

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

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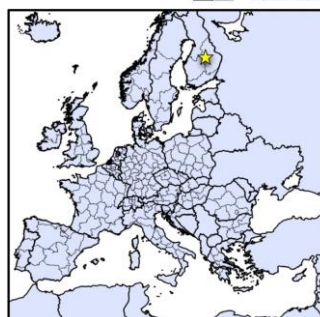
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North Savo region



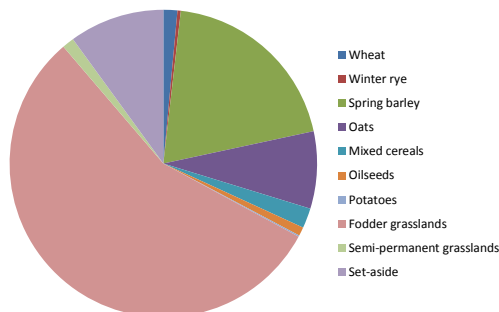
Total area 20 367 km², 17.5% under water, beachline length 17000 km,
 Population density 14.8 persons/km² (Finland average 17.7)
 247000 inhabitants (2010)
 148000 ha farmland (8.8% of land area)
 4200 farms
 38000 dairy cows (10% out of whole Finland)
 Cereals production becoming more popular, e.g.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

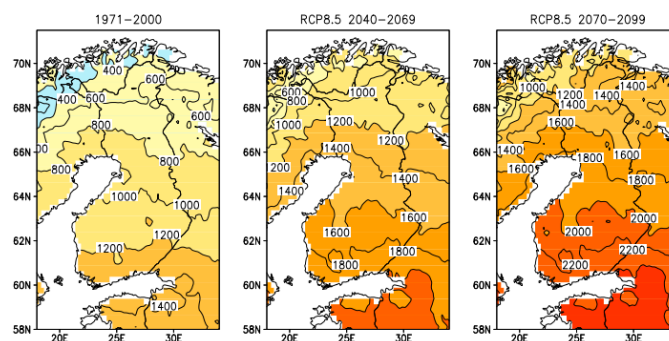


Temperature sum during the growing period may increase considerably – but does not mean only benefits for farming

Source: Ruosteenoja (2016)

Maataloustieteen päivät 2016. www.smts.fi

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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

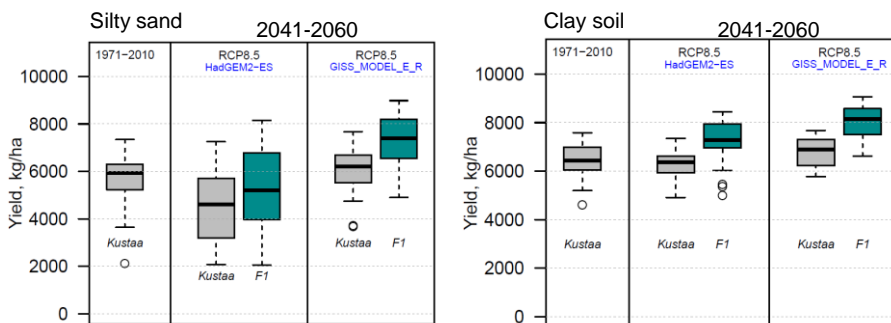
- **Cereals cultivars requiring longer growing season**
 - Decreased vulnerability to (early summer) drought
 - More tolerant of heat stress
- **Earlier sowing times**
- **Improved / changed crop protection needed**
 - Currently no/little fungicide use => can be increased
 - More diverse crop rotations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

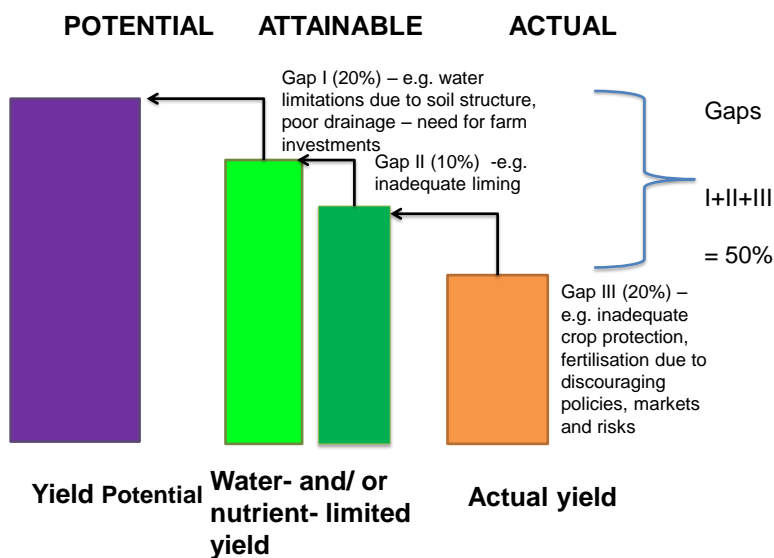
- Current cultivar, Kustaa
- Possible future cultivar, "F1" (only thermal requirement changed)
- Source: Rötter, R. et al. 2013. Modelling shifts in agroclimate and crop cultivar response under climate change. Ecology and Evolution. DOI: 10.1002/ece3.782



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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., Puroola, 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. & Puroola, 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 $\theta = 0.02$			Other crop farm $\theta = 0.0165$		
		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 successful 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, impractical 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, Wageningen 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., Puroila, 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 Puroila, 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



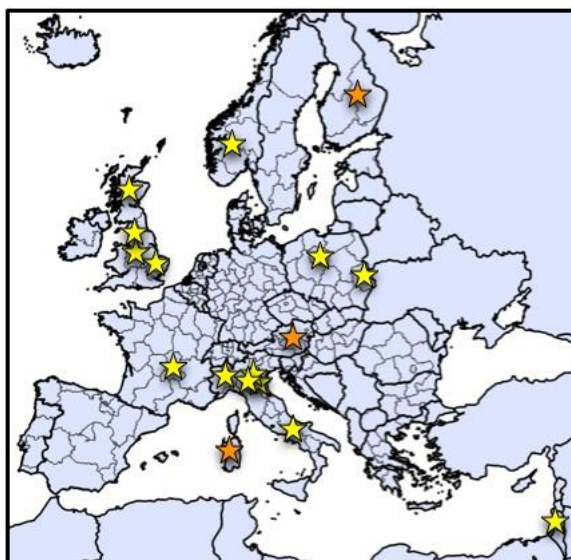
Conclusion

- 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 drainage 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 sustainability 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/>