LOCAL/REGIONAL ENVIRONMENTAL IMPACTS OF (SOLID) BIOFUELS – EVALUATION OF CERTIFICATION SCHEME INDICATORS

Markus A. Meyer, Jörg A. Priess

07/06/2013
EU BC&E 2013

"The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 282826."
Solid biomass and sustainability

Possible EU policy options (EC 2012):
• Similar criteria as for biofuels and bioliquids (option 2)
• Option 2 + criteria for a forest management plan (option 4)
• Option 2 + full sustainable forest management certification (option 5)
Evaluation of certification schemes

(Solid) biofuel production
  e.g. ISCC, IWPB

Agricultural
  e.g. GlobalGAP

Forestry
  Woodfuel indicator sets¹

Global indicator sets

Global indicator sets

Global indicator sets

→ 11 different indicators sets
→ Evaluated for indicator quality and characteristics, comprehensiveness and process representation

Photos: Blogspot, SECTOR, Künzelmann/UFZ, Noy/UN,
1) Woodfuel indicator sets based on Schoenholtz, Miegroet et al. (2000), Newton and Kapos (2002), Smith et al. (2008), Lattimore et al. (2009), Diaz-Chavez (2011) and Stupak et al. (2011).
Local/regional environmental impacts

Soil

Biodiversity

GHG & air pollution

Water

Indicator rating scales

Originally developed for indicators in agro-environmental systems

### Reliability

<table>
<thead>
<tr>
<th>Indicator type (cause vs. effect-related)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Driver management practices</td>
<td></td>
</tr>
<tr>
<td>2 Driver management practices related to state or impact</td>
<td></td>
</tr>
<tr>
<td>3 Pressure emissions</td>
<td></td>
</tr>
<tr>
<td>4 State concentration of pollutant in environmental compartment</td>
<td></td>
</tr>
<tr>
<td>5 Impact environmental changes attributable to emissions</td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Bockstaller et al. (2006)

### Feasibility

<table>
<thead>
<tr>
<th>Required resources (assessment interval)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 daily assessment/measurements required</td>
<td></td>
</tr>
<tr>
<td>2 seasonal assessment/measurements required</td>
<td></td>
</tr>
<tr>
<td>3 annual assessment/measurements required</td>
<td></td>
</tr>
<tr>
<td>4 less than annual measurements</td>
<td></td>
</tr>
<tr>
<td>5 no measurement, only completing of survey</td>
<td></td>
</tr>
</tbody>
</table>
Highly feasible, less reliable indicators

Reliability
Indicator type

Feasibility
Required resources

- Soil quality
- Water quality
- Water availability
- Biodiversity
Employment of the Ecosystem Service concept for the comparative analysis of feedstocks and their environmental effects

**Ecosystem Service (definition):**
ES are the benefits people derive from ecosystems

**Human land use activities**
- Land management in agriculture and forestry

**Ecosystem structures and processes**
- Nutrient turnover and uptake
- Net primary productivity

**Ecosystem capacity**
- Sustained yield
- Biomass production
- Erosion protection

**Ecosystem services**
- Energy source provision
- Fertile soil

**Human benefit**
- Market price for biomass

(Modified from Potschin and Haines-Young (2011), Maes et al. (2012) and van Oudenhoven et al. (2012).)
Process representation in certification schemes

**Ecosystem structures and processes**

- Available water holding capacity [cm³, 33–1500 kPa]
- Saturated hydraulic conductivity [cm³/s]
- Nutrient turnover and uptake [mg/kg]

**Water quality**

- Nutrient sedimentation [mg/l]
- Pesticide immobilization rate [mg active ingredient/l]

**Water availability**

- ∆ groundwater level [mm]
- Evapo-transpiration [mm]
- Precipitation [mm]
- Runoff [mm]

**Biodiversity**

- Structural complexity [various]
- Habitats of special concern [ha]
- Ecological corridors and buffer zones [presence]
- Species richness and evenness [Simpson or Shannon-Wiener index]
- Taxa of special concern [presence]
- Indicator species [n/ha]
- Net primary productivity [t C/(ha•a)]

**Land cover and landscape**

- Land cover type and spatial distribution [ha]

---

**Ecosystem capacity**

**Provisioning**

- Sustained yield [t/(ha•a) or MJ/(ha•a)]

**Regulation and maintenance**

- Min. SOC content [g/kg]
- Max. soil bulk density [g/cm³]
- Max. nutrient removal potential [kg/(ha•a)]
- Recycling/immobilization potential of chemicals [kg active ingredient/(ha•a)]
- Peak storm flow [l/s]
- Minimum base flow [l/s]
- Max. sustainable water use [m³/(ha•a)]
- Minimal population [n] and habitat size [ha]

**Ecosystem integrity**

- Ecosystem integrity [max., min. - indicator species/ha]

---

**Human land use activities**

**Crop type**

- Fertilizer application
- Pesticide application
- Tillage practice
- Preparation and plantation practices

**Irrigation techniques**

- Residue use
- Biodiversity conservation practices
- Landscape conservation and planning

---

**Ecosystem services**

**Provisioning**

- Biomass (nutrition) [MJ or t DM/(ha•a)]

**Regulation and maintenance**

- Mediation of liquid flows [∆ minimum base flow, ∆ peak storm flow]
- Mediation of mass flows [ΔSOC Mg/(ha•a)]
- Water conditions [Δ water quality properties]
- Soil conditions and composition [Δ soil chemical properties, Δ bulk density g/cm³]
- Lifecycle maintenance, habitat and gene pool protection [Δ size of nursery populations (n) and habitats (ha), Δ indicator species]
- Pest and disease control [Δ pest control species (n/ha)]

---

The feedstock provider measures the water use per area and uses irrigation techniques that conserve water most.
The feedstock provider measures the water use per area and uses irrigation techniques that conserve water most.
Comprehensive certification scheme

Ecosystem structures and processes

- Soil quality
  - Soil formation [cm/a]
  - Available water holding capacity [cm, 33>1500 kPa]
  - Saturated hydraulic conductivity [cm³/s]
  - Nutrient turnover and uptake [mg/l]

- Water quality
  - Nutrient sedimentation [mg/l]
  - Pesticide immobilization rate [mg active ingredient/l]

- Water availability
  - Δ groundwater level [mm]
  - Evapo transpiration [mm]
  - Precipitation [mm]
  - Runoff [mm]

- Biodiversity
  - Structural complexity [various]
  - Habitats of special concern [ha]
  - Ecological corridors and buffer zones [presence]
  - Species richness and evenness (Simpson or Shannon-Wiener index)
  - Taxa of special concern [presence]
  - Indicator species [n/ha]
  - Net primary productivity [t C/(ha*a)]

- Land cover and landscape
  - Land cover type [ha] and spatial distribution

Ecosystem capacity

- Provisioning
  - Sustained yield [t/(ha*a) or MJ/(ha*a)]

- Regulation and maintenance
  - Min. SOC content [g/kg]
  - Max. soil bulk density [g/cm³]
  - Max. nutrient removal potential [kg/(ha*a)]
  - Recycling/immobilization potential of chemicals [kg active ingredient/(ha*a)]
  - Peak storm flow [l/s]
  - Minimum base flow [l/s]
  - Max. sustainable water use [m³/(ha*a)]
  - Minimal population [n] and habitat size [ha]
  - Ecosystem integrity [max./min. n (indicator species)/ha]

Ecosystem services

- Provisioning
  - Biomass (nutrition) [MJ or t DM/(ha*a)]
  - Water (nutrition & materials) [groundwater/surface water m³/(ha*a)]

- Regulation and maintenance
  - Mediation by biota and ecosystems [Δ excess nutrient balance/Δ soil and water chemical properties; pesticide application - Δ concentration in soil, water and biota]
  - Mediation of liquid flows [Δ minimum base flow, Δ peak storm flow]
  - Mediation of mass flows [Δ SOC Mg/(ha*a)]

- Water conditions [Δ water quality properties]

- Soil formation and composition [Δ soil chemical properties; Δ bulk density g/cm³]

- Lifecycle maintenance, habitat and gene pool protection [Δ size of nursery populations (n) and habitats (ha); Δ indicator species]

- Pest and disease control [Δ pest control species (n/ha)]

Human land use activities

- Crop type
- Fertilizer application
- Pesticide application
- Tillage practice
- Harvesting practices
- Irrigation practices
- Residue use
- Biodiversity conservation practices
- Landscape conservation and planning
Incomplete certification scheme

Ecosystem structures and processes

- **Soil quality**
  - Soil formation [cm/a]
  - Available water holding capacity [cm, 33>1500 kPa]
  - Saturated hydraulic conductivity [cm³/s]
  - Nutrient turnover and uptake [mg/l]

- **Water quality**
  - Nutrient sedimentation [mg/l]
  - Pesticide immobilization rate [mg active ingredient/l]

- **Water availability**
  - Δ groundwater level [mm]
  - Evapo-transpiration [mm]
  - Precipitation [mm]
  - Runoff [mm]

- **Biodiversity**
  - Structural complexity [various]
  - Habitats of special concern [ha]
  - Ecological corridors and buffer zones [presence]
  - Species richness and evenness [Simpson or Shannon-Wiener index]
  - Taxa of special concern [presence]
  - Indicator species [n/ha]
  - Net primary productivity [t C/(ha*a)]

- **Land cover and landscape**
  - Land cover type and spatial distribution [ha]

Ecosystem capacity

- **Provisioning**
  - Sustained yield [t/(ha*a) or MJ/(ha*a)]

- **Regulation and maintenance**
  - Min. SOC content [g/kg]
  - Max. soil bulk density [g/cm³]
  - Max. nutrient removal potential [kg/(ha*a)]
  - Recycling/immobilization potential of chemicals [kg active ingredient/(ha*a)]
  - Peak storm flow [l/s]
  - Minimum base flow [l/s]
  - Max. sustainable water use [m³/(ha*a)]
  - Minimal population [n] and habitat size [ha]
  - Ecosystem integrity [max./min. n (indicator species)/ha]

Human land use activities

- **Crop type**
- **Fertilizer application**
- **Pesticide application**
- **Tillage practice**
- **Harvesting practices**
- **Irrigation practices**
- **Residue use**
- **Biodiversity conservation practices**
- **Landscape conservation and planning**

Ecosystem services

- **Provisioning**
  - Biomass (nutrition) [MJ or t DM/(ha*a)]
  - Water (nutrition & materials) [groundwater/surface water m³/(ha*a)]

- **Regulation and maintenance**
  - Mediation of liquid flows [Δ minimum base flow, Δ peak storm flow]
  - Mediation of mass flows [ΔSOC Mg/(ha*a)]
  - Soil formation and composition [Δ soil chemical properties; Δ bulk density g/cm³]
  - Lifecycle maintenance, habitat and gene pool protection [Δ size of nursery populations (n) and habitats (ha); Δ indicator species]
  - Pest and disease control [Δ pest control species (n/ha)]
Comparison of feedstocks

- Biomass/energetic yield not assessed (no functional unit)
  - No normalization to compare different feedstocks
## Summary: Comprehensiveness

<table>
<thead>
<tr>
<th>Certification schemes</th>
<th>Indicators</th>
<th>Causal links</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ecosystem structures and processes</td>
<td>Ecosystem capacity</td>
</tr>
<tr>
<td>GBEP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NTA8080</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ISCC</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>REDcert</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GGLS2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>RSB</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>CSBP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IWPB</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SAN</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GlobalGAP</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Forestry</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Green/3 (>66.6%): ++, yellow/2 (33.4-66.5%): +/-, red/1 (<33.3 %): -
Discussion and conclusions

• Emphasize on feasible indicators on land management practices
  → Trade-off between reliability and feasibility

• Assessment focus at plot/farm scale (esp. human land use activities)
  → Impacts on regional scales (e.g. water availability at watershed) hardly covered

• Missing indicators and thresholds
  → Environmental performance measurement/benchmarking of feedstocks hardly possible

To which extent is it necessary and realistic to modify certification schemes for a reliable environmental assessment?

Is the current approach of embedded certification schemes and partly precise legislation suitable?
Thank you for your attention!

markus.meyer@ufz.de
https://www.ufz.de/index.php?en=31220