Water Footprinting and other Agricultural SaaS Solutions

Bertil Abbing
Head of UK Sustainability Analysts
Ecometrica is an end-to-end environmental software-as-a-service (SaaS) provider that is recognized as one of the world’s top Sustainability brands.

We have unrivalled experience in helping businesses and governments identify risks and opportunities by combining satellite earth observation data with local information and business intelligence on the award-winning Ecometrica Platform.

Ecometrica brings together recognized experts in environmental and sustainability accounting, and our software supports all aspects of sustainability planning, operations and reporting.

Our data and software services are available worldwide through our offices in London, Boston, Edinburgh and Montreal.
Content

• Benefits of SaaS
• Waterfoot Printing
• Land Use and Land Use Change (LULUC)
• Soil Moisture Change
• Water Risk and Drought Vulnerability
Benefits of SaaS

- No tedious spreadsheet calculations
- Increased accuracy
- Accessibility
- Cloud based - No software installation
- Automatic updates on a timely basis
- Increased data analysis and results
- No maintenance cost
- No capital expenses
Water footprinting Methodology

Grey Water Footprint Accounting (Franke N.A., et al. 2013)

What is a water footprint?
The water footprint measures the amount of water used to produce each of the goods and services we use. It can be measured for a single process, such as growing rice, for a product, such as a pair of jeans, for the fuel we put in our car, or for an entire multi-national company. The water footprint can also tell us how much water is being consumed by a particular country – or globally – in a specific river basin or from an aquifer.

Source: http://waterfootprint.org
Water footprinting
Calculations

\[ \text{WF}_{\text{proc, green}} = \text{Green Water Evaporation} + \text{Green Water Incorporation} \]
[volume/time]

\[ \text{WF}_{\text{proc, green}} = \frac{\text{CWU}_{\text{green}}}{Y} \]  [volume/mass]

\[ \text{CWU}_{\text{green}} = 10 \times \sum_{d=1}^{\text{lep}} \text{ET}_{\text{green}} \]  [volume/area]

\[ \text{WF}_{\text{proc, blue}} = \text{Blue Water Evaporation} + \text{Blue Water Incorporation} + \text{Lost Returnflow} \]  [volume/time]

\[ \text{WF}_{\text{proc, blue}} = \frac{\text{CWU}_{\text{blue}}}{Y} \]  [volume/mass]

\[ \text{CWU}_{\text{blue}} = 10 \times \sum_{d=1}^{\text{lep}} \text{ET}_{\text{blue}} \]  [volume/area]
Green and Blue water footprint

Green and Blue water consumption are mapped based on the available climate and rainfall models as well as models determining the required amount of water to grow a certain crop.

- Modelling Evapotranspiration (ET) \( (ET = WF_{\text{Green}}) \)
- Evaluate model at regional & global scales
  - Data sets used: FLUXNET-MTE, GLEAM, MODIS
- Precipitation maps
- \( WF_{\text{Blue}} = ET_{\text{max yield}} - \text{Precipitation} \)
Water footprinting Calculations

\[ WF_{proc, grey} = \frac{L}{c_{max} - c_{nat}} \quad [\text{volume/time}] \]

\[ WF_{proc, grey} = \frac{(\alpha \times AR) / (c_{max} - c_{nat})}{Y} \quad [\text{volume/mass}] \]
## Grey water factors

<table>
<thead>
<tr>
<th>Category</th>
<th>Factor</th>
<th>Pesticide</th>
<th>Metal</th>
<th>Nitrogen</th>
<th>Phosphorus</th>
<th>Data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical properties</td>
<td>Contaminant factor $K_{oc}$ (L/kg)</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td>User/Database</td>
</tr>
<tr>
<td></td>
<td>Contaminant factor $K_d$ (L/kg)</td>
<td></td>
<td>√</td>
<td></td>
<td></td>
<td>User/Database</td>
</tr>
<tr>
<td></td>
<td>Persistence half time (leaching)</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td>User/Database</td>
</tr>
<tr>
<td></td>
<td>Persistence half time (run-off)</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td>User/Database</td>
</tr>
<tr>
<td>Environmental factors</td>
<td>N-deposition</td>
<td></td>
<td></td>
<td>√</td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Texture leaching</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Texture run-off</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Erosion potential</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Natural drainage (leaching)</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Natural drainage (run-off)</td>
<td></td>
<td></td>
<td></td>
<td>√</td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Organic Matter content</td>
<td>√</td>
<td></td>
<td></td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>P-content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td>Climate</td>
<td>Rain intensity</td>
<td>√</td>
<td></td>
<td></td>
<td>√</td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Precipitation (mm)</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td>Agricultural practice</td>
<td>Management practice</td>
<td>√</td>
<td></td>
<td>√</td>
<td></td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>Artificial drainage (run-off)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mapping</td>
</tr>
<tr>
<td></td>
<td>Application rate (kg/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>Plant uptake (crop yield)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>N-fixation (kg/ha)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>User</td>
</tr>
</tbody>
</table>
Grey water footprint

Grey water consumption is calculated based on mapped and submitted impact factors and the Grey Water Model by Franke et al. (2013)

\[ \text{GWF} = \frac{\alpha \times \text{Appl}}{c_{\text{max}} - c_{\text{nat}}} \]

- \( \alpha \) – Grey water factors weighted intensity
- \( \text{Appl} \) – Application of chemical – user
- \( c_{\text{max}} \) – Maximal contamination – maps
- \( c_{\text{nat}} \) – Natural contamination – maps

Grey water is the amount of water necessary to assimilate contaminated water (A.Y. Hoekstra, 2012)
Göttingen area - Germany

**Grey Water Footprint**

- Total Grey Water Footprint [L]: 35,918.8
- Breakdown of the Grey Water Footprint:
  - Pesticide GWF: 19,661.3
  - Nitrogen GWF: 6.2
  - Phosphorus GWF: 2,173

**Green Water Footprint - Winter Wheat**

- 75.9 m³/ha - 2011

The Green Water Footprint is the consumed rainfall required for agriculture (here for growing winter wheat).

The green component of crop water use was simulated by a crop model (HCM-GPP-ET model**) for Europe at 0.5 degrees resolution. The actual evapotranspiration (ET), which is the sum of the water evaporated from the soil or crop surface and transpired from crops, i.e., the water required for crop growth, was measured for each month over Europe for winter wheat. Finally the Green Water Footprint dataset (m³/ha - 2011) was calculated as actual ET (in m³/ha - 2011) divided by the crop yield (ton/ha - 2011).

This Green Water Footprint data was one of the products developed by the University of Edinburgh as part of the Global Water Footprint pilot study funded by the DataLab, in partnership with Ecometrica.**

**HCM-GPP-ET model - Aggregated Canopy Model-Gross Primary Productivity-Evapotranspiration version 1**

**Blue Water Footprint - Winter Wheat**

- 34.6 m³/ha - 2011

The Blue Water Footprint corresponds to the surface and groundwater sources used for irrigation for agriculture (here for growing winter wheat).

Water deficits in crop production are usually solved by increasing irrigation (i.e., adding Blue Water). On global scales, green water use is ~4 to 5 times greater than blue water use. The blue component of crop water use was simulated by a crop model (HCM-GPP-ET model**) for Europe at 0.5 degrees resolution. The actual evapotranspiration (ET), which is the sum of the water evaporated from the soil or crop surface and transpired from crops, i.e., the water required for crop growth, was measured for each month over Europe for winter wheat. Finally the Blue Water Footprint dataset was calculated by subtracting the actual ET (which is limited by the amount of available water) from the potential ET (maximum ET if there is no water limitation).

This Blue Water Footprint data was one of the products developed by the University of Edinburgh as part of the Global Water Footprint pilot study funded by the DataLab, in partnership with Ecometrica.

**HCM-GPP-ET model - Aggregated Canopy Model-Gross Primary Productivity-Evapotranspiration version 1**
Calculating emissions from Land Use and Land Use Change (LULUC)

Why calculate emissions from land use and land use change?

- Reporting requirement for countries obligated to submit a National Greenhouse Gas Inventory (Annex I party to the UNFCCC)
- LCA of land-based products (e.g. biofuels, crops, meat)
- Understand impact of deforestation and other primary vegetation loss
Current calculation method

- Guidance, methods, calculation steps and default emission factors provided in Volume 4 (AFOLU) of the IPCC guidelines
- Considers (i) changes in carbon stock in biomass, dead wood, litter and soils (ii) GHG emissions due to land management activities (fire, fertiliser, livestock, flooding)
- Requires background reading and understanding, multiple worksheets and complicated calculation steps
- Specific emission factors may need time consuming research

\[
\Delta C_B = \frac{(C_T - C_R)}{(t_2 - t_1)} \quad \text{(a)}
\]

where

\[
C = \sum_{i,j} \left( A_{i,j} \cdot V_{i,j} \cdot BCEF_{S_{i,j}} \cdot (1 + R_{i,j}) \cdot CF_{i,j} \right) \quad \text{(b)}
\]
LULUC Analysis Steps on the Ecometrica Platform

**Step 1:** Add a ‘test’ area with available sequential land use maps to the Ecometrica platform (Marques de Comillas, Chiapas, Mexico)

**Step 2:** Perform additional analysis to re-classify original datasets into the 6 IPCC categories (Forest Land, Cropland, Grassland, Wetlands, Settlements, Other Land)

**Step 3:** Determine the areas of land covered by each category, and land areas converted from one category to another between two periods

**Step 4:** Input the area data to the calculation steps

**Step 5:** Select appropriate activities which will automatically select the proper emissions factors (IPCC defaults and regionally specific factors)

**Step 6:** Calculate emissions automatically on the platform according to the IPCC Volume 4 (AFOLU)

**Step 7:** Display results on the Ecometrica platform
LULUC questions and activities

Select the IPCC land conversion category

Questions relating to relevant changes in carbon stock for that category are added

Multiple options ‘activities’ available under each question, each activity links to a geographically relevant emission factor
Marques de Comillas
Calculations happen automatically

Carbon sequestration, loss and net change shown for all categories
Soil Moisture Change

https://soil-moisture.rothamsted-ac.ourecosystem.com/interface/
Precipitation Projections

The following graphs present the percent change in precipitation for 2050 (average of 2021-2040) and 2070 (average of 2061-2080) with reference to the baseline period 1960-1990 under two representative concentration pathways (RCPs).

RCP4.5 is an intermediate-emissions scenario, consistent with a future with relatively ambitious emissions reductions and GHG emissions increasing slightly before starting to decline around 2040.

RCP8.5 is the high-emissions scenario, consistent with a future with no policy changes to reduce emissions, and characterized by increasing GHG emissions that lead to high atmospheric GHG concentrations. It is also known as a Business-As-Usual Scenario.

Projected Change in Monthly Precipitation for 2041-2060 compared to the reference period (1960-1990)

Projected Change in Monthly Precipitation for 2061-2080 compared to the reference period (1960-1990)
Thank you

Questions
bertil.abbing@ecometrica.com

About us
www.ecometrica.com

About our partners
www.ed.ac.uk/geosciences
www.le.ac.uk/
www.thedatalab.com
www.rothamsted.ac.uk
www.ukri.org/
www.nceo.ac.uk/
www.carbomap.xyz
www.gov.uk/government/organisations/uk-space-agency
www.envsys.co.uk