The impact of hydropower and bioenergy on the water system

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Water Footprint
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Overview presentation

1. Introduction
2. Water footprint method
3. Hydropower
4. Biomass
5. Conclusions
Introduction
What is water used for?

Estimated annual world water use

km³ per year

1900 1920 1940 1960 1980 2000

SOURCE: FAO Aquastat
WATER WARS

California’s new water policy irrigates the suburbs and dries up rivers and communities.
Energy system

Water system
Carbon Footprint

Water Footprint
Will Water Be ‘The Oil of the 21st Century’?
Method
The water needs for goods and services
Globalization of water

Consumption of water-intensive goods

Production of water-intensive goods

Trade

Local water saving, but also water dependency related to import

Local water consumption and pollution related to export
The water footprint: making a link between consumption in one place and impacts on water systems elsewhere
The water footprint: making a link between consumption in one place and impacts on water systems elsewhere

[Photo: Gleick, 1993]
The concept of ‘virtual water’

Virtual water is the water ‘embodied’ in a product, not in real sense, but in virtual sense. It refers to the water needed for the production of the product.

Global trade in goods and services brings along global trade in ‘virtual water’
The water footprint of a product is the volume of fresh water used to produce the product, summed over the various steps of the production chain.
The water footprint of a product is the same as its ‘virtual water content’, but includes a temporal and spatial dimension: when and where was the water used.
The water footprint consists of three components:
blue wf + green wf + grey wf
Assessing the water footprint of a product requires analysis of the full production chain.
Water Footprint:

1. Calculate reference crop evapotranspiration $ET_0$ (mm/day) 
e.g. Penman-Monteith equation

2. Calculate crop evapotranspiration $Et_c$ (mm/day) 
$Et_c = ET_0 \times K_c$  where $K_c = \text{crop coefficient}$

3. Calculate crop water requirement $CWR$ (m$^3$/ha) 
$CWR = \Sigma Et_c$  [accumulate over growing period]

4. Calculate Water Footprint (m$^3$/ton) 
$CWR$ (m$^3$/ha) / Yield (ton/ha)
1. Calculate reference crop evapotranspiration $ET_0$ (mm/day)
e.g. Penman-Monteith equation
Selection crop area
Selection weather station
2. Calculate crop evapotranspiration $Et_c$ (mm/day)

$$Et_c = ET_0 \times K_c$$ where $K_c = \text{crop coefficient}$

3. Calculate crop water requirement $CWR$ (m$^3$/ha)

$$CWR = \sum Et_c \ [\text{accumulate over growing period}]$$
Calculation crop water requirement (m³/ha)
4. Calculate Water Footprint (m³/ton)

\[ \frac{CWR \ (m^3/ha)}{Yield \ (ton/ha)} \]
Assessing the ‘Water Footprint’ of products

Water Footprint of a Crop
Crop water use (m³/ha) / Crop yield (ton/ha)

Water Footprint of a Crop Product
Distribute the Water Footprint of the Root Product over its derived Products
The water footprint of products

<table>
<thead>
<tr>
<th>1 kg wheat</th>
<th>1 m³ water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 kg rice</td>
<td>3 m³ water</td>
</tr>
<tr>
<td>1 kg milk</td>
<td>1 m³ water</td>
</tr>
<tr>
<td>1 kg cheese</td>
<td>5 m³ water</td>
</tr>
<tr>
<td>1 kg pork</td>
<td>5 m³ water</td>
</tr>
<tr>
<td>1 kg beef</td>
<td>15 m³ water</td>
</tr>
</tbody>
</table>

[Hoekstra & Chapagain, 2008]