GREENHOUSE GAS MITIGATION ANALYSIS

FORESTRY

Lebanon's Second National Communication

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FORESTRY

1.1. INTRODUCTION

In reference to the IPCC Fourth Assessment Report (2007), ecosystems and humans will have to adapt to climate change to address the impacts resulting from the warming which is already unavoidable due to past emissions.

The assessment of the vulnerability of forests to climate change has described the ability of forests in Lebanon to adjust to climate change, and has presented a set of recommendations for policy making and action taking in this respect. Nevertheless, no matter how efficient the adaptation to climate change, if the trend of human pressure is sustained, the resilience of the systems would be seriously compromised. The land and forestry sectors are regarded as sinks for GHGs where in 2004 some 605 Gg CO_2-eq were estimated to have been sequestered. This section describes a set of actions/recommendations aiming to reduce Lebanon's contribution to climate change from land use, specifically forestry activities. The overall objective of the mitigation actions is to reduce the GHG levels in the atmosphere through increased carbon sequestration by forests and soil. In the perspective of reaching this goal, two alternatives could be envisaged:

- Maintaining and conserving existing forest carbon sinks: through forest and soil protection, management practices and preventing forest degradation;
- Improving carbon sequestration by forests and soils through reforestation and afforestation in order to ameliorate the forest cover.

1.2. BASELINE SCENARIO

The National Reforestation Plan (NRP), initiated in 2001 by the Ministry of Environment (MoE), aims at the restoration of the green cover lost throughout the years. Two phases of reforestation activities were executed and the third reforestation phase started in 2009 with a total budget of 2,255,000 USD (2009 - 2014).

The MoE's reforestation/afforestation plan aims to increase the forest cover from 13% of Lebanon's land surface area to 20%. As the reforestation/afforestation activities mainly target the coniferous forests, the forest area increase will concern evergreen forests which would increase from 134,298 to 206,612 ha by 2030, while the areas of deciduous forests should remain the same with sustainable management and conservation.

The net annual emissions of GHG from the forestry sector are negative since growing trees sequester carbon from the atmosphere, while adult trees lock the carbon sequestered in the bark. Table 0-1 shows the area of forests in kha and the number of fruit trees in Lebanon for the year 2004. The GHG inventory has estimated the annual total carbon uptake increment in Lebanon for the year 2004 at around 249.19 kt of carbon.

It should be noted that forests and fruit trees are expressed in different units (kha vs. number of trees) in accordance with IPCC guidelines.

Concerning the fruit trees, it is assumed that their number would increase by 10 percent by 2030, whereby the number of non-forested fruit trees would reach 28,041 thousand, and the number of deciduous fruit trees 22,061 thousand. Table 0-1 shows an estimation of forest areas in kha and the

number of fruit trees in Lebanon for the year 2030. Hence, the total carbon uptake increment[1] for the year 2030 will be around 347.32 kt of carbon.

Table 0-1 Forest area and number of trees in the baseline scenario

	TOTAL FOR THE YEAR 2004	2004	EXPECTED TREND	2030 TOTAL EXPECTED	2030 PROJECTIONS
Area Evergreen stands (ha)	139,522	134,298	Increase from 13% to 20% cover	211,836	206,612
Area Deciduous stands (ha)		5,224			5,224
Number of non-forested evergreen fruit trees ('000)		25,492	10% increase in number of fruit trees	28,041	
Number of other fruit trees ('000)		20,056	10% increase in number of fruit trees	22,061	
Total Carbon uptake increment (kt)		249.19		347.32	

1.3. MITIGATION OPTIONS AND COSTS

To be able to fulfill the expected scheme, i.e. increase forest cover, sustainably manage existing stands, conserve and expand protected areas, a number of projects, efforts and measures should be followed and implemented. The challenge is to reach the high target of 20% forest cover of MoE's plan and to maintain the current and future tree stocks. This can be done through:

Maintaining and conserving existing forest carbon sinks

MANAGING NATURE RESERVES AND PROTECTED AREAS

Nature reserves in Lebanon occupy around 5% of the overall area (MoE, 2006), i.e., an area of 52,260 ha.

In reference to the CBD goal 1 target 1.1, an objective of 10% of the "world's ecological region" should be effectively protected (MoE, 2009). As per the Initial National Communication (1999), two targets that could be realized through reforestation - agro-forestry and urban forestry - were set at two levels:

- The expansion of the forest area from 75,000 hectares to 200,000 hectares (low target).
- The expansion of the forest area from 200,000 hectares to 282,000 hectares (high target).

Working to maintain existing protected areas and to sustain the creation of new protected sites (whether nature reserves or other types of protection) will not only allow Lebanon to enhance biodiversity, but will contribute as well to the mitigation of emissions by conserving existing carbon sinks.

Maintaining forests and preventing forest degradation involves the following management practices:

[1] Total Carbon uptake increment (Kt C) = [(Area of forest $_{\text{per tree type}}$ x Annual growth rate) + (Number of trees $_{\text{per tree type}}$ x Annual growth rate)] x CF

The annual growth rate assumed is 2.5; 1.5; 0.004125; 0.002475 for evergreen forests, deciduous forests, evergreen fruits/olive trees and for deciduous fruit trees, respectively. The carbon fraction, CF = 0.5.

- Adopting sustainable forest management practices in grazing, Non Wood Forest Protection (NWFP), and wood harvesting in forests and other wooded lands (OWL) to address the possible threats to these ecosystems and improve their status;
- Preventing forest degradation and habitat fragmentation through 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; and
- Rehabilitating abandoned lands and degraded zones to ensure natural forest regeneration and development.

According to the current national plans, 72,314 ha will be reforested by 2030. Larger increases in the reforested areas are likely to conflict with the foreseen development and urban expansion trends which Lebanon is already witnessing. Hence, the mitigation option analyzed here consists of maintaining and sustainably managing the existing stocks as well as the new stock to be planted.

Reforestation costs, including initial costs, recurring maintenance costs and monitoring costs are considered to be baseline costs. Additional costs for forest protection and management as carbon sinks, in addition to costs of leakage monitoring, are considered to be mitigation costs and are accounted for (Table 0-2 and Table 0-3).

For this purpose, a management and conservation plan is defined and relevant costs are estimated as follows:

- **For existing forests and OWL,** the measures needed consist of:
  - Wood clipping and pruning of trees, including transportation of pruning residues, at a cost of 1,000 USD/ha. This measure would be repeated twice between 2010 and 2030.
  - 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, at a cost of around 100,000 USD/year.
  - Acquiring 40 vehicles equipped with water tanks and pumps for patrolling all forest and OWL areas throughout the country. The cost per vehicle would amount to 50,000 USD, and these would serve for 20 years. Each vehicle would be in charge of monitoring a specific region to prevent fires, and would simultaneously play the role of a fire monitoring tower by parking in a location with a view on a large green area. The effective duration of operation is 6 months, from June until November, where the vehicles are used in forest protection. The operation costs of these vehicles (fuel, repair and maintenance, etc.) would be 600 USD/month.
  - Hiring 80 forest guards (two guards per vehicle) who would be exclusively in charge of monitoring forests and OWL within a certain area and preventing forest fires. Their role would be to alternate between patrolling of forests and OWL within their area of jurisdiction and stationary monitoring forests from strategic locations in order to prevent fires and fight potential fires with the water tank mounted on their vehicle while they are at their preliminary controllable stages. The role of these guards equipped with vehicles would be preventive and protective, and would also considerably save on firefighting costs. The monthly salary of these guards would be around 1000 USD/ month for 6 months per year.

- Setting up a communication system between guards (e.g., mobile lines with internal extensions between guards) to ensure optimal coordination and supervision of green areas. The cost of such a system would be around 9,000 USD for 80 lines as a capital cost, and a monthly 4,000 USD as O&M cost.
- Managing pests in forests and OWL by spraying pesticides by plane (as currently practiced). This measure would have to be implemented every other year. The cost would amount to around 400,000 USD every year that spraying is carried out. However, research and implementation of other more environment-friendly pest management practices are recommended.

- **For newly reforested areas:** the most cost-effective way of protecting the trees to be planted as per governmental plans until 2030 is to assign the responsibility of monitoring these zones and preventing grazing and deforestation to the forest guards that shall be hired for fire monitoring in existing forests and OWL. These guards would therefore have to be on duty for the remaining 6 months per year (wet season). Violations would be dealt with in coordination with the Internal Security Forces. The guards will be equipped with the communication systems and vehicles for the remaining 6 months, during the wet season.
- The timeframe for costing of the proposed measures for forest management and protection is assumed to be 2011 to 2030.

Table 0-2 Breakdown of the costs of forest protection and management measures

MEASURE	AVERAGE ANNUAL COST (MILLION USD/ YEAR)
Existing forests and OWL	
Clipping and pruning	18.26
Clearing of grass and weeds	0.1
Vehicles (capital cost)	0.1
Vehicles (fuel & maintenance)	0.14
Forest guards	0.48
Communication system	0.02
Pest management	0.40
Subtotal	19.50
Newly reforested areas	
Forest guards	0.48
Communication system	0.02
Vehicles (Fuel & maintenance)	0.14
Subtotal	0.65
Total	**20.15**

Table 0-3 Costs of forest protection and management for selected years

YEAR	2004	2011	2015	2020	2025	2030
Area of forests (ha)	139,522	156,037	166,371	180,289	195,409	211,836
Total CO_2 Uptake Increment (t CO_2)	913,686	996,755	1,048,471	1,117,674	1,208,231	1,273,499
Cost (USD/ha)		112.2	111.4	108.3	109.7	107.1
Cost (USD/tCO_2)		17.6	17.7	17.5	18.0	17.8

The total present value cost (at different discount rates) of managing and protecting the existing forested areas and OWL, as well as managing reforested areas, to ensure that the stocks continue to sequester carbon, are presented in Table 0-4. The costs reflect the investment and operational costs to be incurred between the years 2011 to 2030 to implement the proposed mitigation scenario.

Table 0-4 Total discounted costs for forest protection and management

DISCOUNT RATE	PV (COST IN USD) UP TO 2030	COST (USD) PER TONNE OF INCREMENTAL CARBON SEQUESTERED (UP TO 2030)	COST (USD) PER TONNE OF CO_2 SEQUESTERED (UP TO 2030)
5%	242,899,386	39.4	10.76
10%	162,550,434	26.3	7.20
15%	117,495,326	19.0	5.21

Reducing carbon emissions through improving carbon sequestration by forests

Afforestation and reforestation (A/R) as defined in the CDM framework, which includes agroforestry and sylvo-pastoral systems.

The establishment success rate of seedlings after reforestation depends on the presence of native species and on the age of the seedlings at transplantation. A common misleading assumption might be to estimate the area planted during reforestation/afforestation and extrapolate it to the future area to be forested.

Accordingly, and in order to optimize the success rate of reforestation campaigns, the National Reforestation Plan (NRP) in Lebanon stipulated the use of native species in each site according to the ecological criteria, and the climate and soil characteristics in the related ecosystem. The NRP banned the introduction of non-native species but very limited measures are taken in Lebanon to identify and prevent the introduction of alien species, ascertain the origin of the seedlings, encourage production native species and monitor the establishment and development success of those reforestation campaigns.

Moreover, scientific evidence (Benayas et al, 2005; Castro et al, 2004) has shown that planting methods such as seeding or relying on bushes or species from the understory to initiate successful forest dynamics are more successful than direct planting, but require significantly more time to result in effective ecosystem development. While the reforestation success rate for coniferous, deciduous and mixed wood areas can be as high as 90% in northern humid environments such as parts of the USA

(Department of the Environment, 2001), this rate could go as low as 20-30% (Castro et al, 2004) in stressful environments such as Mediterranean ecosystems including Lebanon. However, no direct assessments have been conducted in Lebanon to substantiate this claim.

When it comes to mitigating the emissions of GHGs, the term 'reforestation' could designate any action aiming at replanting barren or degraded areas with trees that would contribute to the overall carbon sequestration balance. In this perspective, all efforts of agroforestry or even urban greening (recreation areas, urban parks….) should be included. Linking forests and OWL through corridors (fruit trees and local species) is of utmost importance in enhancing the green cover and conserving existing stands. Spillover effects from creating contiguous forest lands include the reduced habitat fragmentation.

The reforestation initiative which has been accounted for in the baseline scenario already presents a huge challenge for Lebanon considering the rapid expansion of built areas. Hence, additional reforestation to exceed 20% of the land area is not a realistic option for Lebanon, and will not be analyzed.

Substituting fossil fuels by forest-based biofuels: a CDM option

Despite the global controversy on the exact contribution of forests in reducing carbon in the atmosphere and enriching it with oxygen, scientific data confirm that they positively contribute to reducing the atmospheric carbon balance (ADEME, 2007). In addition to their role in reducing global C-equivalent rates, forests can positively contribute to mitigating climate change effects by substituting fossil fuels with forest-based fuels.

In France, the energy value of forests was estimated at 9.2 million tonnes of fossil fuel equivalents and would contribute to reducing 4.3 million tonnes of CO_2 per year, which however values the role of forests as a carbon sink more than that of substitution for fossil fuels.

In Lebanon, the forest growth rate is relatively low when compared to the annual demand for wood fuel and unless sustainable forestry practices are adopted and implemented, a recommendation to increase the supply of forest-based fuels is hardly applicable to Lebanon and should be considered with care. OWL can serve as the main source of biofuel from wood clipping and horticulture. The density of forests and OWL can also be reduced to provide biofuel while also reducing the fire risk.

Over the past 15 years, the rate of forest expansion over the globe has been considerably slowed down (Lettens et al, 2008). In Lebanon the forest cover has been reduced to 13% of the total land area (section 1.1). Global future trends can be hardly assessed as they depend on how economy and agriculture would grow with respect to forest ecosystems, and thus the role of forests as a substitute to fossil fuels could gain importance with time.

The above-mentioned measures, if adopted, are expected to positively contribute to mitigating Lebanon's contribution to climate change from the forestry sector. It is well-acknowledged that forests have an important contribution to carbon sequestration even if there remain many uncertainties with regard to the exact magnitude of their contribution.

Past research studies and reports have estimated the cost of some measures related to reforestation, management and protection of the existing forest cover. Table 0-5 summarizes the cost of implementing those activities in Lebanon.

Table 0-5 Cost of forest restoration and protection activities in Lebanon

ACTION	COST (MILLION USD)	SOURCE

Forest protection	2.25 (over 46 years)	INC, 1999
Fire fighting and restoration of burnt sites	6	Sattout et al., 2005
Reforestation (reforested area = 207,000 ha)	500 (over 46 years)	INC, 1999
Reforestation	2.255 (over 5 years)	MoE, 2009
Management of Protected Areas	4.68 (over 5 years)	MoE, 2009 – MoE, 2006

In conclusion, even if the direct benefit of forests in Lebanon cannot be properly highlighted through their contribution to GHG emissions removal, the economic values of those forests in terms of ecosystem services and other secondary benefits (wellbeing, cultural, etc...) should be considered while valuing Mediterranean forests.

Table 0-6 and Table 0-7 present the mitigation strategy for the Forestry sector and associated gaps and constraints.

Table 0-6 Mitigation Action Plan

IMPACT	PROPOSED MITIGATION STRATEGY	ACTIVITIES	RESPONSIBILITY	PRIORITY (ST/ MT/ LT)	INDICATIVE BUDGET (USD)	SOURCES OF FINANCING/ IMPLEMENTATION PARTNERS
Decrease in the regeneration rate population rate and overall area for the most vulnerable species identified: Juniperus excelsa Cedrus libani Abies cilicica Quercus cerris Fraxinus ornus, Ostrya carpinfolia	Maintaining and conserving existing forest carbon sinks	Managing nature reserves and protected areas Adopting sustainable forest management practices Preventing forest degradation and habitat fragmentation, insect and pest management Ensure natural forest regeneration and development	MoA MoE	ST-MT	20 million USD/ year	MoE and MoA budgets UN-REDD Programme International agencies Municipal budgets
	Substituting fossil fuels by forest-based biofuels	Wood clipping and horticulture in OWL. Reduction of forest density to provide biofuel.	MoA MoE Municipalities	ST-MT	Local cost difficult to capture; negligible.	MoE and MoA budgets Municipal budgets

Table 0-7 Constraints to the implementation of Mitigation measures

MITIGATION STRATEGY	CONSTRAINTS/ GAPS				
	LEGAL	INSTITUTIONAL	TECHNICAL	CAPACITY AND AWARENESS	DATA/ INFORMATION GAPS
Maintaining and conserving existing forest carbon sinks	Lack of enforcement of regulations relating to forests	▪ Lack of active cooperation between different departments and authorities. ▪ Poor coordination among main players, including donors or funding agencies. ▪ Inadequate, conflicting or outdated policies.	▪ High cost is the main constraint to adopting better forest management. ▪ Limited budgetary support for effective management for many of the country's protected areas. ▪ High financial inputs required for ensuring natural forest regeneration and development. ▪ Lack of equipment to prevent or intervene in case of emergencies such as forest fires and pest outbreaks.	▪ Lack of vocational training for forest management. ▪ Weak training programs of the personnel at the management and supervisory level. ▪ Limited capacity to respond to emergencies such as fires.	▪ Insufficient data on forests and protected areas. ▪ Absence of a centralized portal database related to biodiversity available for research and management of protected areas and forests.
Substituting fossil fuels by forest-based biofuels	Inadequate enforcement of legislation to regulate and control such activities.		▪ The forest growth rate is relatively low when compared to the annual demand for wood fuel.	Insufficient awareness of the benefits of fossil fuel substitution by biofuels, and of the necessity and way of controlling clipping and horticulture	Insufficient valorization of research. Lack of relevant data and records.

MITIGATION STRATEGY	CONSTRAINTS/ GAPS				
	LEGAL	INSTITUTIONAL	TECHNICAL	CAPACITY AND AWARENESS	DATA/ INFORMATION GAPS
			▪ Lack of relevant plans and organization.	activities.	

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