Total	331,669.56	331,279.94	331,167.25	330,804.06	330,776.75
Perennial	160,185.56	160,126.56	160,100.63	160,047.50	160,041.00
Annual	171,484.00	171,153.38	171,066.63	170,756.56	170,735.75
FO	304.00	62.50	423.69	1,197.00	708.00
Coniferous	31.25	5.31	37.44	126.56	83.44
Broadleaf	251.88	53.31	347.56	1,012.63	568.38
Mixed	20.88	3.88	38.69	57.81	56.19
FO	304.00	62.50	423.69	1,197.00	708.00
Fuel type 3	204.81	34.44	163.69	631.69	157.81
Fuel type 4	59.69	17.06	134.56	379.81	213.00
Fuel type 5	12.75	4.19	1.81	32.56	24.56
Fuel types 6 and 7	26.75	6.81	123.63	152.94	312.63
GO	492.19	96.44	95.94	815.06	42.75
Fuel type 1	287.44	50.06	74.69	638.69	28.19
Fuel type 2	204.75	46.38	21.25	176.38	14.56
CO	528.50	222.69	344.06	334.44	274.81
LS-Total	196.31	682.00	738.00	852.13	191.38
FS	54.44	153.25	362.00	307.31	148.38
Coniferous	9.19	19.13	20.56	35.06	5.75
Broadleaf	43.69	121.94	320.56	241.88	138.25
Mixed	1.56	12.19	20.88	30.38	4.38
GS	29.69	139.13	263.31	181.63	15.69
CS	112.19	389.63	112.69	363.19	27.31
Perennial	31.31	59.00	25.94	53.13	6.50
Annual	80.88	330.63	86.75	310.06	20.81
LF-Total	278.00	278.00	278.00	278.00	278.00
FAO, 2010 and MoE, 2013	278.00	278.00	278.00	278.00	278.00
AFDC	0.00	0.00	0.00	0.00	0.00
LRI	0.00	0.00	0.00	0.00	0.00
Lands converted to Wetland (LW)-Total	NE	NE	NE	NE	NE
OW	NE	NE	NE	NE	NE

	Interpolation				
	2008	2009	2010	2011	2012
FF-Total	255,775.00	255,575.03	255,375.06	254,771.13	254,463.13
Coniferous	34,977.44	34,960.44	34,943.44	34,887.56	34,871.06
Broadleaf	194,300.38	194,131.47	19,3962.56	19,3467.06	193,184.13
Mixed	26,497.19	26,483.13	26,469.06	26,416.50	26,407.94
GG-Total	316,314.69	316,180.03	316,045.37	315,697.12	315,518.06
CC-Total	330,505.06	330,081.53	329,658.00	329,415.12	328,959.31
Perennial	159,937.69	159,719.69	159,501.69	159,376.06	159,235.25
Annual	170,567.38	170,361.84	170,156.31	170,039.06	169,724.06
FO	25.81	427.72	427.72	161.13	603.00
Coniferous	6.56	59.97	59.97	14.63	37.69
Broadleaf	16.56	311.59	311.59	133.56	548.31
Mixed	2.69	56.16	56.16	12.94	17.00
FO	25.81	427.72	427.72	161.13	603.00
Fuel type 3	13.69	184.59	184.59	58.06	262.31
Fuel type 4	8.00	155.59	155.59	53.06	185.13
Fuel type 5	0.00	7.00	7.00	2.88	10.25
Fuel types 6 and 7	4.13	80.53	80.53	47.13	145.31
GO	12.56	271.00	271.00	182.38	242.75
Fuel type 1	6.13	206.72	206.72	109.06	184.88
Fuel type 2	6.44	64.28	64.28	73.31	57.88
CO	542.00	675.09	675.09	585.19	1,305.81
LS-Total	828.50	758.16	758.16	1,195.06	942.88
FS	313.25	199.97	199.97	603.94	308.00
Coniferous	44.88	17.00	17.00	55.88	16.50
Broadleaf	243.69	168.91	168.91	495.50	282.94
Mixed	24.69	14.06	14.06	52.56	8.56
GS	243.56	134.66	134.66	348.25	179.06
CS	271.69	423.53	423.53	242.88	455.81
Perennial	103.31	218.00	218.00	125.63	140.81
Annual	168.38	205.53	205.53	117.25	315.00
LF-Total	52.00	52.00	147.73	52.00	381.21
FAO, 2010 and MoE, 2013	0.00	0.00	95.73	0.00	95.73
AFDC	52.00	52.00	52.00	52.00	52.00
LRI	0.00	0.00	0.00	0.00	233.48
Lands converted to Wetland (LW)-Total	37	NE	NE	NE	NE
OW	37	NE	NE	NE	NE

*NE: Not Estimated **NO: Not Occuring

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Average annual net increment in volume suitable for industrial processing	I_V	3.26	FF/ FL-1a_1of4	0	Irrelevant (IR)	Not needed anymore since a default for G_W is used
Basic wood density	D	3.26	FF/ FL-1a_1of4	0	IR	Not needed anymore since a default for G_W is used
Biomass expansion factor for conversion of annual net increment (including bark) to above ground tree biomass increment	BEF1	3.26	FF/ FL-1a_1of4	0	IR	Not needed anymore since a default for G_W is used
Average annual aboveground biomass increment	G_W	3.26	FF/ FL-1a_1of4	3 (coniferous), 4 (broadleaved), 3.5 (mixed)	IPCC GPG default table 3A.1.5	
		3.26	LF/ FL-2a_1of1	5.725 (coniferous)	IPCC GPG default table 3A.1.6, experts' surveys (E. Chneis)	
Root-shoot ratio appropriate to increments	R	3.26	FF/ FL-1a_1of4	0.27	FAO, 2005	
		3.26	LF/ FL-2a_1of1			
Carbon fraction of dry matter	CF	3.25	FF/ FL-1a_2of4	0.5	IPCC GPG default	
		3.33	FF/ FL-1b_1of3			

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
		3.25	LF/FL-2a_1of1			
		3.57	LF/FL-2b_2of2			
		3.107	GG/GL-1a_2of2			
		3.140	WL-2a2_1of1			
Annually extracted volume of roundwood	H	3.27	FF/ FL-1a_2of4	0	Experts' surveys (E. Chneis, J. Stephan)	
Biomass density	D	3.27	FF/ FL-1a_2of4	0.5001 (coniferous), 0.58 (broadleaved), 0.54 (mixed)	FAO, 2005; IPCC GPG table 3A.1.9; Altaş et al., 2007; Aksu et al., 2001	
			FF/ FL-1a_3of4			
Biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark)	BEF_2	3.27	FF/ FL-1a_2of4	1.3 (coniferous), 1.4 (broadleaved), 1.35 (mixed)	IPCC GPG default table 3A.1.10	
			FF/ FL-1a_3of4			
Fraction of biomass left to decay in forest due to commercial roundwood gathering	F_{BL}	3.27	FF/ FL-1a_2of4	0.15	IPCC GPG default table 3A.1.11	

<table>
<tr><th>Emission factor</th><th>Symbol/ abbreviation</th><th>Page in GPG</th><th>Land use category / sheet name</th><th>Value(s) used</th><th>Source of value</th><th>Notes</th></tr>
<tr>
<td>Annual volume of fuelwood gathering</td>
<td>FG</td>
<td>3.27</td>
<td>FF/ FL-1a_3of4</td>
<td>
<table>
<tr><th>Year</th><th>Non-Coniferous (NC) m³</th><th>Coniferous (C) m³</th></tr>
<tr><td>1994</td><td>14,628.44249</td><td>3,853</td></tr>
<tr><td>1995</td><td>14,652.39207</td><td>3,952</td></tr>
<tr><td>1996</td><td>14,676.49922</td><td>4,045</td></tr>
<tr><td>1997</td><td>14,700.78493</td><td>4,114</td></tr>
<tr><td>1998</td><td>14,725.27473</td><td>4,089</td></tr>
<tr><td>1999</td><td>14,000</td><td>4,081</td></tr>
<tr><td>2000</td><td>15,000</td><td>4,074</td></tr>
<tr><td>2001</td><td>15,000</td><td>4,063</td></tr>
<tr><td>2002</td><td>15,000</td><td>4,051</td></tr>
<tr><td>2003</td><td>15,000</td><td>4,040</td></tr>
<tr><td>2004</td><td>15,000</td><td>4,028</td></tr>
<tr><td>2005</td><td>15,000</td><td>4,017</td></tr>
<tr><td>2006</td><td>15,000</td><td>3,896</td></tr>
<tr><td>2007</td><td>15,000</td><td>3,900</td></tr>
<tr><td>2008</td><td>15,000</td><td>3,900</td></tr>
<tr><td>2009</td><td>15,000</td><td>3,900</td></tr>
<tr><td>2010</td><td>15,000</td><td>3,866</td></tr>
<tr><td>2011</td><td>15,000</td><td>3,833</td></tr>
<tr><td>2012</td><td>14,725.27473</td><td>4,064.725146</td></tr>
</table>
</td>
<td>FOASTAT, 2013</td>
<td>NC volumes for the years 1994-1998 and 2012 are generated by extrapolation of the trend from the years 1999-2011.

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

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Average biomass stock of forest areas	B_W	3.28	FF/ FL-1a_3of4	134 (coniferous), 122 (broadleaved), 128 (mixed)	IPCC GPG default table 3A.1.2	
Fraction of biomass left to decay in forest due to disturbance	F_{bl}	3.28	FF/ FL-1a_4of4	0.415	IPCC GPG default table 3A.1.12	
Annual transfer into dead wood	B_{into}	3.33	FF/FL-1b_1of3	0	Not Available (N/A)	Tier 1 assumes no change
Annual transfer out of dead wood	B_{out}	3.33	FF/FL-1b_1of3	0	N/A	Tier 1 assumes no change
Reference stock of litter under native, unmanaged forest corresponding to state i	$LT_{ref(i)}$	3.35	FF/FL-1b_1of3	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on LTref(i) in state i	$f_{mgt\ intensity(i)}$	3.35	FF/FL-1b_2of3	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting a change in the disturbance regime on LTref (i) in state i	$f_{dist\ regime(i)}$	3.35	FF/FL-1b_2of3	0	N/A	Tier 1 assumes no change
Reference stock of litter under previous state j	$LT_{ref(j)}$	3.35	FF/FL-1b_2of3	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on LTref (j)	$f_{mgt\ intensity(j)}$	3.35	FF/FL-1b_2of3	0	N/A	Tier 1 assumes no change

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Adjustment factor reflecting a change in the disturbance regime on LTref (j)	$f_{dist\ regime(j)}$	3.35	FF/FL-1b_2of3	0	N/A	Tier 1 assumes no change
Time period of the transition from state i to j	T_{ij}	3.35	FF/ FL-1b_3of3	20	IPCC GPG default	
		3.40	FF/ FL-1c1_1of2			
Reference carbon stock	SOC_{REF}	3.40	FF/FL-1c1_1of2	38 (forest soils) 38 (cropland soils) 38 (grassland soils)	IPCC GPG default table 3.2.4	
		3.63	LF/FL-2c1_1of1		IPCC GPG default table 3.3.3	
		3.75	CC/CL-1c1_1of2		IPCC GPG default table 3.4.4	
		3.112	GG/GL-1c1_1of2		IPCC GPG default table 3.4.4	
Adjustment factor reflecting the effect of a change from the native forest to the forest type in state i	$f_{forest\ type\ i}$	3.40	FF/FL-1c1_1of2	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on forest in state i	$f_{man\ intensity\ i}$	3.40	FF/FL-1c1_1of2	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of a change in the disturbance regime to state i with respect to the native forest	$f_{dist\ regime\ i}$	3.40	FF/FL-1c1_1of2	0	N/A	Tier 1 assumes no change

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Adjustment factor reflecting the effect of a change from the native forest to the forest type in state j	$f_{forest\ type\ j}$	3.40	FF/FL-1c1_2of2	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of management intensity or practices on forest in state j	$f_{man\ intensity\ j}$	3.40	FF/FL-1c1_2of2	0	N/A	Tier 1 assumes no change
Adjustment factor reflecting the effect of a change in the disturbance regime to state j with respect to the native forest	$f_{dist\ regime\ j}$	3.40	FF/FL-1c1_2of2	0	N/A	Tier 1 assumes no change
Emission factor for CO_2 from drained organic forest soils	$EF_{Drainage}$	3.42	FF/FL-1c2_1of1	0	IR	No organic soils (expert's surveys, T. Darwish)
		3.63	LF/FL-2c1_1of1			
Mass of available fuel	B	3.49	FF/FL-1d_1of1	12,500 (fuel type 3), 30,000 (fuel type 4), 9,500 (fuel type 5), 12,500 (fuel type 6, 7)	(TRAGSA, 2012)	
Combustion efficiency or fraction of biomass combusted	C	3.49	FF/FL-1d_1of1	0.5	IPCC GPG default table	
		3.120	GG/GL-1d_1of1			

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
CH_4 emission factor	D	3.49	FF/FL-1d_1of1	9	IPCC GPG default table 3A.1.16	
CO emission factor	F	3.49	FF/FL-1d_1of1	130	IPCC GPG default table 3A.1.16	
N_2O emission factor	H	3.49	FF/FL-1d_1of1	0.11	IPCC GPG default table 3A.1.16	
NO_x emission factor	J	3.49	FF/FL-1d_1of1	0.7	IPCC GPG default table 3A.1.16	
Standing biomass stock in terms of carbon in naturally regenerated forest	$B_{standing\ NatR}$	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration
Mortality rate in naturally regenerated forest	M_{NatR}	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration
Annual transfer out of dead wood for naturally regenerated forest area	$B_{out\ NatR}$	3.57	LF/FL-2b_1of2	0	IR	No data on natural regeneration
Standing biomass stock in terms of carbon in artificially regenerated forest	$B_{standing\ ArtR}$	3.57	LF/FL-2b_1of2	0	N/A	Tier 1 assumes no change
Mortality rate in artificially regenerated forest	M_{ArtR}	3.57	LF/FL-2b_1of2	0	N/A	Tier 1 assumes no change
Annual transfer out of dead wood for artificially regenerated forest area	$B_{out\ ArtR}$	3.57	LF/FL-2b_2of2	0	N/A	Tier 1 assumes no change

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Annual change in litter carbon for naturally regenerated forest	DC_{NatR}	3.57	LF/FL-2b_2of2	0	IR	No data on natural regeneration
Annual change in litter carbon for artificially regenerated forest	DC_{ArtR}	3.57	LF/FL-2b_2of2	1	IPCC GPG default table 3.2.1, experts' surveys (E. Chneis)	
Stable soil organic carbon on previous land use, either cropland or grassland, SOC Non-forest Land	$SOC_{Non\text{-}forest\_land}$	3.63	LF/FL-2c1_1of1	0	IPCC GPG default	
Duration of the transition from $SOC_{Non\text{-}forest\ Land}$ to SOC_{ref}	T_{AFF}	3.63	LF/FL-2c1_1of1	20	IPCC GPG default	
Annual growth rate of perennial woody biomass	G	3.71	CC/CL-1a_1of1	2.1 (unburned perennial woody crops)	IPCC GPG default table 3.3.2	
Annual carbon stock in biomass removed	L	3.71	CC/CL-1a_1of1	63 (burned perennial woody crops)	IPCC GPG default table 3.3.2	
Inventory time period	T	3.75	CC/CL-1c1_1of2	20	IPCC GPG default	
		3.112	GG/GL-1c1_1of2			
Stock change factor for land use or land-use change type in the beginning of inventory year	$FLU_{(0\text{-}T)}$	3.75	CC/CL-1c1_1of2	0.82	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Stock change factor for management regime in the beginning of inventory year	$FMG_{(0-T)}$	3.75	CC/CL-1c1_1of2	1	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for input of organic matter in the beginning of inventory year	$FI_{(0-T)}$	3.75	CC/CL-1c1_1of2	1	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for land use or land-use change type in current inventory year	$FLU_{(0)}$	3.75	CC/CL-1c1_2of2	0.82	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for management regime in current inventory year	$FMG_{(0)}$	3.75	CC/CL-1c1_2of2	1	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	
Stock change factor for input of organic matter in current inventory year	$FI_{(0)}$	3.75	CC/CL-1c1_2of2	1	IPCC GPG default table 3.3.4, experts' surveys (J. Stephan)	
Emission factor for climate type c	EF	3.79	CC/CL-1c2_1of1	0	IR	No organic soils (expert's surveys, T. Darwish)
		3.114	GG/GL-1c2_1of1			
Type of lime	type	3.80	CC/CL-1c3_1of1	0	IR	No lime applied (experts' surveys, J. Stephan)
		3.115	GG/GL-1c3_1of1			

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Total annual amount of lime applied	amount	3.80	CC/CL-1c3_1of1	0	Experts' surveys (J. Stephan)	No lime applied
		3.115	GG/GL-1c3_1of1			
Emission factor (carbonate carbon contents of the materials)	EF	3.80	CC/CL-1c3_1of1	0	IR	No lime applied
		3.115	GG/GL-1c3_1of1			
Average annual biomass growth of perennial woody biomass	$G_{perennial}$	3.107	GG/GL-1a_1of2	0	IR	No grassland covered with perennial woody biomass
Average annual biomass loss of perennial woody biomass	$L_{perennial}$	3.107	GG/GL-1a_1of2	0	IR	No grassland covered with perennial woody biomass
Average annual biomass growth of grasses	$G_{grasses}$	3.107	GG/GL-1a_2of2	0	N/A	Tier 1 assumes no change
Average annual biomass loss of grasses	$L_{grasses}$	3.107	GG/GL-1a_2of2	0	N/A	Tier 1 assumes no change
Stock change factor for land use or land-use change type in the beginning of inventory year	$FLU_{(0-T)}$	3.112	GG/GL-1c1_1of2	1	IPCC GPG default table 3.4.5	

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Stock change factor for management regime in the beginning of inventory year	$FMG_{(0\text{-}T)}$	3.112	GG/GL-1c1_1of2	0.95	IPCC GPG default table 3.4.5, Darwish and Faour, 2008	
Stock change factor for input of organic matter in the beginning of inventory year	$FI_{(0\text{-}T)}$	3.112	GG/GL-1c1_1of2	1	IPCC GPG default table 3.4.5, experts' surveys (J. Stephan)	
Stock change factor for land use or land-use change type in current inventory year	$FLU_{(0)}$	3.112	GG/GL-1c1_2of2	1	IPCC GPG default table 3.4.5	
Stock change factor for management regime in current inventory year	$FMG_{(0)}$	3.112	GG/GL-1c1_2of2	0.95	IPCC GPG default table 3.4.5, Darwish and Faour, 2008	
Stock change factor for input of organic matter in current inventory year	$FI_{(0)}$	3.112	GG/GL-1c1_2of2	1	IPCC GPG default table 3.4.5, experts' surveys (J. Stephan)	
Mass of available fuel	B	3.120	GG/GL-1d_1of1	5,000 (fuel type 1), 6,500 (fuel type 2)	TRAGSA, 2012	
CH_4 emission factor	D	3.120	GG/GL-1d_1of1	3	IPCC GPG default table 3A.1.16	
CO emission factor	F	3.120	GG/GL-1d_1of1	97	IPCC GPG default table 3A.1.16	
N_2O emission factor	H	3.120	GG/GL-1d_1of1	0.11	IPCC GPG default table 3A.1.16	
NO_x emission factor	J	3.120	GG/GL-1d_1of1	7	IPCC GPG default table 3A.1.16	
Living biomass immediately following conversion to flooded land	B_{After}	3.140	WL-2a2_1of1	0	IPCC GPG default	

Emission factor	Symbol/ abbreviation	Page in GPG	Land use category / sheet name	Value(s) used	Source of value	Notes
Living biomass in land immediately before conversion to flooded land	B_{Before}	3.140	WL-2a2_1of1	6.08	IPCC GPG default tables 3.4.2, 3.4.3	
Carbon stock in living biomass immediately following conversion to settlements	C_{After}	3.143	LS/ SL-2a_1of1	0	IPCC GPG default	
Carbon stock in living biomass in forest immediately before conversion to settlements	C_{Before}	3.143	LS/ SL-2a_1of1	5 (annual crops), 63 (perennial woody crops), 0.8 (grasslands), 67 (coniferous forests), 61 (broadleaved forests), 64 (mixed forests)	IPCC GPG default tables 3.4.8, 3.3.2, 3.4.2, 3A.1.2	

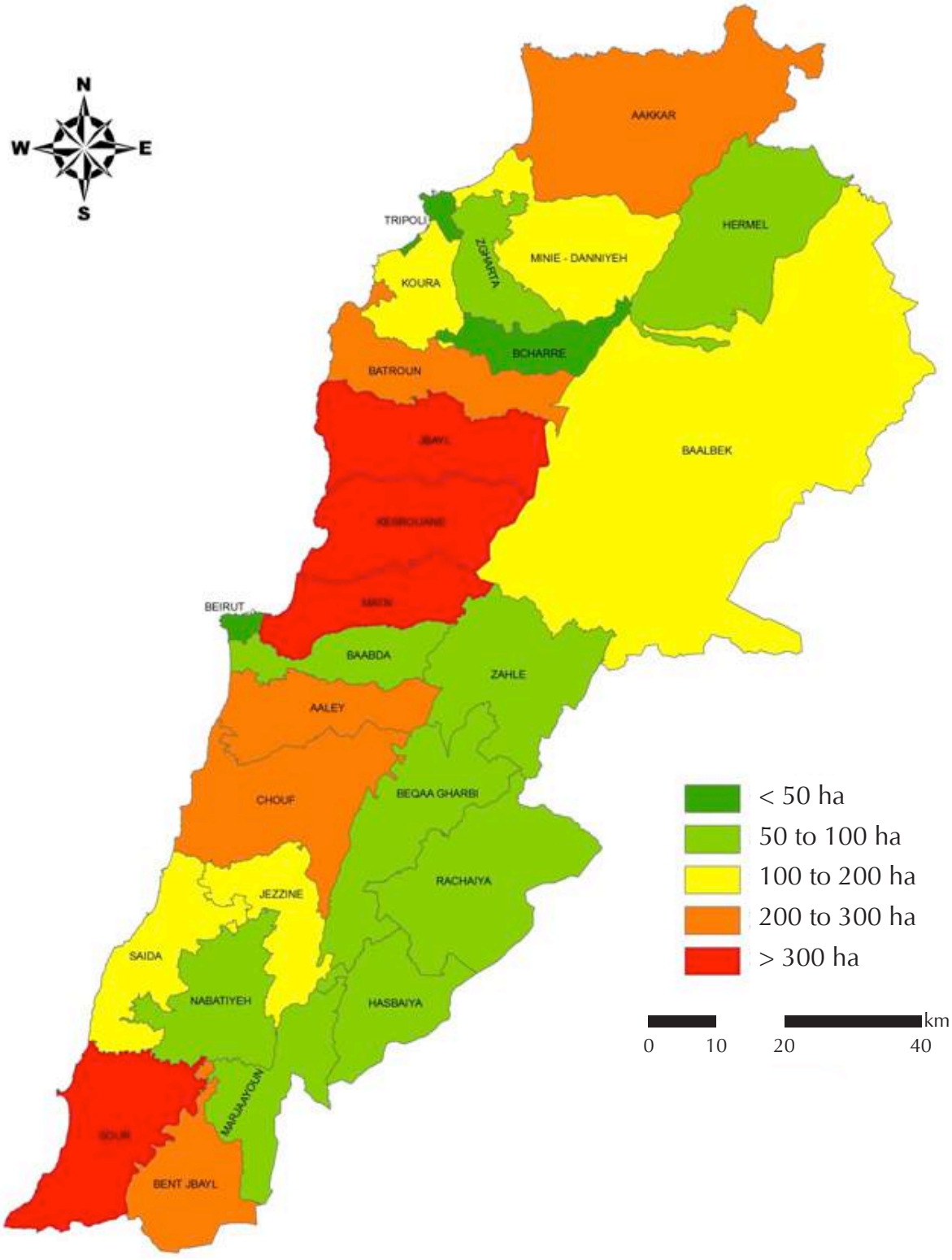
Annex IV: Identified uncertainties of E/R factors

Emission factor	Symbol/ abbreviation	Uncertainty assessment value (%)	Source
Average annual aboveground biomass increment in natural regeneration and in plantations	G_W	50	IPCC, 2003 - p.3.32
Root-shoot ratio appropriate to increments	R	30	IPCC, 2003 - p.3.31
Carbon fraction of dry matter	CF	2	IPCC, 2003 - p.5.17
Biomass density	D	20 (coniferous), 30 (broadleaf and mixed)	IPCC, 2003 - p.3.31
Biomass expansion factor for converting volumes of extracted roundwood to total aboveground biomass (including bark)	BEF_2	30	IPCC, 2003 - p.3.31
Fraction of biomass left to decay in forest from fuelwood gathering	F_{BL}	Not Applicable (NA)	Not relevant since tier 1 assumes that no biomass left to decay is transferred to DOM.
Annual volume of fuelwood gathering	FG	Not Estimated (NE)	Undetermined FAOSTAT data uncertainty depends on the data quality of many sources combined and on the methodology used to collect the data from different sources.
Average biomass stock of forest areas	B_W	216.42 (coniferous), 123.77 (broadleaf), 121.09 (mixed)	Calculated using the ranges in table 3A.1.2. (IPCC, 2003- p.3.157)
Fraction of biomass left to decay in forest due to disturbance	F_{bl}	50.74	Calculated using the values in table 3 A.1.13 (IPCC, 2003- p.3.180)
Reference carbon stock	SOC_{REF}	95	IPCC, 2003, table 3.2.4 - p.3.43

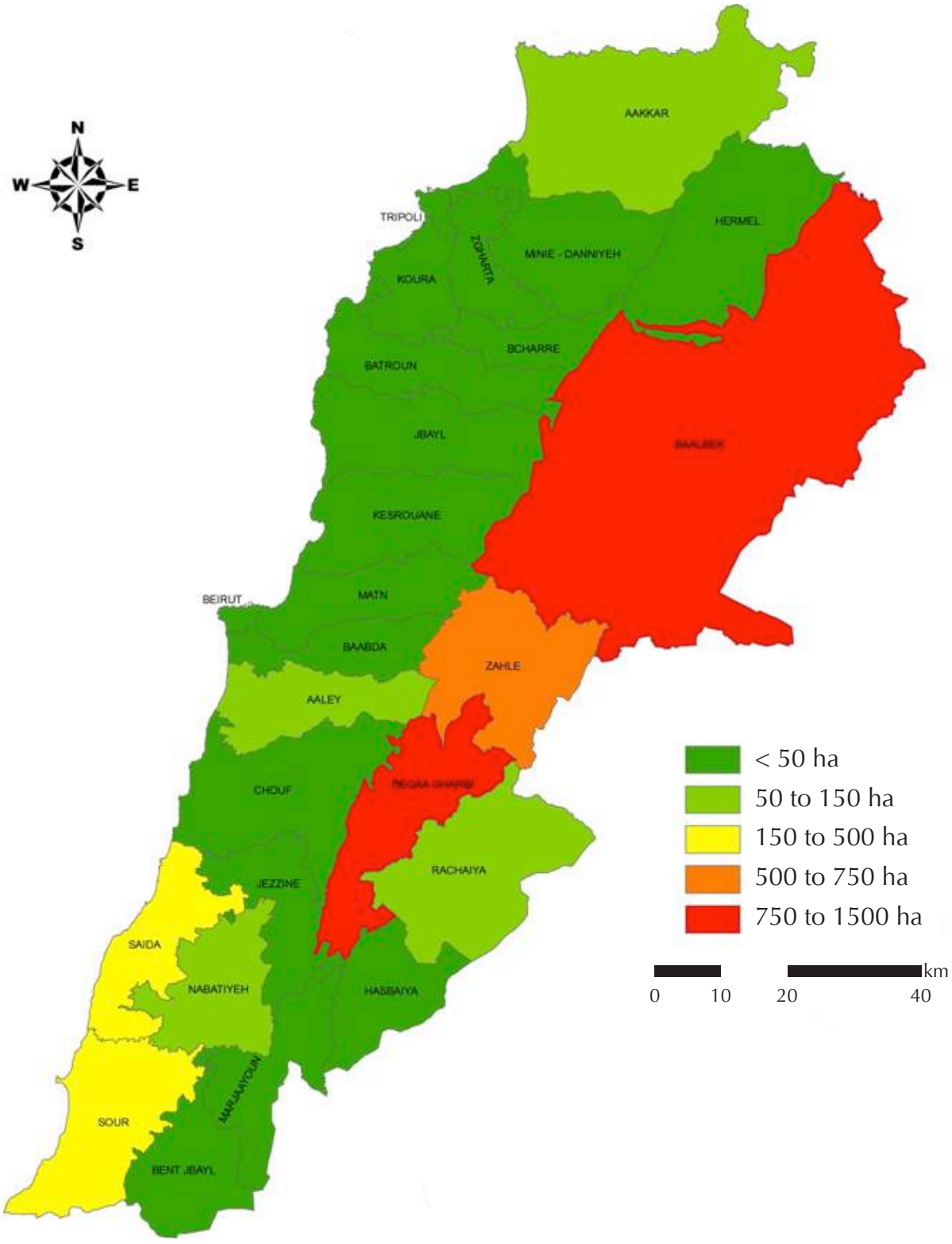
Emission factor	Symbol/ abbreviation	Uncertainty assessment value (%)	Source
Mass of available fuel	B	10	Liu et al., 2013
Combustion efficiency or fraction of biomass combusted	C	2	IPCC, 2003 - p.5.17
CH_4 emission factor	D	70	IPCC, 2003 - p.3.50
CO emission factor	F	70	IPCC, 2003 - p.3.50
N_2O emission factor	H	70	IPCC, 2003 - p.3.50
NO_x emission factor	J	70	IPCC, 2003 - p.3.50
Annual growth rate of perennial woody biomass	G	75	IPCC, 2003 - p.3.73
Annual carbon stock in biomass removed	L	75	IPCC, 2003 - p.3.73
Living biomass in land immediately before conversion to flooded land	B_{Before}	75	IPCC,2003, table 3.4.2 - p.109
Root to shoot ratio in living biomass in lands converted to wetland	R	95	IPCC,2003, table 3.4.3 - p.3.110
Carbon stock in living biomass in forest immediately before conversion to settlements	C_{Before}	Annual crops 75, perennial 75, grass 75	IPCC, 2003, p.3.73 and table 3.3.7 - p.3.87

Annex V: Maps

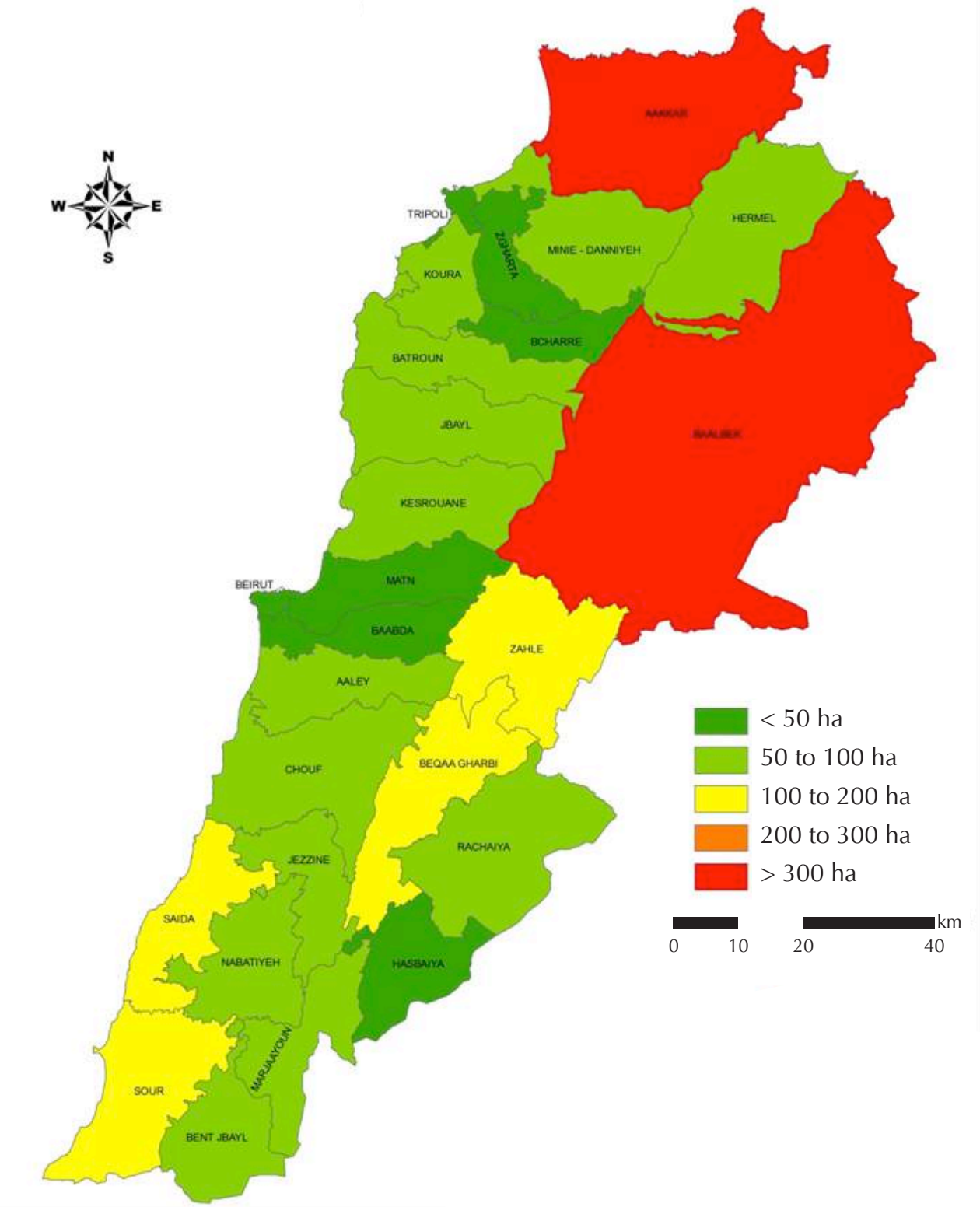
Forest land conversion to settlement (1998-2012)



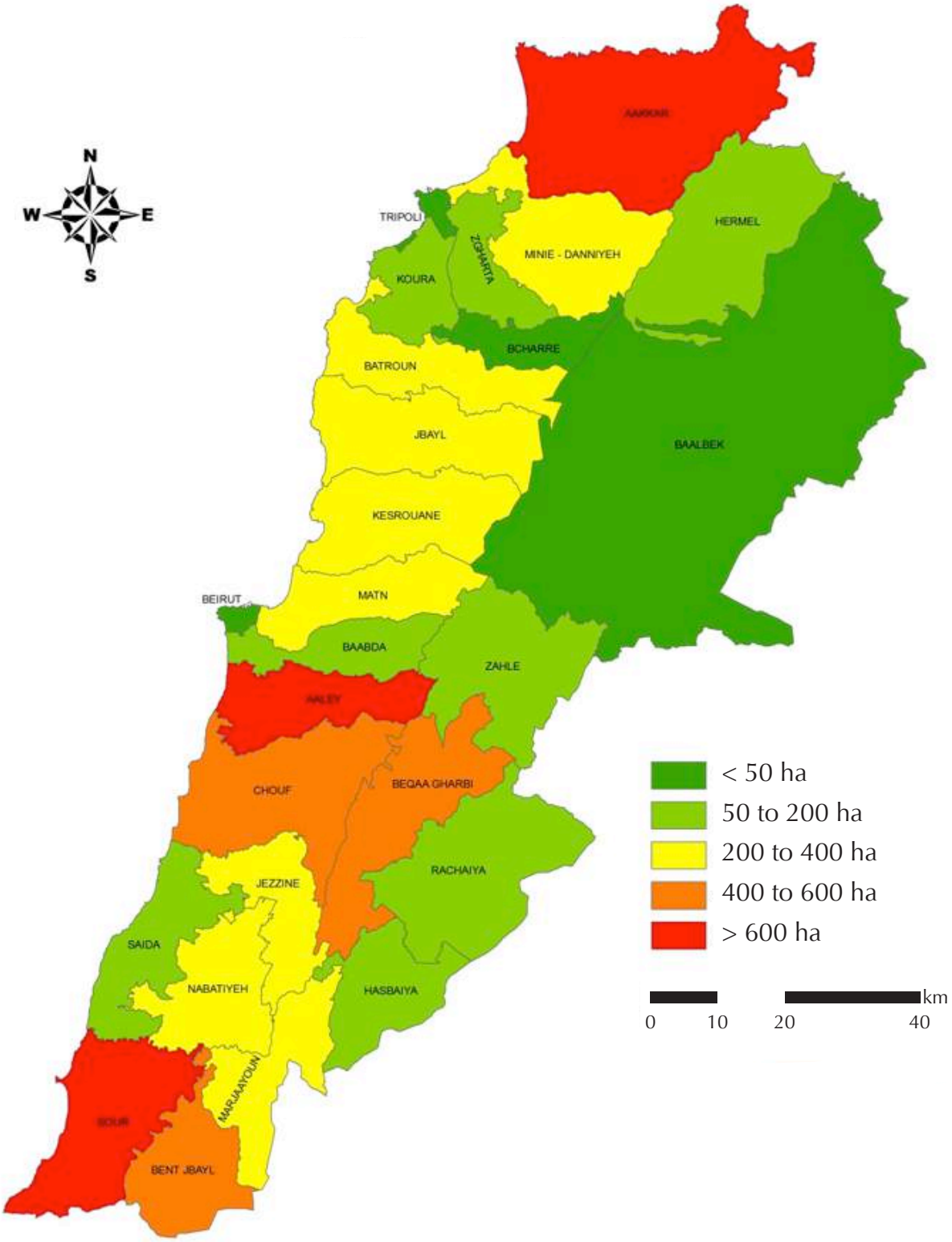
Cropland conversion to settlement (1998-2012)



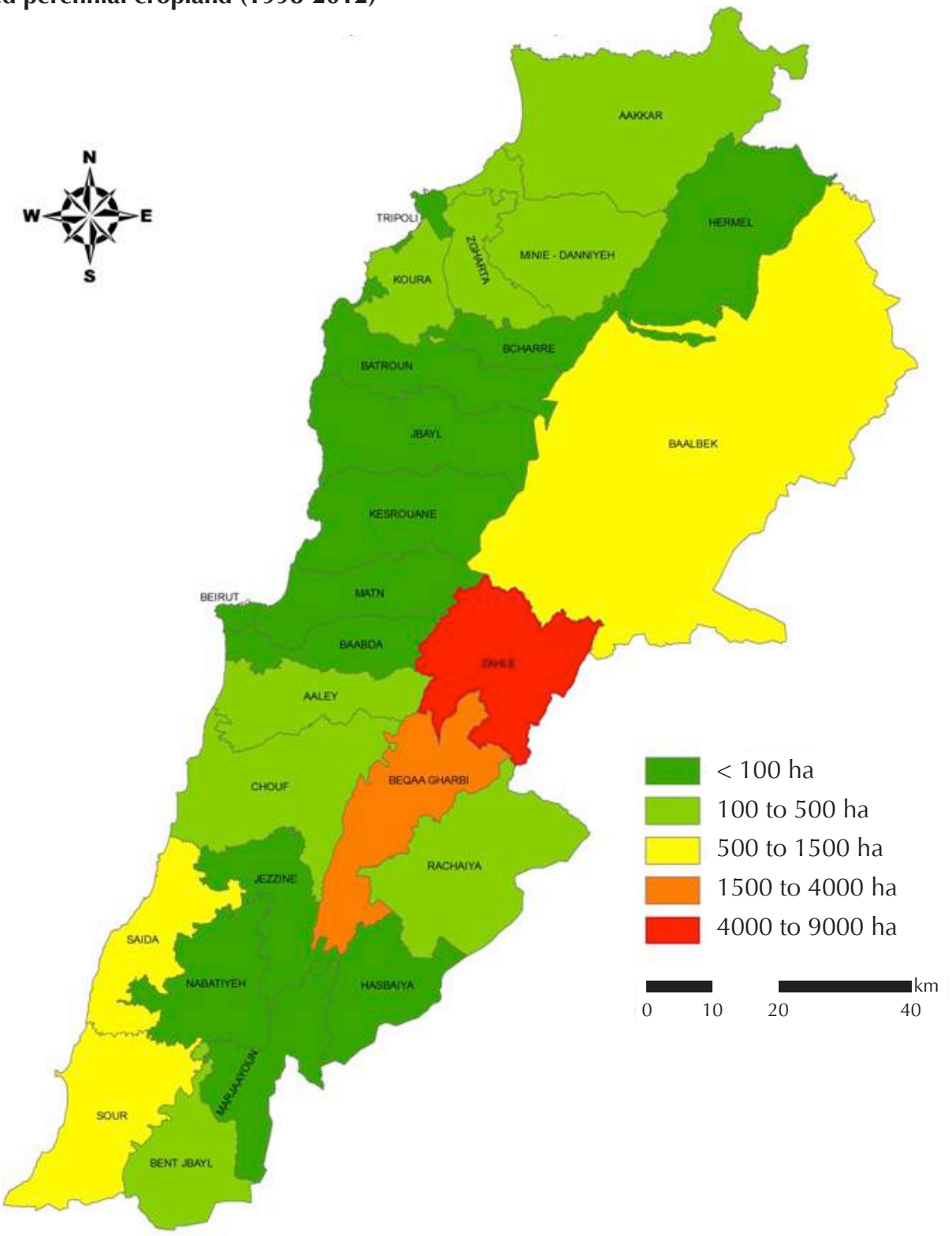
Grassland conversion to settlement (1998-2012)



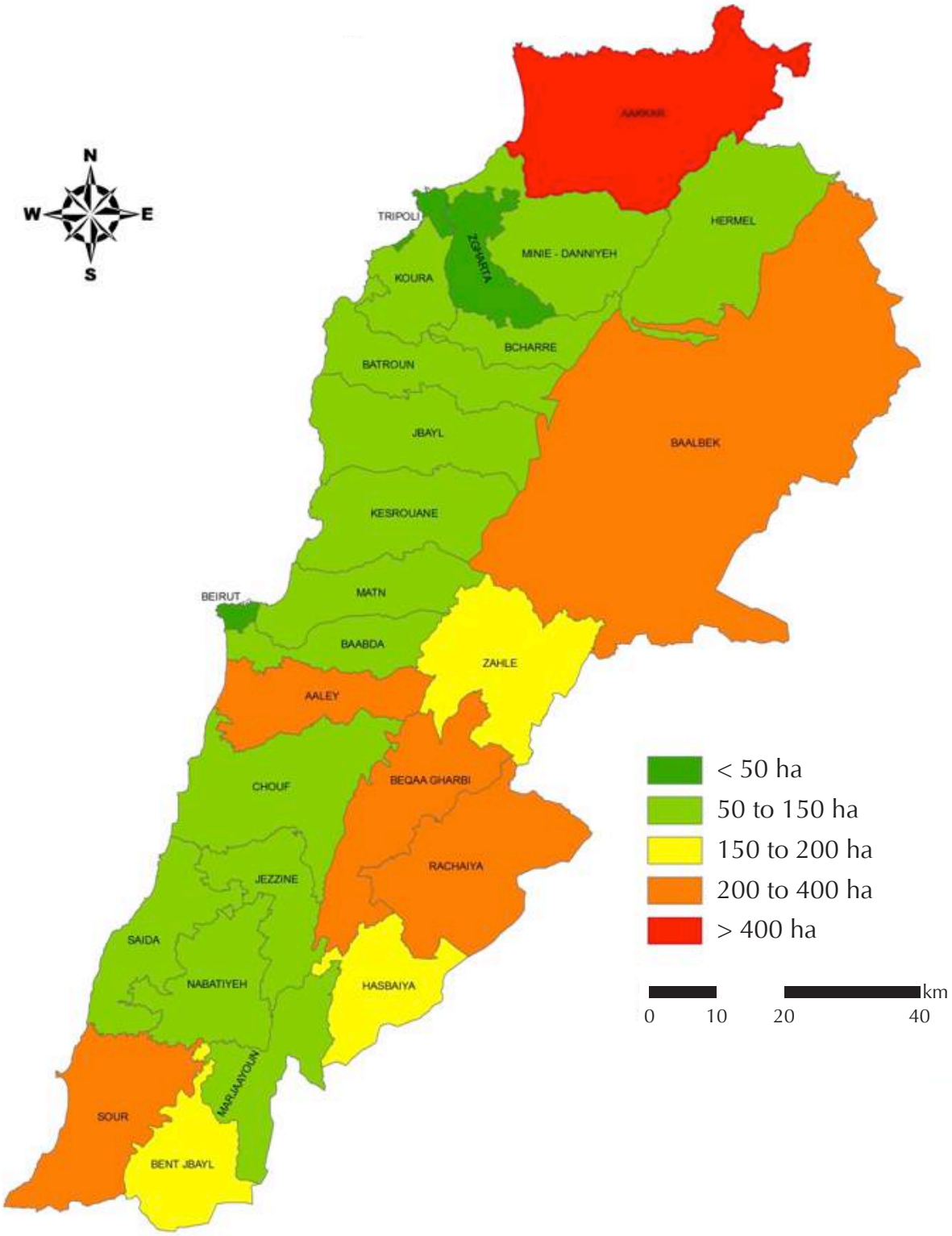
Burned forest land (1998-2012)



Burned perennial cropland (1998-2012)



Burned grassland (1998-2012)



Annex VI: Expert meeting participants (09-09-2013 at the MoE)

Participants (in alphabetical order)	**Institution/organization**
Christine Maksoud	National Council for Scientific Research
Dalia Jawhary	Society for the Protection of Nature in Lebanon
Fady Asmar	Freelance consultant
Garo Haroutunian	United Nations Development Programme-Ministry of Environment
George Mitri	Institute of the Environment - University of Balamand
Hanadi Musharrafiyeh	ELARD
Karine Zoghby	United Nations Development Programme-Association for Forests, Development and Conservation
Lea Kai Aboujaoudé	United Nations Development Programme-Ministry of Environment
Maya Nehme	Lebanon Reforestation Initiative
Mireille Jazi	Institute of the Environment - University of Balamand
Raymond Khoury	Green Plan
Richard Paton	Lebanon Reforestation Initiative
Roland Riachi	CREG Grenoble-ESCWA
Roula Daiaa	Institute of the Environment - University of Balamand
Roula Sheikh	Ministry of Environment
Sleiman Skaff	Lebanese Agriculture Research Institute
Tala Moukaddem	Society for the Protection of Nature in Lebanon
Talal Darwish	National Council for Scientific Research
Vahakn Kabakian	United Nations Development Programme-Ministry of Environment
Yara Daou	United Nations Development Programme-Ministry of Environment
Zeina Tamim	Ministry of Agriculture