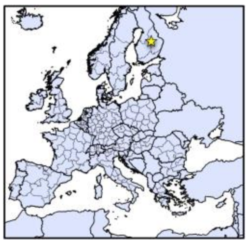

More strategic farm management needed to adapt to climate change in the North Savo region

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Rotterdam, "Adaptation Futures 2016"
May 11 2016
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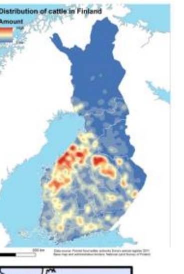
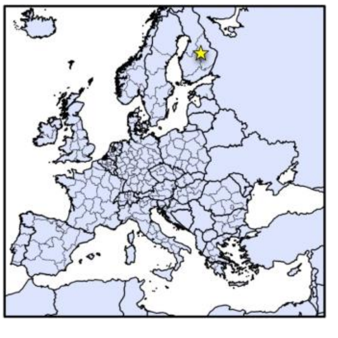
North Savo region

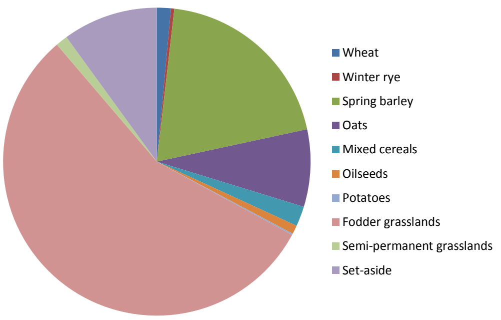


Total area 20 367 km2, 17.5% under water, beachline length 17000 km,
Population density 14.8 persons/km2 (Finland average 17.7)
247000 inhabitants (2010)
148000 ha farmland (8.8% of land area)
4200 farms
38000 dairy cows (10% out of whole Finland)
Cereals production becoming more popular, e.g. wheat, 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)

	Pohjois-Savo
Dairy cows	38.1
Suckler cows	5.7
Bulls (>1 year)	14.4
Heifers	21.5
Calves	40.6
Cattle total	**120.3**
Fattening pigs	9.9
Pigs, 20-50 kg	7.1
Piglets	11.9
Sows	4.0
Pigs, total	**33.0**
Laying hens	18.2
Other poultry	4.6
Poultry, total	**29.5**
Sheep	3.4
Goats	0.3
Horses (at farms)	2.3

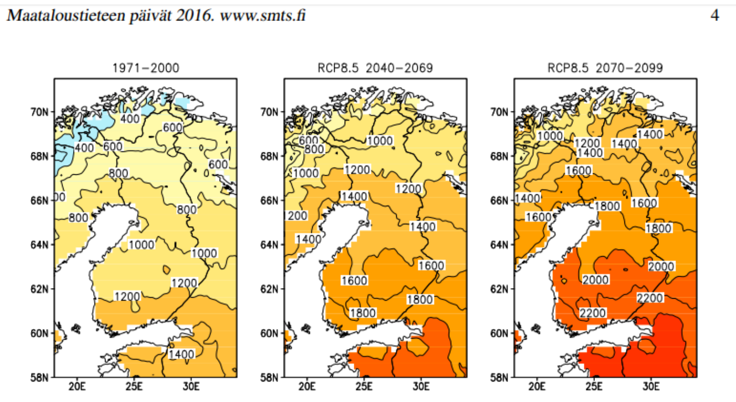
Projected climate change in Finland up to 2100, reference period 1971-2000

Source: Jylhä et al 2009, Ruosteenoja 2013

- Annual average temperature +2 - + 6 °C
  - In winter +3-+9 °C - **Decreased length of thermal winter, reduced snow cover ands permafrost**
  - **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 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
- **Reduced snow cover and permafrost**
- Increased cloudiness

Temperatute sum during the growing period may increase considerably – but does not mean only benefits for farming

Source: Ruosteenoja (2016)



Median changes in selected agro-climatic indicators relative to 1971-2000

GISS-ER/**B1**

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

IPSL-CM4/**A2**

	2011-2040	2041-2070	2071-2100
Sowing date change (nr of days)	-9	-15	-17
Proportion of suitable sowing days	20	28	32
Date of the last spring frost (days)	-18	-24	-24
Effective radiation change (%)	5	-3	-13
Effective growing days (change in days)	7	31	52
Rain 3-7 weeks after sowing, change, mm	-6,4	-9,5	-12,3
Proportion of dry days in AMJ, change (%)	2	19	21
Proportion of dry days in JJA, change (%)	2	13	17
Extreme high temp stress, change (days)	1	4	6
Temperature sum accumulation during grain filling, change, C	2,3	3,7	5,4

Source: R. P. Rötter , J. G. Höhn & S. Fronzek (2012) Projections of climate change impacts on crop production: A global and a Nordic perspective, Acta Agriculturae Scandinavica, Section A – Animal Science, 62:4, 166-180, DOI: 10.1080/09064702.2013.793735

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

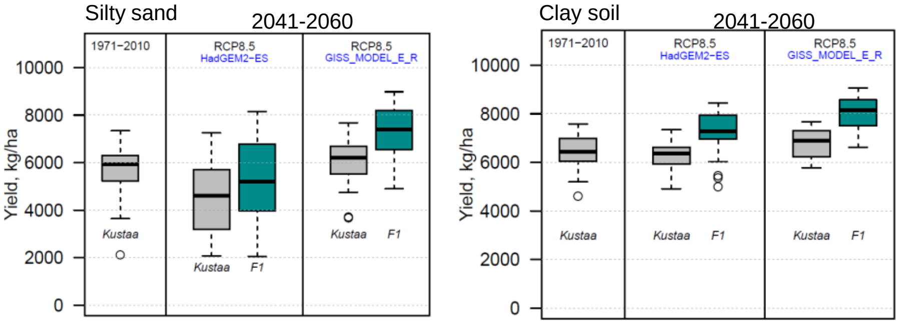
- **Cereals cultivars requiring longer growing season**
  - Decreased vulnerability to (early summer) drought
  - More tolerant of heat stress
- **Earlier sowing times**
- **Improved / changed crop protection needed**
  - Currently no/little fungicide use => can be increased
  - More diverse crop rotations 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…

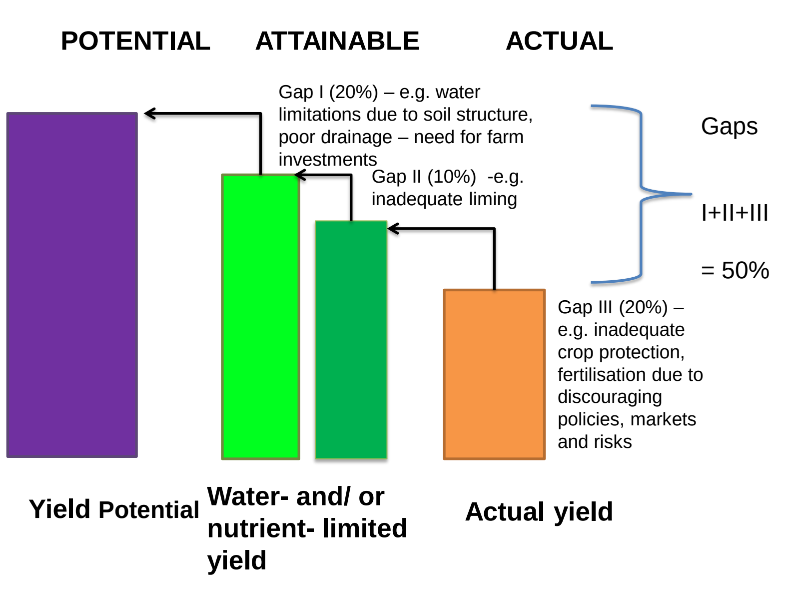
Future rainfed potential yields of barley in North Savo

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)
- Source: Rötter , R. et al. 2013. Modelling shifts in agroclimate and crop cultivar response under climate change. Ecology and Evolution. DOI: 10.1002/ece3.782



Yield gaps and their drivers



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

**) Liu, X., Lehtonen, H., Purola, T., Pavlova, Y., Rötter, R. & Palosuo, T. 2016. Dynamic economic modelling of crop rotations with farm management practices under future pest pressure. Agricultural Systems (2016), pp. 65-76 DOI: 10.1016/j.agsy.2015.12.003*

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
LP: Low price; MP: Moderate price; HP: High price. Moderate prices = 2008-2013 average prices; Low prices = -20%, High prices +20% from the MP level. Source: Lehtonen, H., Liu, X. & Purola, T. 2015. Balancing Climate Change Mitigation and Adaptation with Socio-Economic Goals at Farms in Northern Europe. Chapter 11 in book "Climate adaptation and food supply chain management in Europe", edited by A. Paloviita & M. Järvelä, to be published by Routledge

	Actual yield [kg/ha]	Specialized cereals farm θ = 0.02			Other crop farm θ = 0.0165		
		LP	**MP**	HP	LP	MP	HP
Average Yields	Spring wheat [3068]	2670 (-14.5%)	**3190 (3.8%)**	3364 (8.8%)	-	-	-
	Winter wheat [3066]	-	-	-	-	-	-
	Barley [3000]	2555 (-17.4%)	**2958 (-1.6%)**	3203 (7.9%)	2704 (-9.9%)	2942 (-1.9%)	3207 (6.9%)
	Oats [2786]	2469 (-12.9%)	**2898 (3.9%)**	3034 (8.2%)	2538 (-8.9%)	2855 (2.5%)	3036 (9.0%)
	Hay [3615]	3191 (-13.3%)	**3795 (4.7%)**	3963 (8.8%)	3138 (-13.2%)	3634 (0.5%)	3886 (7.5%)
	Oilseed [1305]	1106 (-18%)	**1368 (4.6%)**	1452 (10%)	-	-	-
Share of fungicide treated barley		0	0	116	0	0	97
Average pH		5.59	6.50	6.63	5.59	6.28	6.61
GHG emissions overall tons /year (normalized 10 ha)		23.49	28.75	31.52	16.90	22.00	24.34
GHG emission from organic soils (normalized 1 ha) /year		18.21	19.30	19.34	15.60	17.01	17.07

Note: [*] show the actual average yields (kg/ha) in North Savo of Finland 1995–2012 .

Adaptation solutions, grass

- From 2 cuts to 3 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 +10-15% from the baseline period up to middle-century (Höglind et al. 2013)
- Little change in the variation of grass yields in North Savo in A1B
- => The buffer stocks can be filled up more frequently in A1B scenario than in the current climate
- The share of years of silage deficit decreases if buffer stock size unchanged (can be slightly reduced)
- 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. Biosystems Engineering 140: 11-22. doi: 10.1016/j.biosystemseng.2015.08.006.

Improved drainage and soil structure needed in both cereals and grass cultivation

- Increasing inter-annual variation of precipitation - excess water, droughts – drainage and water retention important
- Improved water retention and drainage:
  - May reduce / prevent crop yield loss
  - Provide opportunities for higher yields
- Soil trafficability should be ensured or improved
  - There is a need to widen currently narrow time windows for sowing and harvesting (esp. silage grass)
- Avoid and reduce soil compaction
- However, relatively less focus on drainage, water management and soil improvements in the farmers' actions / policy system!
  - Current policies incentivise for extensive cultivation, reduced nutrients

Price to be paid for increased resilience?

- Drainage and soil improvements are costly - Not sure how well such investments pay off (markets)
- Farmers need to accept lower margins if increasing diversity of crop rotations
  - Farmers already use different grass seed mixes at different field parcels to cope with uncertain weather conditions – at least some mixes at some field parcels will provide succescul crop yield and quality
  - Specialisation reduces costs and improves profits ↔ Excessive specialisation is risky

Some evidence for trade-off between (short-term) profits and long-term resilience in the literature

- THE NETHERLANDS: Flevoland farmers keep winterwheat to maintain SOM – needed to cultivate high value crops
  - » “Our results suggest that in Flevoland, although farmers do have more objectives, inpractical decision-making they focus on economic result maximization, while for strategic decision-making they account for objectives influencing long-term performance and indicators associated with sustainability, in this cases oil organic matter”
- Source: Mandryk, M. et al. 2014. The role of farmers' objectives in current farm practices and adaptation preferences: A case study in Flevoland, the Netherlands. Regional Environmental Change 08/2014; 14(4). DOI: 10.1007/s10113-014-0589-9
- Mandryk, M. 2016: Integrated assessment of farm level adaptation to climate change in agriculture. PhD Thesis, Wageninger University, 2016
- Finland: Higher prices needed for higher use of inputs and higher yields – higher pest pressure promotes crop rotation; there must be a good reason for crop rotation!
  - » Liu, X., Lehtonen, H., Purola, T., Pavlova, Y., Rötter, R. & Palosuo, T. 2016. Dynamic economic modelling of crop rotations with farm management practices under future pest pressure. Agricultural Systems (2016), pp. 65-76 DOI: 10.1016/j.agsy.2015.12.003
  - » Lehtonen, H., Liu, X. and Purola, T. 2016. Balancing climate change mitigation and adaptation with socio-economic goals at farms in northern Europe. In: Paloviita, A. and Järvelä, M. (Eds) 2015. Climate Change Adaptation and Food Supply Chain Management (Routledge Advances in Climate Change Research), Routledge, London, 264 pp. ISBN13: 978-1138796669; http://www.tandf.net/books/details/9781317634034/. p. 132-146.
  - » Lehtonen, H. 2015. Evaluating adaptation and the production development of Finnish agriculture in climate and global change. Agricultural and Food Science 24: 219-234. http://ojs.tsv.fi/index.php/AFS/article/view/51080

Investments in adaptation capital

- ”Adaptation capital” can be e.g.:
  - New cultivars tuned to longer growing season
  - Increasing knowledge and skills of farmers to cope with adverse / extreme events
  - Improved drainage and water systems: requires capital investments
  - Improved soil structure: requires more diverse crop rotations (deep-rooted crops, organic matter)
    - Constrained by limited demand and low prices of protein crops w.r.t. to the costs – e.g. faba beans, oilseeds, clover
- Increasing adaptation capital is a long-term process

Revised policies could help farmers

- Increased co-funding (e.g. shift from CAP pillar 1) for long-term investments of drainage and soil structure – Could this also improve farmers' relative position on land markets?
- Promotion for home-grown proteins – more diverse rotations
- Payments for eco-system services from more diverse crop rotations
- Cost compensations based on (monitored) biodiversity / reduced nutrient (N,P) leaching?
- All this requires more long-term management paradigm !
  - Not yet shared all, but relatively few, farmers

Conclusion

- More strategic and longer term management is needed to cope with the climate and market challenges and realise opportunities
  - E.g. more long-term investments in soil and drainege are needed
- Some reduction in specialisation and profits seems inevitable – at least in the short run
- Land markets and rental contracts should become more flexible to account for long-term investments
- Policies could focus more on CC adaptation since it is often in synergy with other sustainabilty targets (e.g. water protection)
- Individual farmers need to consider how their aims and motives are coupled with CC challenges
  - Orientation and ”farming identity”
  - Implications for debt/equity, profits, labour demand, risks, cost structure, use of own /purchased labour

Kiitos!
Thank you!

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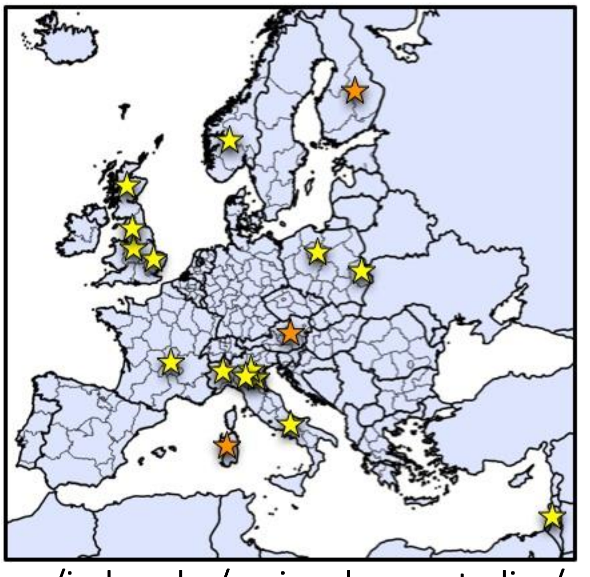

http://macsur.eu/index.php/regional-case-studies/