Modelling hydrological services for ecosystem accounting

Confidence Duku (Wageningen University, Netherlands)
Prof. Dr. Lars Hein (Wageningen University, Netherlands)
Dr. Sander Zwart (Africa Rice Center, Cotonou, Benin)
What are hydrological services?

• **Contribution to benefits** produced by terrestrial ecosystem effects on freshwater

• **Provisioning**
  1. Food production
  2. Domestic use
  3. Energy production

• **Regulating**
  1. Not too much (**flood control**)
  2. Not too little (**drought mitigation**)
  3. Not too dirty (**water quality**)

• **Habitat and maintenance**
Key challenges in modelling hydrological services

- Modelling **service capacity** and **service flow**
- Modelling **intermediate services**
- **Spatial explicitness**
- **Process representation**
- **Temporal resolution**
- For accounting: need to work at aggregated scales
Overview of models/tools available

- Traditional hydrological models
- ES specific models

Level of expertise required:
- Low
- High

Process representation, Data requirements, Temporal resolution:
- Low
- High
1. Water for household consumption
   - Groundwater
   - Surface water
2. Water for rainfed agriculture
3. Water flow regulation by forests & woodlands
Study area

- Upper Oueme watershed: 14,500km²
- Population: 700,000
- Smallholder rainfed agriculture
Modelling framework

-SWAT model

Neitsch, S.L et al. (2009)
Modelling framework

- Affont Pont - Validation
- Igbomakoro - Validation
- Beterou - Validation

Discharge (m$^3$/s) vs Time (days)

Red: Observed  Blue: Simulated
Water for households (Groundwater)

Groundwater recharge

Groundwater use

C. Duku et al./Hydrology and Earth System Sciences 19 (2015) 4377-4396
Water for households (Surface water)

Water yield

Surface-water use

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## Accounting for hydrological services

<table>
<thead>
<tr>
<th>Accounting units</th>
<th>Groundwater (10^3 m^3 yr^-1) recharge</th>
<th>Groundwater (10^3 m^3 yr^-1) extracted</th>
<th>Surface water (10^3 m^3 yr^-1 water yield)</th>
<th>Surface water (10^3 m^3 yr^-1 extracted)</th>
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</thead>
<tbody>
<tr>
<td>Affon-Pont</td>
<td>121,000</td>
<td>123</td>
<td>624,000</td>
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<tr>
<td>Aguimo</td>
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<td>Aval-Sani</td>
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<td><strong>Total</strong></td>
<td><strong>2,190,000</strong></td>
<td><strong>2,700</strong></td>
<td><strong>8,694,000</strong></td>
<td><strong>558.2</strong></td>
</tr>
</tbody>
</table>
Trends in hydrological services production

Groundwater recharge

Water yield

\[ SS = 19 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 5.4 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 3.0 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 2.5 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 1.6 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]

\[ SS = 117 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 79 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 31 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
\[ SS = 8 \times 10^6 \text{ m}^3 \text{ yr}^{-1} \]
Water for rainfed agriculture

- Days WITHOUT crop water stress/Length of growing period
- Crop-independent indicator

C. Duku et al./Hydrology and Earth System Sciences 19 (2015) 4377-4396

ISEE2016
Jun 26 – 29, Washington D.C.
Water flow regulation by forests & woodlands

Water availability

Irrigation potential

C. Duku et al./Agriculture, Ecosystems and Environment 230 (2016) 105-115
Key messages

• Water is a main (the main) limitation to crop production in the sub-humid Sudanian agro-ecological zone

• Water flows and land management are closely connected

• The ecosystem accounting approach facilitates integrated analysis of land and water resources

• There are important trade-offs: reducing forest cover (e.g. for dryland cropping) reduces downstream irrigation potential (as has been quantified in this study)

• Science-based expansion of food production required to meet food requirements of an expanding population under climate change.
THANK YOU

Email: confidence.duku@wur.nl

This research was funded by the European Commission through the International Fund for Agricultural Development (IFAD).