Assessment of Land Degradation Neutrality (LDN) Using Earth Observation Datasets in Southern Tunisia

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United Nations/Romania Conference on Agriculture
06-10 May 2019, Cluj-Napoca, Romania
TUNISIA

Long.: 7° - 12°E
Lat.: 32° - 38°N
Area: 165 000 km²
Population: 12 M

Climate variability
Mediterranean Sea
Sahara
Coastline spans: 1300 km
Land Degradation in Tunisia

Farming lands: $\frac{1}{3}$ of Total Area

75% of Tunisian territory is threatened by Land Degradation

- Compaction
- Hydromorphy
- Depletion
- Pollution
- Urbanisation
- Salinisation
- Wind erosion
- Water erosion

A Major Threat to Ecological Functioning, Food Production and Livelihood Development
Land Degradation: a Major Problem in Southeastern Tunisia

- Sandy soils with medium water storage capacity
- Aridity, extreme events
- Limited natural resources
- Sparse vegetation cover

LAND DEGRADATION

38% of Medenine governorate territory (MEHAT, 2012)
● Alarming state of Land Degradation

● A National Concern for SD, Biodiversity Conservation and CC Mitigation and Adaptation

● Concerted Efforts with the International Communities such as The United Nations Convention to Combat Desertification (UNCCD)
Goal SDG 15.3
“By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world” (UN, 2017).

Land Degradation Neutrality (LDN)
UN 2030 Agenda for SD

A state of **No Net Loss** of healthy and productive land

**Avoidance of the land degradation:**
- Reducing or reversing destruction,
- Conservation and improvement of ecosystem services
LDN Indicators Computation

Application of a tiered approach (UNCCD, 2016):

- **Tier 1 (default method):** Global/regional earth observation, geospatial information and modelling.
- **Tier 2:** National statistics and national earth observation.
- **Tier 3 (most detailed method):** ground measurements (field trips, GPS points collect…).
LDN assessment: Setting an LDN baseline: 2015

Identifying trends, drivers of LD, and LDN hotspots

Monitoring and reporting on progress towards LDN
Study area in southeastern Tunisia

- Climate: upper arid to lower arid
- Rainfall: less than 200 mm/year
- Vegetation: Chamaephytes
- Farming System: agriculture using rainwater
Earth Observation Data And Open Source Applications

Mapping and Analyzing the 3 UNCCD LDN Indicators

- Land Cover Change
- Land Productivity Change
- Soil Organic Carbon Stock
Flowchart of the Methodology

Indicators
- Land cover
  - Remote sensing (Landsat)
- Land productivity
  - Earth observation (Modis EVI)
- Carbon stock
  - Trend.Earth tool

Methods of computation
- Area (per land cover class)
- Net Primary Productivity
- Soil Organic Carbon (SOC)

Metrics
- Baseline status ($t_0$)

Baseline status ($t_0$)
- ND
- D

Monitoring period ($t_1$)
- IOAO
- Positive
- Stable
- Negative

Land degradation Neutrality status ($t_0$-$t_1$).
- Net gains.

Comparison of gains and losses ($t_0$-$t_1$)

ND : not degraded
D : degraded
1OAO : “one-out, all-out” approach

Global Datasets: ESA CCI LC maps (300 m)

1. Reclassify LC maps to the 7 UNCCD LC classes
2. Perform an LC transition analysis
3. Identify degradation transitions (-), (+), (0).
Indicator 2: Land Productivity

Land Productivity
(annual integrals NDVI)

Trend

State

Performance
Indicator 3: Soil Organic Carbon (SOC)
The integration of the 3 LDN indicators: **ONE-OUT ALL-OUT** rule.

Area: potentially degraded by any of the sub-indicators considered potentially degraded for reporting purposes (Kust et al., 2017).
## Land Cover Change by Cover Class (1999-2015)

<table>
<thead>
<tr>
<th>Cover Class</th>
<th>Baseline area (sq. km)</th>
<th>Target area (sq. km)</th>
<th>Change in area (sq. km)</th>
<th>Change in area (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasslands</td>
<td>431,45</td>
<td>383,79</td>
<td>-47,65</td>
<td>-11,05%</td>
</tr>
<tr>
<td>Croplands</td>
<td>61,97</td>
<td>61,97</td>
<td>0,00</td>
<td>0,00%</td>
</tr>
<tr>
<td>Wetlands</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00%</td>
</tr>
<tr>
<td>Artificial areas</td>
<td>0,05</td>
<td>0,05</td>
<td>0,00</td>
<td>0,00%</td>
</tr>
<tr>
<td>Other lands</td>
<td>1 834,17</td>
<td>1 881,82</td>
<td>47,65</td>
<td>2,60%</td>
</tr>
<tr>
<td>Water bodies</td>
<td>7,73</td>
<td>7,73</td>
<td>0,00</td>
<td>0,00%</td>
</tr>
<tr>
<td>Land Cover Map Degradation</td>
<td>Area (sq.km)</td>
<td>Percent of Total Land Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------</td>
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<td></td>
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</tr>
<tr>
<td>Total land area:</td>
<td>2 327,6</td>
<td>100,00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area with improved land cover:</td>
<td>0,3</td>
<td>0,01%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area with stable land cover:</td>
<td>2 279,4</td>
<td>97,93%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area with degraded land cover:</td>
<td>48,0</td>
<td>2,06%</td>
<td></td>
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</tr>
</tbody>
</table>
Implementation SLM practices and the achievement of soil and water conservation (SWC) national strategy objectives between 1990 and 2011.

Origin of changes:

- Anthropogenic pressure, settlement, agricultural policies and national development strategies.
- Bio-physical conditions (arid and semi-arid environment)
- Management and overexploitation of natural resources: overgrazing, and expansion of cultivation.
Land Productivity State Degradation of "Dhahar-Jeffara" Transect

Created using trends.earth. Projection: decimal degrees, WGS84.

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<tr>
<td>Total land area:</td>
<td>2 327.6</td>
</tr>
<tr>
<td>Land area with improved productivity:</td>
<td>183.6</td>
</tr>
<tr>
<td>Land area with stable productivity:</td>
<td>2 127.7</td>
</tr>
<tr>
<td>Land area with degraded productivity:</td>
<td>15.1</td>
</tr>
</tbody>
</table>
Grasslands

- 36.71 km²
- 392.71 km²
- 0.21 km²

Croplands

- 11.75 km²
- 47.05 km²

• Impacts of **seasonal and yearly precipitation changes** on vegetation covers.
• Anthropic pressures: **land use changes** (further degradation in sensitive areas).

Results obtained from **TE** approaches:

- A stable productivity from 2001 to 2017
Indicator 3: Soil Organic Carbon (SOC)
Soil Organic Carbon Map of "Dhahar-Jeffar" Transect in 1999 (Tons/ha)
## Soil Organic Carbon Change from Baseline to Target (1999-2015)

<table>
<thead>
<tr>
<th>Category</th>
<th>Baseline SOC (tons/ha)</th>
<th>Target SOC (tons/ha)</th>
<th>Baseline area (sq. km)</th>
<th>Target area (sq. km)</th>
<th>Baseline SOC (tons)</th>
<th>Target SOC (tons)</th>
<th>Change in SOC (tons)</th>
<th>Change in SOC (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tree-covered areas</strong></td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0</td>
</tr>
<tr>
<td><strong>Grasslands</strong></td>
<td>10,90</td>
<td>10,22</td>
<td>431,45</td>
<td>383,79</td>
<td>470285,75</td>
<td>392306,36</td>
<td>-77979,39</td>
<td>-16,58%</td>
</tr>
<tr>
<td><strong>Croplands</strong></td>
<td>13,73</td>
<td>13,73</td>
<td>61,97</td>
<td>61,97</td>
<td>85090,24</td>
<td>85053,62</td>
<td>-36,62</td>
<td>-0,04%</td>
</tr>
<tr>
<td><strong>Wetlands</strong></td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0,00</td>
<td>0</td>
</tr>
<tr>
<td><strong>Artificial Areas</strong></td>
<td>14,00</td>
<td>14,00</td>
<td>0,05</td>
<td>0,05</td>
<td>72,84</td>
<td>72,84</td>
<td>0,00</td>
<td>0</td>
</tr>
<tr>
<td><strong>Other lands</strong></td>
<td>8,95</td>
<td>8,93</td>
<td>1834,17</td>
<td>1881,82</td>
<td>1641 797,55</td>
<td>1680 215,53</td>
<td>38417,98</td>
<td>2,34%</td>
</tr>
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<td>Area (sq km)</td>
<td>Percent of Total Land Area</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land area with improved soil organic carbon:</td>
<td>0,6</td>
<td>0,03%</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Land area with stable soil organic carbon:</td>
<td>2 276,6</td>
<td>97,81%</td>
<td></td>
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<tr>
<td>Land area with degraded soil organic carbon:</td>
<td>49,7</td>
<td>2,14%</td>
<td></td>
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<tr>
<td>Land Degradation Dynamics</td>
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</tr>
<tr>
<td>Land area improved:</td>
<td>178,6</td>
</tr>
<tr>
<td>Land area stable:</td>
<td>2 074,2</td>
</tr>
<tr>
<td>Land area degraded:</td>
<td>73,3</td>
</tr>
</tbody>
</table>
Combination of the Indicators: LDN Status Assessment

Local LDN Indicators Framework Dhahar-Jeffara transect

<table>
<thead>
<tr>
<th></th>
<th>Grassland</th>
<th>Cropland</th>
<th>Wetlands</th>
<th>Bare soil</th>
<th>Artificial areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cover</td>
<td>Degraded</td>
<td>Stable</td>
<td>Stable</td>
<td>Improved</td>
<td>Stable</td>
</tr>
<tr>
<td>Land Productivity</td>
<td>Not degraded</td>
<td>Not degraded</td>
<td>Not degraded</td>
<td>Not degraded</td>
<td>Not degraded</td>
</tr>
<tr>
<td>Soil Organic Carbon</td>
<td>Degraded</td>
<td>Stable</td>
<td>Stable</td>
<td>Stable</td>
<td>Stable</td>
</tr>
<tr>
<td>State</td>
<td>Degraded</td>
<td>Stable</td>
<td>Stable</td>
<td>Stable</td>
<td>Stable</td>
</tr>
</tbody>
</table>
Land Cover Map of «Dhahar-Jeffara» Transect

Land Category

- **Cropland**
  - Use: agricultural production
  - Land cover: Cropland
  - Land area: 61,97 km²
  - LP area: 58,8 km²
  - SOC: 13,73 t/ha

- **Grassland**
  - Use: Grazing
  - Land cover: Grassland
  - Land area: 431,45 km²
  - LP area: 381,4 km²
  - SOC: 10,9 t/ha

- **Bare soil**
  - Use: abiotic surfaces (sand, rocks, bedrocks...)
  - Land cover: Bare soil
  - Land area: 1834,17 km²
  - LP area: 1822,39 km²
  - SOC: 8,95 t/ha

- **Wetland**
  - Use: habitat for some local animals and plants
  - Land cover: Wetland
  - Land area: 61,97 km²
  - LP area: 58,8 km²
  - SOC: 13,72 t/ha

- **Artificial Surfaces**
  - Use: Urban areas, extraction sites...
  - Land cover: Artificial Surfaces
  - Land area: 61,97 km²
  - LP area: 58,8 km²
  - SOC: 13,72 t/ha

Metric Values at Baseline (t0)

- Land area: 61,97 km²
- LP area: 58,8 km²
- SOC: 13,73 t/ha

Metric Values at Target (t1)

- Land area: 61,96 km²
- LP area: 58,8 km²
- SOC: 13,72 t/ha

Land degradation state

- No significant change
  - Status: Stable

- Negative change
  - Status: Degraded

Symbols & Acronyms

- **No significant change in the metric**: Stable (No change)
- **Positive change in the metric**: Stable
- **Negative change in the metric**: Degraded land (Negative change)

LP = Land Productivity | SOC = Soil Organic Carbon

*This chart simplifies the computed values of the three LDN indicators and identifies hence their states of degradation during the reporting period (1999-2015) in Dhahar-Jeffara transect.*
Drivers of Land Degradation

- Land abandonment
- Lack of responsible land use planning
- Exploitation of natural resources (water sources)
- Overgrazing 
- Changes in the grassland class
- Climate change (extreme events).
- Soil erosion (water and wind)
- Salinization
- Unsustainable agricultural practices and techniques
• Geospatial data under GIS Open Source environment
• Analyzing and evaluating **LD status**
• Weighing the progress towards **LDN** at a local scale
• **Dahar-Jeffara transect:**
  ○ **Stable state** towards LD in the last 20 years (**89,11%**).
  ○ **Improved land:** 7.68% of total area.
  ○ **Degraded land:** 3.15% of the transect area.

- Effective management of LD risks,
- Achieving LDN by planning degradation control and integrating restoration actions
- Track the impact of land use, human activity and development.
Thanks!

شكرا