Finnish Pilot study: North Savo region

Luke Team:

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North Savo region

Total area 20 367 km², 17.5% under water, beachline length 17000 km, Population density 14.8 persons/km² (Finland average 17.7) 247000 inhabitants (2010) 148000 ha farmland (8.8% of land area) 4200 farms 38000 dairy cows (10% out of whole Finland) Cereals production becoming more popular, e.g. wheat, not only barley Income/cap: 17000 eur (Finland average 18800 eur 2010) http://www.pohjois-savo.fi/fi/pohjois-savo/
Agricultural activities

Land use distribution in North Savo (utilised agric. land 147,684 ha)

Number of livestock animals (1000 heads) in North Savo region 2011.
Source: Official farm statistics (www.mmmtike.fi)

<table>
<thead>
<tr>
<th></th>
<th>Pohjois-Savo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy cows</td>
<td>38.1</td>
</tr>
<tr>
<td>Suckler cows</td>
<td>5.7</td>
</tr>
<tr>
<td>Bulls (&gt;1 year)</td>
<td>14.4</td>
</tr>
<tr>
<td>Heifers</td>
<td>21.5</td>
</tr>
<tr>
<td>Calves</td>
<td>40.6</td>
</tr>
<tr>
<td><strong>Cattle total</strong></td>
<td><strong>120.3</strong></td>
</tr>
<tr>
<td>Fattening pigs</td>
<td>9.9</td>
</tr>
<tr>
<td>Pigs, 20-50 kg</td>
<td>7.1</td>
</tr>
<tr>
<td>Piglets</td>
<td>11.9</td>
</tr>
<tr>
<td>Sows</td>
<td>4.0</td>
</tr>
<tr>
<td><strong>Pigs, total</strong></td>
<td><strong>33.0</strong></td>
</tr>
<tr>
<td>Laying hens</td>
<td>18.2</td>
</tr>
<tr>
<td>Other poultry</td>
<td>4.6</td>
</tr>
<tr>
<td><strong>Poultry, total</strong></td>
<td><strong>29.5</strong></td>
</tr>
<tr>
<td>Sheep</td>
<td>3.4</td>
</tr>
<tr>
<td>Goats</td>
<td>0.3</td>
</tr>
<tr>
<td>Horses (at farms)</td>
<td>2.3</td>
</tr>
</tbody>
</table>
Land use (ha, %) at dairy farms

- Other crops
- Other set aside
- NMF
- Pasture Grass
- Grassland Silage
- Oilseeds
- Mixedgrain
- Oats
- Barley
- Rye
- Wheat
Projected climate change in Finland up to 2100, reference period 1971-2000

Source: Jylhä et al 2009, Ruosteenoja 2013

- Annual average temperature +2 - +6 °C
  - In winter +3-+9 °C
  - In summer +1-+5 °C
- Annual precipitation + 12 - 22%
  - In winter +10 - 40%
  - In summer + 0 - 20%
- Increased evapotranspiration during the growing period – threat of worsening early summer drought
- Growing season length +30–45 days until 2100
- Temperature sum during growing period:
  - Middle Finland 1100 -> 1600 degree days;
  - Southern Finland 1300 -> 1900;
  - Northern Finland 900 -> 1200 degree days
- Increasing frequency:
  - rainy days, heavy rainfalls, dry spells
- Decreased length of thermal winter
- Reduced snow cover and permafrost
- Increased cloudiness
### Median changes in selected agro-climatic indicators relative to 1971-2000

**GISS-ER/B1**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>2011-2040</th>
<th>2041-2070</th>
<th>2071-2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sowing date change (nr of days)</td>
<td>-3</td>
<td>-3</td>
<td>-4</td>
</tr>
<tr>
<td>Proportion of suitable sowing days</td>
<td>12</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Date of the last spring frost (days)</td>
<td>-6</td>
<td>-5</td>
<td>-7</td>
</tr>
<tr>
<td>Effective radiation change (%)</td>
<td>13</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Effective growing days (change in days)</td>
<td>20</td>
<td>26</td>
<td>41</td>
</tr>
<tr>
<td>Rain 3-7 weeks after sowing, change, mm</td>
<td>1,8</td>
<td>1,4</td>
<td>10,8</td>
</tr>
<tr>
<td>Proportion of dry days in AMJ, change (%)</td>
<td>0</td>
<td>1</td>
<td>-4</td>
</tr>
<tr>
<td>Proportion of dry days in JJA, change (%)</td>
<td>-6</td>
<td>-4</td>
<td>-14</td>
</tr>
<tr>
<td>Extreme high temp stress, change (days)</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Temperature sum accumulation during grain filling, change, C</td>
<td>1,4</td>
<td>1,5</td>
<td>1</td>
</tr>
</tbody>
</table>

**IPSL-CM4/A2**

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<th>2071-2100</th>
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<tbody>
<tr>
<td>Sowing date change (nr of days)</td>
<td>-9</td>
<td>-15</td>
<td>-17</td>
</tr>
<tr>
<td>Proportion of suitable sowing days</td>
<td>20</td>
<td>28</td>
<td>32</td>
</tr>
<tr>
<td>Date of the last spring frost (days)</td>
<td>-18</td>
<td>-24</td>
<td>-24</td>
</tr>
<tr>
<td>Effective radiation change (%)</td>
<td>5</td>
<td>-3</td>
<td>-13</td>
</tr>
<tr>
<td>Effective growing days (change in days)</td>
<td>7</td>
<td>31</td>
<td>52</td>
</tr>
<tr>
<td>Rain 3-7 weeks after sowing, change, mm</td>
<td>-6,4</td>
<td>-9,5</td>
<td>-12,3</td>
</tr>
<tr>
<td>Proportion of dry days in AMJ, change (%)</td>
<td>2</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>Proportion of dry days in JJA, change (%)</td>
<td>2</td>
<td>13</td>
<td>17</td>
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<td>1</td>
<td>4</td>
<td>6</td>
</tr>
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<td>2,3</td>
<td>3,7</td>
<td>5,4</td>
</tr>
</tbody>
</table>


Indicators selected by Rötter et. al. (2010), Trnka (2011),
Climate (and management) related problems

- Spatio-temporal variability of crop yields (among field plots, years, etc.)
- Feed quality losses
- Winter time damages
- Soil compaction, wet conditions
- Plant pests becoming more frequent

Some climate related problems in North Savo region:

Ice encasement, due to warmer winters (hypoxia, frost). Photo: P. Virkajärvi (top),

Problems due to soil compaction. Photo: H. Mäkipää (middle),

Compacted soil, heavy axle loads. Photo: A. Mustonen (bottom, right);
Winter related damages (left, bottom. Photo P. Virkajärvi); effects of summer drought (bottom, middle. Photo E. Juutinen)
Adaptation solutions, cereals

- **Cereals cultivars requiring longer growing season**
  - Decrease vulnerability to (early summer) drought
  - More tolerant of heat stress
- **Earlier sowing times**
- **Improved / changed crop protection needed**
  - Currently no/little fungicide use => can be increased
  - More diverse crop rotations may relieve disease pressure
    - higher yielding oilseed /clover crops and cultivars => more protein production?
- **Adjusted fertilisation levels and timing/split applications**
  - Timely split applications according to development phases
  - According to yield potential of different crops and cultivars
- **Improved soil structure, soil pH, drainage**
  => resilience, extra costs...
Assumptions used in WOFOST simulations, for evaluating changes in water-limited yields

• Water-limited production situation – no nutrient limitations

• Sowing dates: calculated with a temperature threshold (8 °C) for the 10-day running mean.
  – Baseline period in Kuopio: mean 135 days (mid-May), std 9 days
  – 2041-2060 (RCP8.5, HadGEM2-ES): mean 119 days (late April), std 7 days
  – 2041-2060 (RCP8.5, GISS_MODEL_E_R): mean 135 days (mid-May), std 9 days

• No autumn cutoff other than maximum duration of 260 days

• Soil water content in spring assumed to be at field capacity
Future rainfed potential yields of barley in North Savo

Water-limited yields simulated with model WOFOST using different emission scenario (RCP8.5) / climate model combinations for Kuopio (10 x 10 km grid)

- Current cultivar, Kustaa
- Possible future cultivar, "F1" (only thermal requirement changed)
Yield gaps and their drivers

**POTENTIAL**

- Gap I (20%) – e.g. water limitations due to soil structure, poor drainage – need for farm investments

**ATTAINABLE**

- Gap II (10%) - e.g. inadequate liming

**ACTUAL**

- Gap III (20%) – e.g. inadequate crop protection, fertilisation due to discouraging policies, markets and risks

Gaps I+II+III = 50%

Yield Potential

Water- and/ or nutrient- limited yield

Actual yield
SIMULATE actual yields subject to different crop prices

Farm level economic analysis through dynamic optimisation over 30-40 years, adjusting
(1) N-fertilisation;
(2) soil improvements (liming, affecting soil pH value);
(3) fungicide use
(4) land use and crop rotation - monoculture implies increased disease pressure

… through production functions and crop yield responses
⇒ Joint yield effects of N fertilisation, liming and fungicide use, crop rotation
⇒ Yields, gross margins

Policies play a role: eligibility conditions, agri-environmental schemes

Simulated farm management and yields in 3 price scenarios for two farm types

Simulated average yields, profit, soil pH and times of fungicide usage over the next 30 years under chosen scenario settings of crop prices with low (current) disease pressure setting. 


<table>
<thead>
<tr>
<th>Actual yield [kg/ha]</th>
<th>Specialized cereals farm $\theta = 0.02$</th>
<th>Other crop farm $\theta = 0.0165$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LP</td>
<td>MP</td>
</tr>
<tr>
<td>Spring wheat [3068]</td>
<td>2670</td>
<td>3190</td>
</tr>
<tr>
<td>(14.5%)</td>
<td>(3.8%)</td>
<td>(8.8%)</td>
</tr>
<tr>
<td>Winter wheat [3066]</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barley [3000]</td>
<td>2555</td>
<td>2958</td>
</tr>
<tr>
<td>(-17.4%)</td>
<td>(-1.6%)</td>
<td>(7.9%)</td>
</tr>
<tr>
<td>Oats [2786]</td>
<td>2469</td>
<td>2898</td>
</tr>
<tr>
<td>(-12.9%)</td>
<td>(3.9%)</td>
<td>(8.2%)</td>
</tr>
<tr>
<td>Hay [3615]</td>
<td>3191</td>
<td>3795</td>
</tr>
<tr>
<td>(-13.3%)</td>
<td>(4.7%)</td>
<td>(8.8%)</td>
</tr>
<tr>
<td>Oilseed [1305]</td>
<td>1106</td>
<td>1368</td>
</tr>
<tr>
<td>(-18%)</td>
<td>(4.6%)</td>
<td>(10%)</td>
</tr>
<tr>
<td>Share of fungicide treated barley</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average pH</td>
<td>5.59</td>
<td>6.50</td>
</tr>
<tr>
<td>GHG emissions overall tons/year (normalized 10 ha)</td>
<td>23.49</td>
<td>28.75</td>
</tr>
<tr>
<td>GHG emission from organic soils (normalized 1 ha)/year</td>
<td>18.21</td>
<td>19.30</td>
</tr>
</tbody>
</table>

Note: [*] show the actual average yields (kg/ha) in North Savo of Finland 1995–2012.
Simulated (low disease pressure, median price, left) land use over 30 years vs observed land use (right) on cereals farms in North Savo region Finland 2000-2013
Simulated land use over 30 years (left) vs observed land use on other crop farms in North Savo region (right) Finland 2000-2013
Adaptation solutions, grass

• Three cuts per year
  – Earlier cuts

• New grassland species and cultivars
  – More resistant to heat stress and drought
  – Better nutritive value
  – Sufficient winter hardiness

• Adjusted fertilisation levels
  – Proper timing, according to developmental phases
  – According to yield potential of different crops and cultivars

• Prevention of soil compaction
  – Drainage, sufficient
  – Development of machinery/use of machinery
The cost of managing farm level grass yield risk - Slightly decreasing in A1B!

- Excess silage grass area (own land + rented land) is kept to hedge against drought and silage deficit (buffer stocks of silage used)
- The mean yield of grass is gradually increasing from the baseline period up to middle-century
- Little change in the variation of grass yields in North Savo
- => The buffer stocks can be filled up more frequently in the climate scenario than in the baseline
- The average standard deviation of harvested yield decreases considerably in A1B, as well as the share of years of silage deficit
- Still the cost of risk remains significant – farmers need to keep sufficient grassland area and buffer stocks
  - Source: Kässi, P., Känkänen, H., Niskanen O., Lehtonen, H. & Höglind, M. 2014 Farm level approach to manage grass yield variation under climate change in Finland and North-Western Russia (submitted)
Farm level and regional perspectives

Stakeholder workshops revealed disappointments to current policies

”Policy schemes favor part-time farms, but are difficult /impossible for full-time, expanding farms”; ”It is easier to adapt to climate change than to EU and national policy changes”

➢ “Some policy schemes discourage productivity growth, re-organisation and structural change”

➢ “Overall effect of many individual retarding effects accumulate, making ambitious farmers frustrated”

Now aver size of dairy farms 35 cows/farm. Fewer and larger dairy farms - Expanding dairy farms need land
Frictions on land market => high land prices => intensive production, higher yields demanded

How to improve functioning of land markets? – short rental contracts, low commitments for land maintenance

How to improve ”land availability” for agricultural activities producing most value added in the region?
…while simultaneously decreasing GHG emissions?

Land clearance has been a solution for some individual farms, despite high costs
This is due to incoherent policies
Summary on adaptation options in Northern Savo, Finland

- Increasing grass growth benefits dairy and beef
- Inter-annual volatility of grass yield increases
- Managing grassland yield variation: cost of drought risk relieved if moderate warming (e.g. A1B), but may increase if strong warming
- Increase in attainable yields of cereals and oilseeds is uncertain, more frequent droughts on sandy soils
  - New breeds such as heat/drought tolerant cereals cultivars, one important part of the solution!
  - More emphasis on maintaining soil quality!
- Positive market development + more flexible encouraging policies needed for medium/long-term investments in:
  - drainage, soil structure, lower axle loads, cultivars, crop rotation, manure spreading

Photos: Pentti Raiskio/Luke
Kiitos!
Thank you!

Contact: Heikki.Lehtonen@luke.fi

http://macsur.eu/index.php/regional-case-studies/