Models From LRI’s Landscape Restoration Interventions for Climate Change Adaptation & Mitigation in Lebanon

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Overview of LRI

- Lebanese NGO specialized in landscape restoration since 2010
- Reforestation - one primary activity
- Contributing to the Lebanese Ministry of Agriculture 40 Million Tree Program
- Surface area planted to date: 1435 Ha
- Seedlings planted by LRI since 2011: 973,935
Historical Carbon Sequestration Service of Lebanese Forests

- Inscriptions to mark the boundary of ~80% of Lebanese forests decreaded by Roman Emperor August Hadrien (117-138 B.C)

- Area of dense forests of *Cedrus libani*, *Abies cilicica*, *Juniperus excelsa* and *Quercus spp.* during the Romain Era: **172,000 Ha**

- **1,201,420 Tonnes** of CO$_2$ annually removed from the atmosphere

(Source: L. Charbel, 2019)
Lebanon’s INDC:

- Unconditional Target: 15% reduction in GHG emissions by 2030 compared to the Business-As-Usual (BAU) scenario in 2030
- Conditional Target: 30% reduction in GHG emissions by 2030 compared to the BAU scenario

- GHGs covered: CO$_2$, CH$_4$, N$_2$O

- Two of the main pillars to mitigate GHG emissions under INDC:
  - 40 Million -Tree Program
  - Landscape degradation neutrality

- Lebanon’s green cover removed 3.5 million Tonnes of CO$_2$ emissions from the atmosphere in 2013

(Source: Ministry of Environment, 2015)
In 2013:
• Lebanon’s emissions reached 26.3 million Tonnes CO₂ eq
  - 23% of emissions from the transportation sector

(Source: MoE, 2017)
Mitigation Through Reforestation
A Static Model

Advanced Car Rental
- GHG emissions from transportation service
- Reputation as green company

Lebanon Reforestation Initiative
- Reforestation
- Carbon sequestered equivalent to GHG emitted
Mitigation Through Reforestation
A Static Model

Private Sector Company
- 658 cars of different specifications
- Annually travelled distance of car flee

Lebanon Reforestation Initiative
- Area to be converted to forest based on IPCC guidelines (C sequestered in growing trees)
- Number of trees to be planted (500 / Ha)

Agreement
- Funding for mitigation based on cost of planting required number of trees (one-way assumption)
- Reporting based on number of trees planted
Mitigation Through Reforestation
A Dynamic Model

Indices showing health, growth, change in dynamics
Additivity of benefits from previous landuse
Resilience to weather fluctuations
Accounting for group of services (i.e. erosion reduction, C sequestration)
Comparison between ecosystem behavior and services delivery under different bioclimatic zones
Monitoring of ecosystem through remote sensing
A Forest in the Making

Characteristics of Study Area

- Area: 45.2 Ha
- Elevation range: 890 - 1010 m
- Seedlings planted: 45,980
- 13 species (mostly deciduous)
## Examples of Monitoring Indices

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Resolution</th>
<th>Index</th>
<th>Dates</th>
<th>Calculation Method</th>
<th>Proxy For</th>
<th>Site</th>
</tr>
</thead>
</table>
• Atmospheric correction  
• Square \((\text{NDVI} - \text{NDVI min}) / (\text{NDVI max} - \text{NDVI min})\) | Green cover change | Change of herbaceous cover (mostly) considering resolution of imagery & age of trees planted |
• Atmospheric correction  
• \((\text{NIR} - \text{SWIR}) / (\text{NIR} + \text{SWIR})\) | Moisture content in leaves and reflection of water availability in soil | Change of moisture content in herbaceous cover &/ or trees depending on age of trees planted |
• Atmospheric correction  
• Mean red range bands / mean green bands range | Green cover foliage growth & canopy stress | Health & growth of herbaceous cover & trees planted (after a certain age) |
A forest in The Making - Dynamic Model -

Change in Proportion of Vegetation Before and After Planting in Anjar

Spring 2009 / 2008
Before Planting

Spring 2013, 2014 / 2009
During Planting

Spring 2016 / 2013, 2014
After Planting

Spring 2017 / 2016
After Planting

Spring 2018 / 2017
After Planting

Legend
- Site Border
- Change in PV
  - Decrease
  - No Change
  - Increase

Scale: 0 - 400 Meters
A forest in The Making - Dynamic Model

Area Gain (m²) in Proportion of Vegetation - Anjar Site -

Area Gain (m²) in NDMI - Anjar Site -

Fluctuation in Precipitation (%) - Haouch El Oumara Station
Altitude 920 m

Area Gain (m²) in RGR - Anjar Site -
# A forest in The Making - Dynamic Model

## Avoided Social Cost of Carbon

<table>
<thead>
<tr>
<th>Region</th>
<th>Total Lands converted to Forests from the previous year</th>
<th>New land added to the category: Land converted to Forest</th>
<th>Total lands in the category: Lands converted to Forest</th>
<th>$G_W$ (tonnes d.m. ha$^{-1}$ yr$^{-1}$)</th>
<th>$R$ (Dimensionless)</th>
<th>$G_{Total,EXT,MAN}$ (tonnes d.m. ha$^{-1}$ yr$^{-1}$)</th>
<th>Carbon Fraction (tonnes C (tonne d.m.$^{-1}$))</th>
<th>DCLR$^{Growth}$ (tonnes C yr$^{-1}$)</th>
<th>CO$_2$ removal (tonnes)</th>
<th>Above and Below ground Biomass Starting year 6</th>
<th>Avoided Social Cost of Carbon (USD) (2011 prices) per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anjar</td>
<td>45.2</td>
<td>0</td>
<td>45.2</td>
<td>6.45</td>
<td>0.27</td>
<td>8.1915</td>
<td>0.5</td>
<td>185.1279</td>
<td>-678.8</td>
<td>84,850</td>
<td>(Source: IPCC Good Practice Guidance for LULUCF)</td>
</tr>
</tbody>
</table>

**Carbon Fraction (tonnes C (tonne d.m.$^{-1}$))**

- Total above-ground and below-ground non-woody biomass (tonnes d.m. ha$^{-1}$)
- Total increase in above-ground biomass area excluding trees (removal of 26% of total area)
- Total Tonnes of C (litter) remaining on site
- CO$_2$ removal (tonnes)
- Proxy of grass decomposing to soil organic matter

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<tr>
<td>0.5</td>
<td>6.1</td>
<td>0.999</td>
<td>3.04695</td>
<td>-11.17</td>
<td>1,396.58</td>
<td>(Source: IPCC Good Practice Guidance for LULUCF)</td>
</tr>
</tbody>
</table>
A forest in The Making - Dynamic Model
Avoided Social Cost of Carbon

<table>
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<tr>
<th>Mass (kg of soil loss per Ha per year)</th>
<th>Total area of site (Ha)</th>
<th>Emission Factor (kg N)-1</th>
<th>Kg of N2O-N released yearly due to erosion of mineral soils</th>
<th>Avoided N2O emissions (Tonnes)</th>
<th>Equivalent to Avoided CO2 emissions (tonnes)</th>
<th>Avoided Social Cost of Carbon (USD) (2011 prices) per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>50000</td>
<td>45.2</td>
<td>0.01</td>
<td>22600</td>
<td>35.51</td>
<td>10,583.25</td>
<td>1,322,907.14</td>
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<tr>
<td>200000</td>
<td>45.2</td>
<td>0.01</td>
<td>90400</td>
<td>142.05</td>
<td>42,333.02</td>
<td>5,291,628.57</td>
</tr>
</tbody>
</table>

Données météo
Cartes topographiques
Données pédologiques
Images satellitaires
Études de terrain

Erosivité des pluies
Longueur de la pente
Angle de la pente
Erodibilité des sols
Couvret végétal
Mesures anti-érosives

Quantification des pertes de terre

Données météo
Cartes topographiques
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A = R*LS*K*C*P

Carte du risque éroso
THANK YOU