How to meet the water deficit

- Develop new resources
- Water demand management
- Reuse water

Water reuse means collecting wastewater that flows into sewers, preferably treating it, then transferring it to land for irrigating crops.

Jordan and water reuse – Direct reuse

Direct irrigation around water treatment plants
- e.g. As Samra, Ramtha, Wadi Mousa.

Jordan and water reuse – Indirect reuse
Sustainability of reuse

- How does water reuse affect the soil?
- Can and should a threshold of use be given based on water quantity and quality inputs, soil conditions, climate, crop and management strategies employed?
- What do farmers think about the water, how do they manage it?
- What are organisations doing in all this – importance of policy?

Methods

- Soil sampling, experimentation and analysis
- Mathematical computer modelling (Hydrus)

Methods

- Semi-structured interviews with Jordanian farmers using the water – Direct and indirect water reusers.
- Semi-structured interviews with governmental, non-governmental, international, research and private organisations involved with water reuse.

Water quality – inputs to the soil

Inputs to the water that will affect the soil sustainability.
- Domestic uses, industrial waste, desalination brine …? 
- Biological contaminants
- Very very few heavy metals.
- Plant toxic ions (Na, Cl, B)
- Organic matter and NPK

<table>
<thead>
<tr>
<th>Location</th>
<th>Month and year of sampling</th>
<th>Solutes detected in the water (mg l-1)</th>
<th>Additional parameters</th>
<th>Total Organic Carbon (TOC) ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kirbet As Samra</td>
<td>Nov 2006</td>
<td>Chloride (Cl): 440.05, Sodium (Na): 253.30, Boron (B): 1.84</td>
<td>Electrical Conductivity (EC) dS m-1: 2.04, pH: 7.83, Sodium Adsorption Ration (SAR): 5.82</td>
<td>8.12 n/a</td>
</tr>
<tr>
<td></td>
<td>May 2007</td>
<td>174.25, 265.31, 0.84</td>
<td>1.48</td>
<td>7.83 5.82 10.97</td>
</tr>
<tr>
<td>Jordania</td>
<td>Nov 2006</td>
<td>328.63, 184.38, 0.89</td>
<td>1.47</td>
<td>7.84 3.65 10.73</td>
</tr>
<tr>
<td>Jordania</td>
<td>May 2007</td>
<td>408.80, 127.84, 3.20</td>
<td>1.05</td>
<td>7.79 3.45 10.73</td>
</tr>
<tr>
<td>Deir Alla</td>
<td>May 2007</td>
<td>258.94, 173.07, 1.82</td>
<td>2.08</td>
<td>7.90 3.48 9.40</td>
</tr>
</tbody>
</table>

Results – soil sustainability

To what extent do solutes accumulate in the soil?

<table>
<thead>
<tr>
<th>Location</th>
<th>Year</th>
<th>Solutes detected in the soil (mg l-1)</th>
<th>Additional parameters</th>
<th>Total Organic Carbon (TOC) ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2006</td>
<td>Chloride (Cl) 305.12, Sodium (Na) 215.50, Boron (B) 0.97</td>
<td>Electrical Conductivity (EC) dS m-1: 2.04, pH: 7.83, Sodium Adsorption Ration (SAR): 5.82</td>
<td>8.12 n/a</td>
</tr>
<tr>
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</tbody>
</table>

Results – soil sustainability

EC of soil irrigated for extensive periods of time

- 2006 irrigation under plastic
- 15 yrs irrigation all + vegetation
- Unirrigated control
Modelling
- Hydus model
- Parameterised with lab and field data and experiments
- Pedo-transfer systems
- Management methods - combination of rainfall and irrigation – do more salts percolate through the profile?

![Graph showing concentration over time](image)

Farmer management strategies
Indirect reuse (Jordan Valley)
- Leaching – quantities and timings controlled by water allocation - mainly in JV.
- Water shortage
- Mismanagement of resources
Direct reuse
- Nutrients – awareness of fertilisers in the water
- Communication with treatment plant manager

Farmer perceptions
Farmers – direct reuse
“I like the wastewater because before the treatment plant there was no water for supplementary irrigation. I make more money now”.

Farmers – indirect reuse
“The water has bad things in it for the plants, there are no good things”.

Farmer perceptions
Water reuse is a very sensitive topic – the Saudis still do not import Jordanian produce.
All interviews moved onto:
- Water shortage – this is the biggest issue in the JV.
  (But not at As Samra – here water is used without care for water scarcity)
- Mismanagement of resources – in the JV.
- Lack of support for agriculture – everywhere.
Management is critical – what do the organisations say?

- Water reuse as a “necessary evil” in a water scarce country
- Essential but not desirable
- A terminology and perception issue?????

Management is critical – what do the organisations say?

- Risks to the soil are important – but less important than risks to human health
- 50% recognised damage to soil as a risk
- None considered the role of water management in mitigating this risk.

Organisation priorities:
- Farmer training
- Monitoring
- Research

Management is critical – what do the organisations say?

- Water allocation and potential conflict between direct and indirect water users.
- Is the water a waste?
  Low value commercial crops (fodder, reeds, wood etc) versus high value vegetables

Conclusions

- The soil analysis reveal that the application of “revived” water does alter the soil chemistry.
- The alterations are dependent on the quantity of water applied, rainwater inputs and management methods.
- Very important that lab and field studies are not extrapolated directly to the farm. Must consider farmer’s knowledge and management methods.

Conclusions

- As the use of revived water rises the ratio of direct to indirect irrigation will depend on the policy of decision makers and decision making (as a response to policy) by farmers.
- Ensuring soil sustainability is imperative and achievable through water management both on and off the farm.

Thank You

With thanks to the Leverhulme Trust, my translators and all the farmers and organisation representatives who kindly took the time to speak with me.