Impact assessment of water and nutrient reuse in hydroponic systems using Bayesian Belief Networks
Martin Zimmermann¹*, Michaela Fischer²

¹ ISOE – Institute for Social-Ecological Research, Hamburger Allee 45, 60486 Frankfurt am Main, Germany, Tel.: +49 (0) 69 707 6919-44, zimmermann@isoe.de

² ISOE – Institute for Social-Ecological Research, Hamburger Allee 45, 60486 Frankfurt am Main, Germany, Tel.: +49 (0) 69 707 6919-40, fischer@isoe.de

* Corresponding author

Appendix A: Function tables and conditional probability tables (CPT) of impact variables

Table A.1: Conditional probability table on product confidence

<table>
<thead>
<tr>
<th>Production system</th>
<th>Consumer acceptance measures</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ornamental plant production</td>
<td>Quality label</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>Regionally produced</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>No measures</td>
<td>92%</td>
<td>8%</td>
</tr>
<tr>
<td>Food production</td>
<td>Quality label</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>Food production</td>
<td>Regionally produced</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Food production</td>
<td>Branded products</td>
<td>42%</td>
<td>58%</td>
</tr>
<tr>
<td>Food production</td>
<td>No measures</td>
<td>56%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Table A.2: Function table on groundwater recharge

<table>
<thead>
<tr>
<th>Type of area</th>
<th>Landscaping measures</th>
<th>Groundwater recharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former agricultural area</td>
<td>No measures</td>
<td>Highly reduced</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Wetland system</td>
<td>Reduced</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Landscape integration</td>
<td>Reduced</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Both measures</td>
<td>Neutral</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>No measures</td>
<td>Neutral</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Wetland system</td>
<td>Improved</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Landscape integration</td>
<td>Improved</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Both measures</td>
<td>Highly improved</td>
</tr>
</tbody>
</table>
**Table A.3: Conditional probability table on biodiversity**

<table>
<thead>
<tr>
<th>Type of area</th>
<th>Size</th>
<th>Measures</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>No measures</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Wetland system</td>
<td>21%</td>
<td>79%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Landscape integration</td>
<td>37%</td>
<td>63%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Both measures</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>No measures</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Wetland system</td>
<td>34%</td>
<td>66%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Landscape integration</td>
<td>41%</td>
<td>59%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Both measures</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>No measures</td>
<td>23%</td>
<td>77%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Wetland system</td>
<td>47%</td>
<td>53%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Landscape integration</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Both measures</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>No measures</td>
<td>26%</td>
<td>74%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Wetland system</td>
<td>48%</td>
<td>52%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Landscape integration</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Both measures</td>
<td>77%</td>
<td>23%</td>
</tr>
</tbody>
</table>
Table A.4: Conditional probability table on landscape quality

<table>
<thead>
<tr>
<th>Type of area</th>
<th>Size</th>
<th>Measures</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>No measures</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Wetland system</td>
<td>28%</td>
<td>72%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Landscape integration</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Large-scale</td>
<td>Both measures</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>No measures</td>
<td>7%</td>
<td>93%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Wetland system</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Landscape integration</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Former agricultural area</td>
<td>Small-scale</td>
<td>Both measures</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>No measures</td>
<td>53%</td>
<td>47%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Wetland system</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Landscape integration</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Large-scale</td>
<td>Both measures</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>No measures</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Wetland system</td>
<td>66%</td>
<td>34%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Landscape integration</td>
<td>76%</td>
<td>24%</td>
</tr>
<tr>
<td>Former industrial area</td>
<td>Small-scale</td>
<td>Both measures</td>
<td>84%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Table A.5: Function table on economic viability

<table>
<thead>
<tr>
<th>Production system</th>
<th>Lighting and heating</th>
<th>Size</th>
<th>Water regime</th>
<th>Economic viability</th>
<th>Rate of return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food production</td>
<td>With</td>
<td>Large-scale</td>
<td>Open system</td>
<td>Negative</td>
<td>-5 %</td>
</tr>
<tr>
<td>Food production</td>
<td>With</td>
<td>Large-scale</td>
<td>Closed system</td>
<td>Negative</td>
<td>-5 %</td>
</tr>
<tr>
<td>Food production</td>
<td>With</td>
<td>Small-scale</td>
<td>Open system</td>
<td>Very positive</td>
<td>6 %</td>
</tr>
<tr>
<td>Food production</td>
<td>With</td>
<td>Small-scale</td>
<td>Closed system</td>
<td>Very positive</td>
<td>6 %</td>
</tr>
<tr>
<td>Food production</td>
<td>Without</td>
<td>Large-scale</td>
<td>Open system</td>
<td>Positive</td>
<td>1 %</td>
</tr>
<tr>
<td>Food production</td>
<td>Without</td>
<td>Large-scale</td>
<td>Closed system</td>
<td>Positive</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Food production</td>
<td>Without</td>
<td>Small-scale</td>
<td>Open system</td>
<td>Very negative</td>
<td>-12 %</td>
</tr>
<tr>
<td>Food production</td>
<td>Without</td>
<td>Small-scale</td>
<td>Closed system</td>
<td>Very negative</td>
<td>-12 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>With</td>
<td>Large-scale</td>
<td>Open system</td>
<td>Negative</td>
<td>-10 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>With</td>
<td>Large-scale</td>
<td>Closed system</td>
<td>Very negative</td>
<td>-14 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>With</td>
<td>Small-scale</td>
<td>Open system</td>
<td>Very negative</td>
<td>-17 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>With</td>
<td>Small-scale</td>
<td>Closed system</td>
<td>Very negative</td>
<td>-19 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>Without</td>
<td>Large-scale</td>
<td>Open system</td>
<td>Negative</td>
<td>-4 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>Without</td>
<td>Large-scale</td>
<td>Closed system</td>
<td>Negative</td>
<td>-8 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>Without</td>
<td>Small-scale</td>
<td>Open system</td>
<td>Very negative</td>
<td>-12 %</td>
</tr>
<tr>
<td>Ornamental plant production</td>
<td>Without</td>
<td>Small-scale</td>
<td>Closed system</td>
<td>Very negative</td>
<td>-13 %</td>
</tr>
</tbody>
</table>
Impact assessment of water and nutrient reuse in hydroponic systems using Bayesian Belief Networks
Martin Zimmermann1*, Michaela Fischer2

1 ISOE – Institute for Social-Ecological Research, Hamburger Allee 45, 60486 Frankfurt am Main, Germany, Tel.: +49 (0) 69 707 6919-44, zimmermann@isoe.de

2 ISOE – Institute for Social-Ecological Research, Hamburger Allee 45, 60486 Frankfurt am Main, Germany, Tel.: +49 (0) 69 707 6919-40, fischer@isoe.de

* Corresponding author

Appendix B: Examples of the model’s behaviour
Figure B.1: Large-scale hydroponic food production system with acceptance and landscaping measures
Figure B.2: Large-scale hydroponic food production system without acceptance and landscaping measures.