Emergy signature as a basis for sustainability valuation of agro-ecosystems

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Publication date:
2011

Document version
Early version, also known as pre-print

Citation for published version (APA):
Emery signature as a basis for sustainability valuation of agro-ecosystems

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1. Background
- Humans depend on the ecological resources for the inevitable needs of food, feed and energy
- Human engineered ecosystems have resulted in adverse impacts on the ecosystems
- Agro-ecosystems constitute over 37% of the earth’s surface (Porter et al., 2009)
- Agro-ecosystems are the biggest contributor to the worsening ecosystem service provision
- Reduction in the capacity of the ecosystems for provision of ecosystem services (MEA, 2005)

2. Problem formulation
- Ecosystem services are integral to the ecological sustainability and the economic prosperity
- A renewed perspective towards a sustainable society (Rydborg & Haden, 2006)
- Need for holistic accounting procedures to account for economic, social and ecological costs
- Emergy analysis (Odum & Odum, 2006) takes account of the environment and the economic inputs

3. Objective
- Assess emery input in a novel food and energy production (CFE) system compared with conventional wheat production system in Denmark
- To evaluate the sustainability of the two production systems based on emery indices

4. Materials and methods
- Emergy analysis steps (Odum & Odum, 2000; Brown et al., 2004)
- Setting up system boundary after which inputs and outputs crossing the boundary are quantified
- Inputs are converted into a common currency of solar amperes based on transformity coefficients
- Assessment of the fraction of renewable, non-renewable, purchased resources
- Use of emery indices (EYR, EIR, ELR, ESI, EFR) for sustainability valuation

5. Results

Table 1: Comparative emery indices in conventional wheat and combined food and energy systems of production

<table>
<thead>
<tr>
<th>Emery Indices</th>
<th>Parameters</th>
<th>Conventional wheat</th>
<th>CFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total exported energy (J ha⁻¹ year⁻¹)</td>
<td>T</td>
<td>1.76E+11</td>
<td>2.80E+11</td>
</tr>
<tr>
<td>Transformity (Sej J⁻¹)</td>
<td>Y/T</td>
<td>1.67E+04</td>
<td>3.42E+03</td>
</tr>
<tr>
<td>Yield (Sej ha⁻¹ year⁻¹)</td>
<td>Y</td>
<td>2.93E+15</td>
<td>9.55E+14</td>
</tr>
<tr>
<td>Total non-renewable (Sej ha⁻¹ year⁻¹)</td>
<td>R</td>
<td>2.07E+14</td>
<td>2.07E+14</td>
</tr>
<tr>
<td>Total purchased (Sej ha⁻¹ year⁻¹)</td>
<td>F</td>
<td>2.69E+15</td>
<td>7.30E+14</td>
</tr>
<tr>
<td>Renewable fraction</td>
<td>R/(R+N+F)</td>
<td>0.07</td>
<td>0.22</td>
</tr>
<tr>
<td>Emery yield ratio (EYR)</td>
<td>Y/F</td>
<td>1.90</td>
<td>1.31</td>
</tr>
<tr>
<td>Environment loading ratio (ELR)</td>
<td>(F+N)/R</td>
<td>13.17</td>
<td>3.61</td>
</tr>
<tr>
<td>Emery sustainability index (ESI)</td>
<td>EYR/ELR</td>
<td>0.08</td>
<td>0.36</td>
</tr>
<tr>
<td>Emery investment ratio (EIR)</td>
<td>F/R+N</td>
<td>11.22</td>
<td>3.25</td>
</tr>
<tr>
<td>Emery footprint ratio (EFR)</td>
<td>R+N+F/R</td>
<td>14.17</td>
<td>4.61</td>
</tr>
</tbody>
</table>

Fig. 3: Illustration of main emery flows and their interactions in combined food and energy system (CFE) in Taastrup in Denmark

Fig. 4: Sustainability indices in CFE and conventional wheat

References