Environmental issues and water scarcity

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Resource smart systems needed to deliver on sustainable development goals

These are food systems in which the environmental bases to deliver food security for current and future generations is not compromised
Pressures on natural resources are increasing.

Population growth and urbanisation

Climate change

Supermarketisation

Dietary changes
Food systems differ widely interconnected and same resources
The food system is failing on sustainability…

- Agriculture currently consumes 75% of total global water withdrawals from rivers and aquifers, many of which are overexploited (~30% livestock)

- Of 11.5 billion ha of vegetated land on earth, around 24% has undergone human induced soil degradation

- Agriculture directly contributes 10-12% of GHG emissions
John Beddington’s Perfect Storm Scenario

- 19-35% in water availability for agriculture
- Increase in water scarcity for man 7 – 67%
Water scarcity

Although generally considered a wet country, Scotland can be vulnerable to periods of dry weather, which can result in pressure upon the environment and water users in some areas. In addition, climate change is likely to bring uncertainty and, with a projected decrease in summer rainfall, may exert pressure in areas that have not yet experienced water scarcity.

It is vitally important that Scotland is prepared to deal with water scarcity both now and in the future and people work together to plan for and manage water scarcity events. The National Water Scarcity Plan sets out how we will work with water users (authorised abstractors and recreational users) and key organisations, such as Scottish Water, to manage water resources during periods of low rainfall. All water users have a role to play to ensure that resources are used sustainably and the potential impact on the environment is reduced.

Current situation

- [Water Scarcity Situation Report - 16 November 2018](#)

The report above will always be the most recent. Previous reports for 2018 are also available.
Under pressure: Preparing for UK water shortages

12 September 2017
Gemma Holmes

Climate change is likely to contribute to increased risk of water supply deficits. Although plans to manage the UK’s water supply and demand are in place, water companies may need to be more ambitious as they develop strategies for the future, says Gemma Holmes.

When the UK experiences several months, or years, of low rainfall there is a risk of water shortages, droughts and the dreaded hosepipe bans. A severe drought could lead to household water supplies being cut for part, or all, of the day and makeshift water tanks being set up in our streets. In England and Wales, we use 16 billion litres of clean drinking water every day – that’s equivalent to 6,400 Olympic sized swimming pools. Currently, water companies can provide slightly more than we need – 2 billion litres are available above and beyond what we’re using. In some areas, though, such as south east England, there is no surplus and, as such, these regions are more likely to face supply restrictions in a dry year. Water companies are currently working to address the potential shortfalls.

Climate change is likely to mean higher temperatures which may drive up the demand for water (alongside population growth) and increase evaporation from reservoirs and water courses during spring and summer. The impact of climate change on total rainfall is uncertain, but the rain that does fall is likely to arrive in heavier bursts in winter and summer. Heavier rain tends to flow off
Catchment management abstraction showing blue water supply in catchments
• **Water scarcity:**
  • annual renewable supply (ARS) < 1,000 m³/person

• **Water stress:**
  • extraction > 20% of ARS
Dimensions of water scarcity

- scarcity in availability of fresh water of acceptable quality with respect to aggregated demand, in the simple case of physical water shortage

- scarcity in access to water services, because of the failure of institutions in place to ensure reliable supply of water to users

- scarcity due to the lack of adequate infrastructure, irrespective of the level of water resources, due to financial constraints
Water availability and dairying

Highly dependent on water in its various forms
Important to know the water demand of a dairy system
Global milk production (FAO, April 2018)

### PRODUCTION: TOTAL MILK

*thousand tonnes*

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>801 316</td>
<td>799 097</td>
<td>810 652</td>
<td>1.4</td>
</tr>
<tr>
<td>India¹</td>
<td>155 693</td>
<td>159 396</td>
<td>165 612</td>
<td>3.9</td>
</tr>
<tr>
<td>EU</td>
<td>162 900</td>
<td>163 000</td>
<td>165 400</td>
<td>1.5</td>
</tr>
<tr>
<td>United States</td>
<td>94 619</td>
<td>96 343</td>
<td>97 735</td>
<td>1.4</td>
</tr>
<tr>
<td>China</td>
<td>42 666</td>
<td>41 952</td>
<td>41 289</td>
<td>-1.6</td>
</tr>
<tr>
<td>Pakistan</td>
<td>41 592</td>
<td>39 652</td>
<td>40 167</td>
<td>1.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>34 860</td>
<td>33 878</td>
<td>35 233</td>
<td>4.0</td>
</tr>
<tr>
<td>Russian Fed.</td>
<td>30 791</td>
<td>30 752</td>
<td>30 990</td>
<td>0.8</td>
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<tr>
<td>New Zealand²</td>
<td>21 909</td>
<td>21 568</td>
<td>21 341</td>
<td>-1.1</td>
</tr>
</tbody>
</table>

¹/ Dairy years starting April of the year stated (production only).
²/ Dairy years ending May of the year stated (production only).
The Volumetric Water Consumption of British Milk
Water footprint definition

- Water Footprint is measured in terms of volume of water consumed, evaporated and polluted

- Three corresponding categories:

  - **Blue Water Footprint:** the amount of surface water and groundwater required (evaporated or used directly) to make a product

  - **Green Water Footprint:** the amount of rain water required (evaporated or used directly) to make a product

  - **Grey Water Footprint:** the amount of freshwater required to mix and dilute pollutants enough to maintain water quality according to certain standards as a result of making a product

  [www.waterfootprint.org](http://www.waterfootprint.org) and ISO 14046 [2016]
Physical and virtual water flows in whole dairy system

Inputs: Electricity, Fertiliser, etc.

Feed System: Green water, Virtual water, Leaching & runoff, Incorporated, Blue water, Effluent.

Livestock System: Virtual water, Incorporated.

Processing System: Virtual water, Incorporated, Effluent, Blue water, Blue water, Effluent.

Surface & Groundwater Resources

Figure 1 Physical and virtual water flows in the whole dairy system. Note that this analysis only goes up to the farm gate, so that processing is limited to cooling in the dairy parlour.
## Total water used in British dairy systems

Table 1: Averaged total water used in British dairy systems, litres per kg fat and protein corrected milk (FPCM). This is to the farm gate, and does not include water used subsequently for milk processing.

<table>
<thead>
<tr>
<th>Production system</th>
<th>Blue water, l/kg FPCM</th>
<th>Green water, l/kg FPCM</th>
<th>Total water use, l/kg FPCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring calving</td>
<td>7.4</td>
<td>678</td>
<td>685</td>
</tr>
<tr>
<td>Autumn calving</td>
<td>7.5</td>
<td>683</td>
<td>691</td>
</tr>
<tr>
<td>All-year calving</td>
<td>7.5</td>
<td>681</td>
<td>688</td>
</tr>
<tr>
<td>Zero grazing</td>
<td>7.6</td>
<td>706</td>
<td>713</td>
</tr>
<tr>
<td>Organic</td>
<td>8.1</td>
<td>1,006</td>
<td>1,014</td>
</tr>
</tbody>
</table>

**Notes.**
Values for green water use would normally be rounded to 2 significant figures, but the whole values have been shown to illustrate the relatively small effect of blue water and be arithmetically correct.

1 kg FPCM is 1.01 litre milk
Effect of milk yield level on water consumption

Table 10 Effects of milk yield level on the water consumption in average British milk production

<table>
<thead>
<tr>
<th>Production system</th>
<th>Yield, kg/year</th>
<th>Blue water consumption relative to medium yield</th>
<th>Green water consumption relative to medium yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5470</td>
<td>115%</td>
<td>118%</td>
</tr>
<tr>
<td></td>
<td>6470</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>7470</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td>Autumn calving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6770</td>
<td>107%</td>
<td>116%</td>
</tr>
<tr>
<td></td>
<td>7770</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>8770</td>
<td>91%</td>
<td>93%</td>
</tr>
<tr>
<td>Spring calving</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6770</td>
<td>116%</td>
<td>116%</td>
</tr>
<tr>
<td></td>
<td>7770</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>8770</td>
<td>91%</td>
<td>92%</td>
</tr>
</tbody>
</table>
Breakdown of blue and green water in average milk production

- **Blue Water**
  - Wash water: 40%
  - Drinking water: 40%

- **Green Water**
  - Bedding: 20%
  - Grazing: 20%
  - Silage: 20%
  - Concentrates: 20%
Breakdown of blue and green water in average milk production
Consumptive water use in selected dairy systems

**Major results**

**CWU** = Consumptive water use
Table 2. Total green and blue water use per kilogram of animal product

<table>
<thead>
<tr>
<th>Product</th>
<th>Average(^2) green water use, L/kg</th>
<th>Average blue water use, L/kg</th>
<th>Range of blue water use,(^3) L/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>14,414</td>
<td>550</td>
<td>0 to 1,471</td>
</tr>
<tr>
<td>Pork</td>
<td>4,907</td>
<td>459</td>
<td>205 to 3,721</td>
</tr>
<tr>
<td>Chicken</td>
<td>3,545</td>
<td>313</td>
<td>24 to 995</td>
</tr>
<tr>
<td>Eggs</td>
<td>2,592</td>
<td>244</td>
<td>24 to 1,360</td>
</tr>
<tr>
<td>Milk</td>
<td>863</td>
<td>86</td>
<td>0 to 147</td>
</tr>
</tbody>
</table>

\(^1\)Data from Mekonnen and Hoekstra (2010).
\(^2\)Average = weighted average for 7 countries (Australia, Brazil, China, India, the Netherlands, Russia, United States) and 3 systems (grazing, mixed, industrial).
\(^3\)Range = least to greatest footprint among the 21 countries or systems.
Environmental impacts of milk production

- Global warming
- Nutrient enrichment
- Carbon sequestration / soil fertility
- Biodiversity
A Sustainable Agricultural Land Management Strategy for N. Ireland – Launched 21/10/16
With United Support from UFU & Environment NGOs!!!

“To provide Farmers, Policy Makers & Regulators, with a Strategy for Land Management, that delivers a Future for N. Ireland Agriculture, which is Economically, Environmentally & Socially Sustainable; while achieving the “Ambition,” laid out in the “Going for Growth” Report.”
Observations
Current Environmental Performance in N.I.

Since 2004 - N balance down 10%; N efficiency up 12%
   P balance down 32%; P efficiency up 28.5%
N Levels in Water, Good 15 – 20mg

But
- 62% of Water Bodies failing Good Quality Status
   EU average 47% failing Good Water Quality status
- 80% of P enters water by “Over Land” flow
- The Tail of our Phosphate legacy, 50 Years ????
- Only One, of 49 Priority Habitats, at Favourable Status
Observations of Current Farming Production Efficiencies & Practices in N.I.

- **Grass DM Utilisable Yields** – NI Average 5.1t/ha/yr  
  Top Grassland Yields 16t/ha/yr
- **Soil Analysis** – Only 2% analysed on an annual basis
- **Soil pH** – Optimal 6.0, 64% not achieving optimal
- **% Soils at optimal fertility** – 18%
- **30% of Land in rented on 11 month lease** - Conacre
Our Conclusions :-
Creating a GPS Base Line from the Start
“Measuring & then Managing!!”

1. GPS Soil Sampling & Analysis of Productive Land
   pH, P,K, Soil Organic Matter, Mg, Calcium, 2 ha areas
Creating a GPS Base Line from the Start
“Measuring & then Managing!!”

2. Measuring Grass Growth (DM t/ha)

GPS Digital Recording by “Hand” or by “Machine”
Creating a GPS Base Line from the Start
“Measuring & then Managing!!”

3. Aerial LiDAR Survey over Total of N. Ireland
Water “Run Off,” Auditing Above Ground Carbon & EFAs

R. Cassidy, AFBI
Creating a GPS Base Line from the Start
“Measuring & then Managing!!”

4. Hourly Monitoring of Catchment Water Quality
60 – 80 of 403 NI Catchments to be Real Time monitored
Results used through Discussion Groups to secure change

D. Wall, Teagasc
Creating a GPS Base Line from the Start
“Measuring & then Managing!!”

5. **Creation of Central Database** to collate results & other relevant data e.g. Tellus, Priority Habitats, LPIS maps, Weather Records etc.

6. **An Online, Cloud-based, Decision Support Tool** to give farmers & chosen “advisers” access to comprehensive detailed information about their own farm and not their neighbours, or wider catchment, to empower farmers to make “informed” decisions of how to manage land in best way.
Cryptosporidiosis in Ireland

- Among the highest incidence in the world
- Source is animal manure / slurry
- Infective oocysts are very hard to eliminate in treated water
Cryptosporidiosis

• Approach currently reactive
• Galway
  – >700 estimated cases (severe diarrhoea)
  – 120,000 under boil water notice for 5 months
  – Cost €19M to households and hotels*
• Roscommon
  – Boil water notice for 8 years

• Prevention cheaper than remediation
• Yet slurry spreading continues, sometimes in poor conditions

(*Chyzheuskaya et al. EID 2017, 23, 1650)  
Source: Patrcik Bresnihan, TCD (WISDOM project)
Water for thought

• Water is essential to life and to agriculture

• 70%. Freshwater used in agriculture and increasing

• Water foot printing – increasing

• Models - Assessing both consumptive water use and degradative water use

• Reducing amount of water used per unit product – especially in areas of high water stress

• Water quality – and impact on human health
A world leading Institute working with a great industry to deliver a world leading food system
Figure 6: Conceptual framework for assessing the potential impact of livestock farming on aspects of water quality

Pressure
(nutrient surplus, agricultural inputs)
Function of:
✓ Crop and nutrient management (nutrient surplus, nutrient use efficiency)
✓ Herd/grazing management

Pathway
(overland flow, percolation/infiltration)
Function of:
✓ Precipitation surplus
✓ Precipitation intensity frequency distribution
✓ Soil properties/hydrology

Ameliorating factors
(e.g. denitrification, attenuation of phosphorus, dilution by water from other land uses within catchment)
Function of:
✓ Soil properties
✓ Hydrology/geology
✓ Landscape/Connectivity

Receptor
(resulting loss to water)

In excess of local ecological threshold
Yes → Ecological impact
No → In excess of human health threshold

In excess of human health threshold
Yes → Health impact
No → No impact
Figure 3: Physical flows of water at the dairy farm level (from Gac et al., 2012)
Figure 2. from Impacts on quality-induced water scarcity: drivers of nitrogen-related water pollution transfer under globalization from 1995 to 2009

Holistic view of water scarcity problem by regions

Water scarcity

measures:
freshwater available for human requirements

→ implies that dry areas are not Necessarily water scarce).

Physical water scarcity:
• >75% of river flows are withdrawn for agriculture, industry and domestic purposes.

Economic water scarcity:
• <25% of water withdrawn from rivers for human purposes but not enough water infrastructure to make water available for use

For assessing the environmental impacts of consumptive water use (where consumptive water use is water removed from available supplies without return to a water resource system):

- Quantities of water used (including water withdrawal and release)
- Types of water sources used (including for water withdrawal and water receiving body)
- Forms of water use (irrigation, storage)
- Changes in drainage, stream flow, groundwater flow or water evaporation that arise from land use change, land management activities and other forms of water interception (where relevant to the scope and boundary of the study)
- Locations of water use (including for water withdrawal and release) that are required to determine any related environmental condition indicator of the area where the water use takes place
- Seasonal changes in water flows, water withdrawal and release, when relevant
- Temporal aspects of water use, including, if relevant, timing of water use and length of water storage

Source: ISO 14046
Meat and milk comprises approx 25% of global water footprint.

Table 2. The water footprint of 2 different diets in industrialized countries

<table>
<thead>
<tr>
<th>Item</th>
<th>Meat diet</th>
<th>Vegetarian diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kcal/day¹</td>
<td>L/kcal²</td>
</tr>
<tr>
<td>Animal origin</td>
<td>950</td>
<td>2.5</td>
</tr>
<tr>
<td>Vegetable origin</td>
<td>2,450</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>3,400</td>
<td>3,600</td>
</tr>
</tbody>
</table>
For assessing the impacts of degradative water use, data describing water quality should also be collected:

- Quality of water used from the different types of water resources
- Emissions to air, water and soil with impact on water quality
- Locations of water use influencing water quality
- Seasonal changes in water quality

Source: ISO 14046