Table 3-14 Emission reduction potential and cost of mitigation from the proposed measures

	Mitigation Option 1: Improved Breeding & Feeding Management	Mitigation Option 2: Nutrient Management
Emission Reduction (in tCO_2 eq.)by 2030	78,631	399,000
Cost (USD/tCO_2 eq.)	55	5
Total Cost (in USD million)	4.33	2.0

cost of machinery) while a budget of USD 105 million is needed to convert the same area to drip irrigation. The lack of information on the sequestration of CO_2 by soils in Lebanon limits the analysis of the sequestration potential from the shift to drip irrigation, and the calculation of the cost of this measure per tCO_2 eq.

3.4. Forestry

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. Mitigation actions are designed to increase carbon sequestration by forests and soil by maintaining and conserving existing forest carbon sinks and increasing forest cover by reforestation and afforestation.

3.4.1. Baseline scenario

The MoE's and MoA's reforestation/afforestation plan aims at increasing the forest cover from 13% of Lebanon's land surface area to 20%. 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 3-15 shows the area of forests in kha and the number of fruit trees in Lebanon for the year 2004, as well as projections under a baseline scenario with a 2030 horizon. The GHG inventory has estimated the annual total carbon uptake increment in Lebanon for the year 2004 at around 249.19 kt of carbon.

3.4.2. Mitigation options and costs

Mitigation scenario 1: Maintaining and conserving existing forest carbon sinks

Maintaining forests and nature reserves can be achieved through:

- Adopting sustainable forest management practices such as grazing, Non Wood Forest Poducts (NWFP), and harvesting of wood in forests and other wooded lands (OWL) to address the possible threats to these ecosystems and improve their status;

Table 3-15 Forest area and number of trees in the baseline scenario

	Total for the year 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 (1,000)		25,492	10% increase in number of fruit trees		28,041
Number of other fruit trees (1,000)		20,056	10% increase in number of fruit trees		22,061
Total Carbon uptake increment (kt)		249.19			347.32

- 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 leakage monitoring and their incurred costs between 2011 and 2030 are as follows (Table 3-16 and Table 3-17):

- 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 in case it is not already being undertaken by local people;

- 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 USD 100,000/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 USD 50,000, and these would serve for 10 years. 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 USD 600/month;

- Each vehicle will be run by 2 forest guards, who would be in charge of 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. The incurred costs are USD 1,000/month as salaries for the forest guards;

- 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 USD 9,000 for 80 lines as a capital cost, and a monthly USD 4,000 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 USD 400,000 every year that spraying is carried out. However, research and implementation of other more environment-friendly pest management practices are recommended.

Table 3-16 Breakdown of the costs of forest protection and management measures

Measure	Average annual cost (USD million/year)
Clipping and pruning	18.27
Clearing of grass and weeds	0.10
Vehicles (capital cost)	0.10
Vehicles (fuel & maintenance)	0.28
Forest guards	0.96
Communication system	0.04
Pest management	0.40
Total	20.15

Table 3-17 Costs of forest protection and management for selected years

Year	2015	2020	2030
Area of forests (ha)	166,371	180,289	211,836
Total CO_2 Uptake Increment (tCO_2)	1,048,471	1,117,674	1,273,499
Cost (USD/ha)	111.4	108.3	107.1
Cost (USD/tCO_2)	17.7	17.5	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 3-18. The costs reflect the investment and operational costs to be incurred between the years 2011 to 2030 to implement the proposed mitigation scenario.

Table 3-18 Total discounted costs for forest protection and management

Discount Rate	PV (cost in USD) up to 2030	Cost (USD/t of incremental C sequestered) (up to 2030)	Cost (USD/ tCO_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

Mitigation scenario 2: Afforestation and reforestation including agroforestry and sylvo-pastoral systems

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, the climate and soil characteristics in the related ecosystem and has banned the introduction of non-native species. However, very limited measures are currently taken to identify and prevent the introduction of alien species, ascertain the origin of the seedlings, encourage production of native species and monitor the establishment and development success of those reforestation campaigns. In addition to the control of the alien species, a forest genetic resources conservation and management strategy should be implemented, including the management of seeds provenances.

Reforestation success rate for coniferous, deciduous and mixed wood areas can be as low as 20-30% (Castro et al., 2004) in stressful environments such as Mediterranean ecosystems including Lebanon. 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.

Any action aiming at replanting trees on barren or degraded areas that were previously covered by forests and would contribute to the overall carbon sequestration balance is identified as “reforestation”. The action of establishing forests on sites that were not previously considered as forests is called afforestation. In this perspective, all efforts of agroforestry or even urban greening (recreation areas, urban parks, etc.) are included. Linking forests and OWL through corridors (forest trees, wild 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.

Mitigation scenario 3: Substituting fossil fuels by forest-based biofuels: a CDM option

In addition to their role in reducing global carbon equivalent rates, forests can positively contribute to mitigating climate change effects by substituting fossil fuels with forest-based 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 and should be considered with care. 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.

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

3.5. Waste

The waste sector, including wastewater, is the largest source of CH_4 emissions in Lebanon. The sector generated 2,227 Gg CO_2 eq. in 2004, or 11% of the total GHG emissions for the same year. Calculations for the years 2000 to 2004 indicate an increase of 28% in waste GHG emissions by 2004 (base year 2000).

The discussion on mitigation potential from the waste sector will focus on solid waste management which accounts for the majority of emissions in this sector.