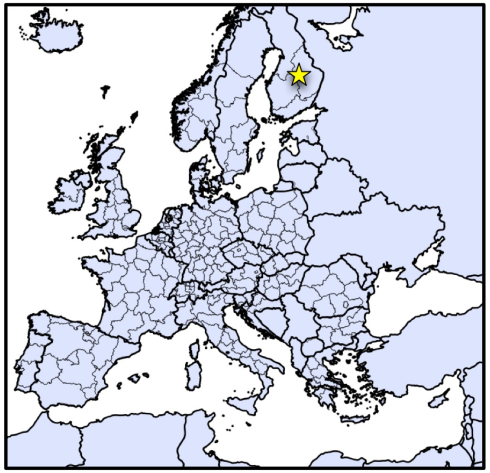

Sector level agricultural development following different adaptations to climate change

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MACSUR TradeM meeting, Reading, UK, April 9 2015

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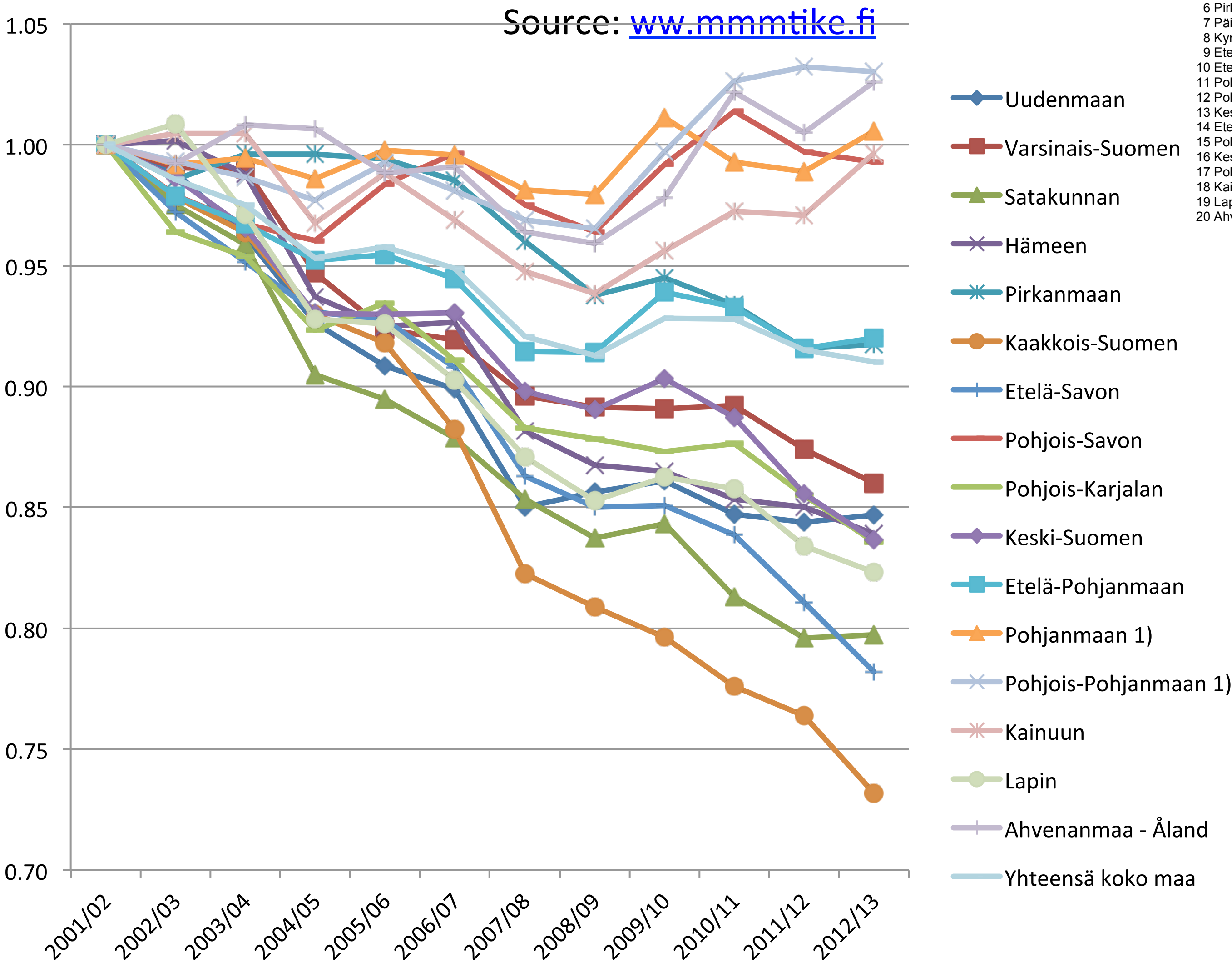
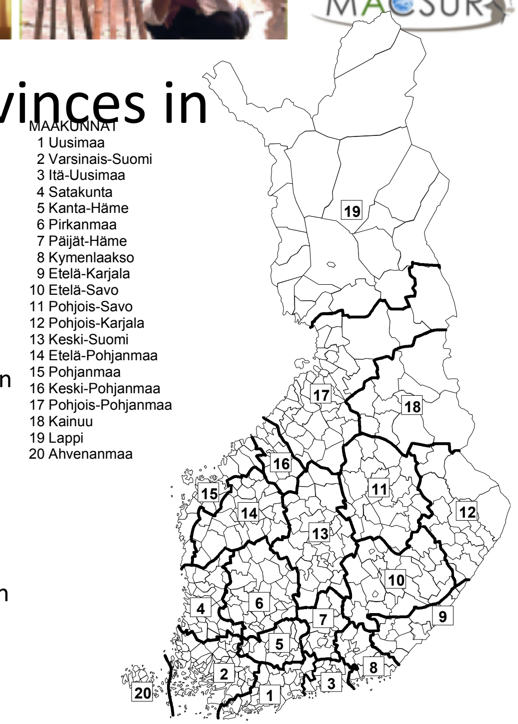
Contents

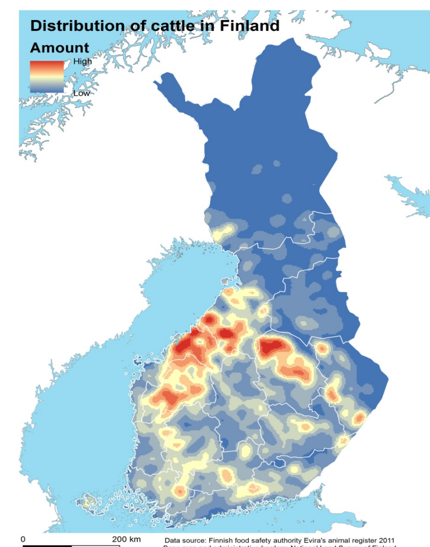
- Research problem and its motivation
- Climate and market scenarios
- Methods
- Scenarios
- Results
- Conclusions

Development of milk production in different provinces in Finland, 2001/2002 = 1

Source: www.mmmtike.fi





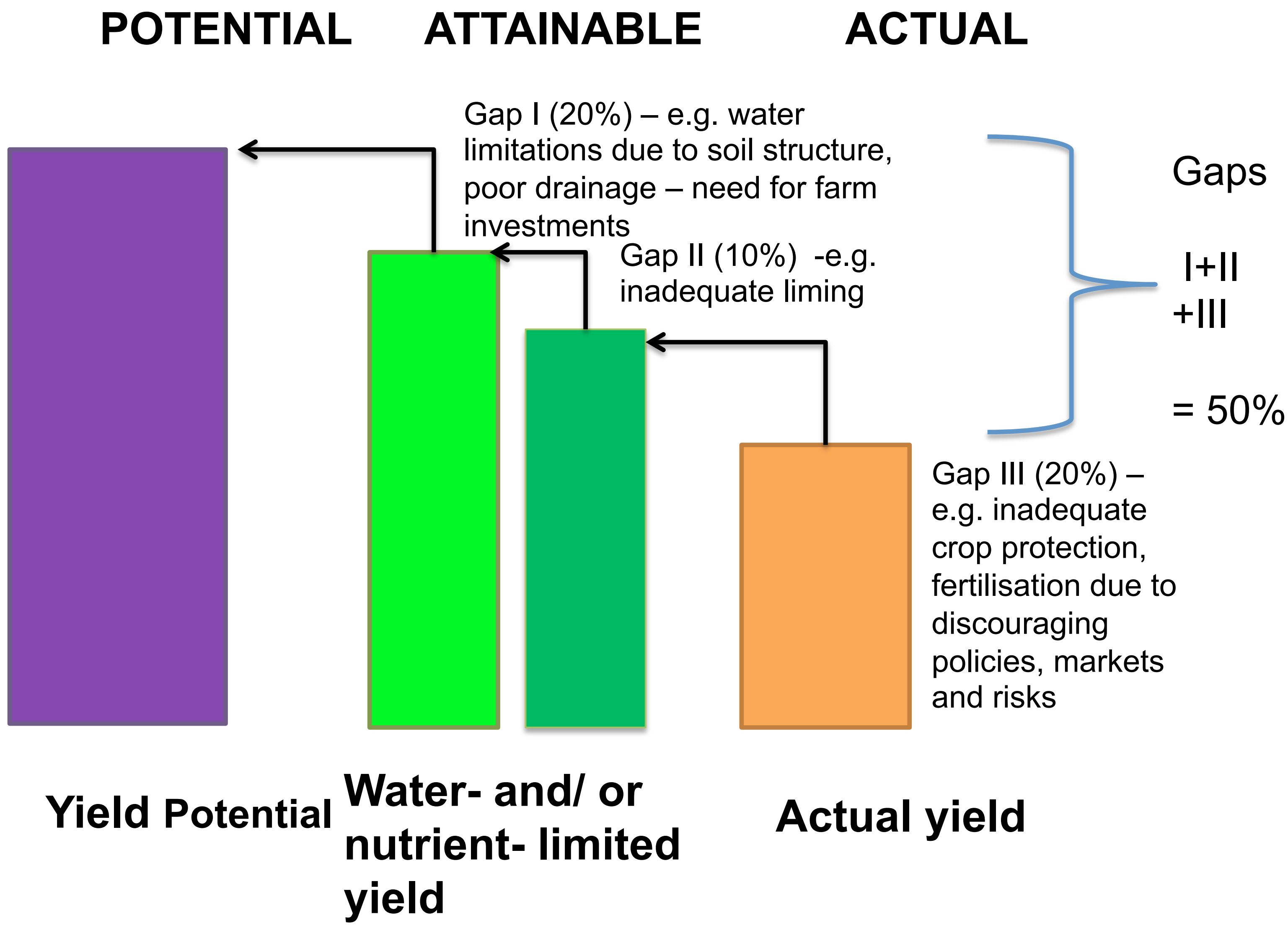


Sector level analysis: Key market and policy issues identified

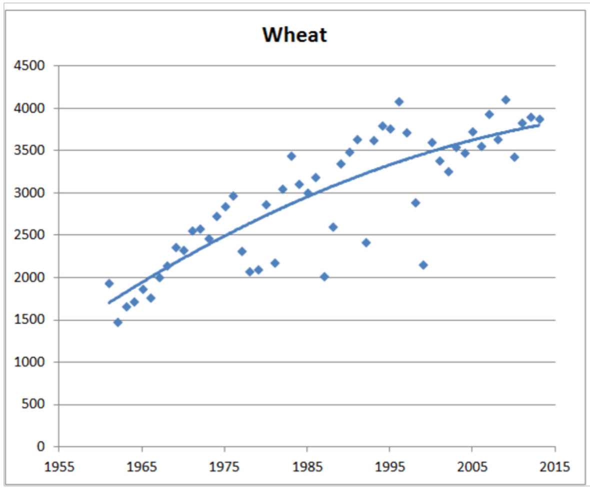
on the basis earlier research, as well as shared MagPie (global model at PIK Potsdam) results on global prices and food diets from SSP1,2,3 - transferred to MTT Dremfia sector model

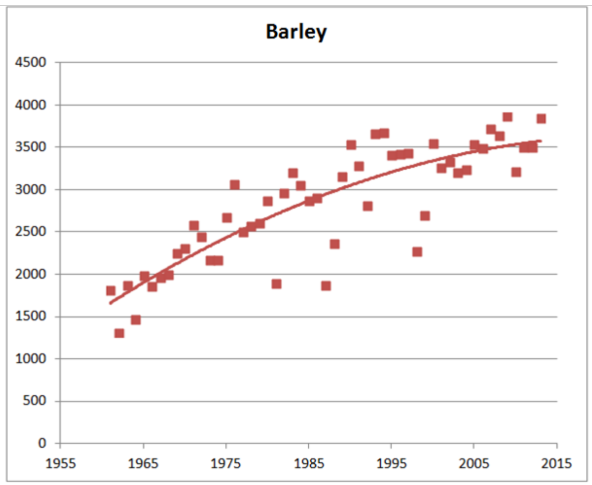
- Prices are the main drivers:
  - Milk and meat prices with respect to feed prices
  - Other input prices
    - Energy and fertiliser taxes affect agriculture
    - Labour, machinery, construction, affected by public regulations
- Production linked national payments important for milk production
  - 20-30% less milk production if no national payments in Finland
  - Area based subsidies and entitlement conditions maintain land prices
- Fertilisation limits, nutrient leaching /GHG abatement policies
    - Agri-environmental schemes, combined with increased per hectare subsidies, seen as a primary reason for stagnating yields after 1990's
      - Peltonen-Sainio, P., Salo, T., Jauhiainen, L., Lehtonen, H. & Sieviläinen, E. 2015. Static yields and quality issues: Is the agrienvironment program the primary driver? AMBIO. ISSN 0044-7447. DOI 10.1007/s13280-015-0637-9
    - From restrictive / passive policies to productivity encouraging schemes?

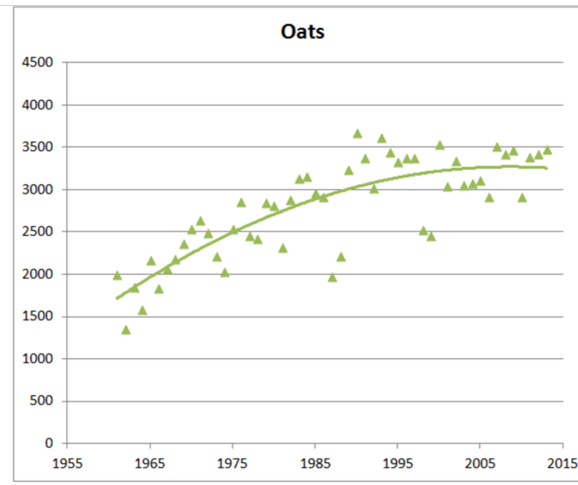
Yield gaps and their drivers



Agri-environmental schemes, combined with increased per hectare subsidies, seen as a primary reason for stagnating yields after 1990's







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Future yields quite uncertain, despite increasing potential yields…

- Peltonen-Sainio et al., 2009, conclude that **yield potential of main agricultural crops in Finland may increase considerably** due to climate change and increasing temperature sum during the growing period. However, this requires crop cultivars capable of utilizing the longer growing period. Furthermore, realisation of increased yield potential requires adaptation to 1) elevated daily mean temperatures that interfere with development rate of seed crops under long days, 2) relative reductions in water availability at critical phases of yield determination, 3) greater pest and desease pressure, 4) other uncertainties caused by weather extremes, 5) generally greater need for inputs such as fertilizers for non-nitrogen fixing crops.
  - Peltonen-Sainio, P., Jauhiainen, L., Hakala, K. & Ojanen, H. 2009. Climate change and prolongation of growing season: changes in regional potential for field crop production in Finland. Agricultural and Food Science 18: 171-190.
- Rötter et al. (2013) estimated yields of cereal crops in Finland for 21st century under SRES A2 climate scenario. The results suggest that **the water limited yields of major crops under climate change will most likely sustain close to the current level**, if new cultivars, better tuned to longer growing season, are adopted. Particularly, on sandy soils, or at other soils prone to drought, yields of some crops may still decrease due to increased frequency of drought – Soil types play a significant role
  - Rötter et al. 2013. Modelling shifts in agroclimate and crop cultivar response under climate change. Ecology and Evolution 3 12: 4197-4214.
- The yield response to climate change (A1B) was 11% for grass production in southern Finland and >20% in middle parts of Finland (North Savo region) with the assumption of optimal overwintering conditions and current CO2 level. However, possible problems in overwintering may decrease the yield potential or increase costs.
  - Höglind, M., Thorsen, S.M. & Semenov, M, A. 2013. Assessing uncertainties in impact of climate change on grass production in Northern Europe using ensembles of global climate models. Agricultural and Forest Meteorology, Volume 170, 15 March 2013, Pages 103–113.

SIMULATED 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

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 .

Simulated yields, South-West Finland

		S1	S2	S3	S4	S5	S6
Average Yields	Spring wheat [3557]	3842 (+8.0 %)	**3740 (+5.1%)**	3750 (+5.4%)	3604 (+1.3%)	3557 (+0.0%)	3545 (-0.3%)
	Winter wheat [3794]	-	-	-	-	-	-
	Barley [3550]	3513 (-1.0%)	**3610 (+1.7%)**	3927 (+10.6%)	3217 (-9.4%)	3300 (-7.0%)	3624 (+2.1%)
	Oats [3574]	-	**3811 (+6.6%)**	3812 (+6.6%)	3557 (-0.5%)	3529 (-1.3%)	3501 (-2.0%)
	Oilseed [1400]	1503 (+7.4%)	**1510 (+7.9%)**	1516 (+8.0%)	1397 (-0.2%)	1505 (+7.5%)	1513 (+8.1%)
Annual average gross margin per ha, eur		201	**263**	342	183	242	306
Share of fungicide treated barley		0%	**14%**	100%	0	0	100%
Average pH		6.44	**6.57**	6.69	6.07	6.62	6.66

S1: Low- disease-pressure with Low-price exp.
S2: Low-disease-pressure with Current-price exp.
S3: Low-disease-pressure with high-price exp.
S4: High-disease-pressure with Low-price exp.
S5: High-disease-pressure withCurrent-price exp.
S6: High-disease-pressure with High-price exp.

Simulated farm level crop yields over a 30 year-period in South-West Finland in cases of low and high disease pressure scenarios, and low, median and high prices (+/- 20% of the median): 6 scenarios overall

Liu, X., Lehtonen, H., Purola, T., Pavlova, Y., Rötter, R. & Palosuo, T. (submitted) 2014. Dynamic economic modelling of crop rotation choice with farm management practices under future pest pressure challenges. Agricultural Systems

Yield and price –scenarios 2014-2020-2030-2040-2050 - compared to the baseline

The first three scenarios (in bold text) are the main scenarios, while the other 2 ("what if adaptation fails despite high prices") are for sensitivity analysis.

	Successful adaptation, very high prices (SuA_VHP)	**Moderate adaptation (MoA)**	**Little adaptation (LiA)**	Little adaptation, high prices (LiA_HP)	No adaptation, high prices (NoA_HP)
Crop yield, until 2050	+30%	+10%	-10%	-10%	-20%
Cereals prices, from 2030	+30%	0%	0%	+10%	+10%
Meat prices, from 2030	+15%	0%	0%	+5%	+5%
Dairy product prices, from 2030	+7.5%	0%	0%	+2.5%	+2.5%

Global prices, range -5-+30%, reported e.g. Nelson, G.A., Valin, H., Sand, R.D., Havlík, P., Ahammadd, H., Derynge, D., Elliott, J., Fujimori, S., Hasegawah, T., Heyhoed, E., Kylei, P., von Lampe, M., Lotze-Campen, H., Mason d'Croza, D., van Meijl, H., van der Mensbruggh, D., Müller, C., Popp, A., Robertson, S., Schmid, E., Schmitz, C., Tabeau, A. and Willenbockel, D. 2013. Climate change effects on agriculture: Economic responses to biophysical shocks. PNAS, March 4, 2014, vol. 111, no. 9. www.pnas.org/cgi/doi/10.1073/pnas.1222465110

It is assumed here that significant increase in yields in Finland is possible only if high prices flexible agri-environmental policies

Baseline 2015-2020-2030-2050

- Unchanged yields (1995-2013) and agricultural policy (2014-2020) are assumed
- Future prices of agricultural outputs close to average prices of 2008-2013
  - OECD-FAO agricultural outlook 2014 (www-agri-outlook.org)

Other assumptions

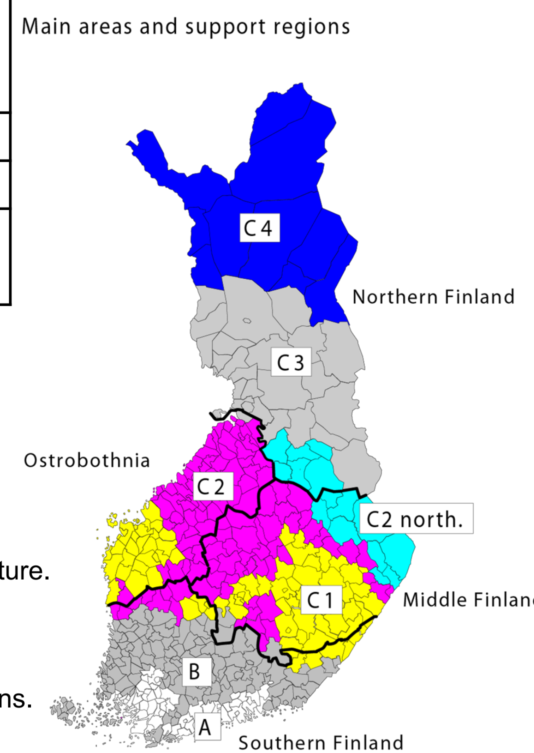
- Nitrogen use efficiency (NUE) constant
  - e.g. 10% higher yields => +10% N fertilisation
- NUE may increase due to new cultivars
- However, precipitation patterns, droughts, extreme events, soil structure, drainage… all influence NUE
- An economist finds it comfortable to assume unchanged NUE!
  - This is however a major issue affecting the results!

Sector model

DREMFIA sector model; 4 main regions divided in zones based on agricultural policy : 14 regions, + 3 small regions (not visible here)

DREMFIA sector model simulates production and foreign trade of agricultural commodities, as well as land use (areas under crops and set aside) and production intensity (fertilization, manure use) annually from 1995 up to 2020 and produces a steady state static equilibrium for 2030, 2040 and 2050. The model assumes rational economic behavior and competitive markets, replicates realized production and land use 1995-2012, and produces consistent development paths of agriculture.

	Cereals (1000 ha)	Grasslands (1000 ha)	Milk yield per cow (litres)	Milk production (million litres)	Beef (million kg)	Pigmeat (million kg)	Poultry meat (million kg)
DREMFIA	1132.6	605.3	7.867	2258.5	82.4	203.7	95.1
Observed	1144.7	656.3	7.850	2200.7	81.6	204.2	100.2
Relative difference	-1.1%	-7.8%	+0.2%	+2.6%	+4.0%	-0.3%	-5.1%

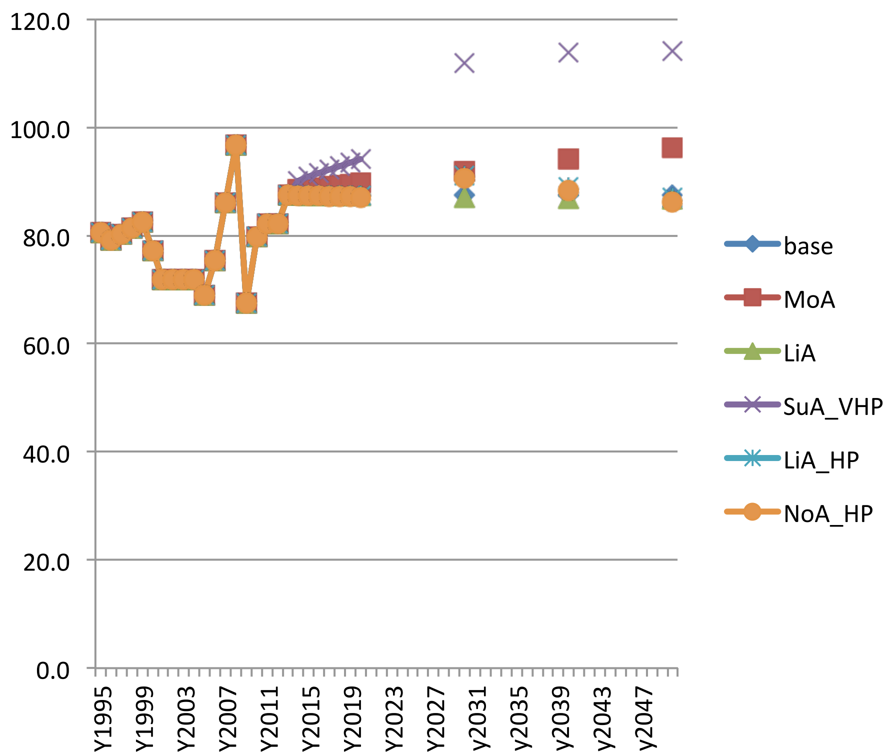


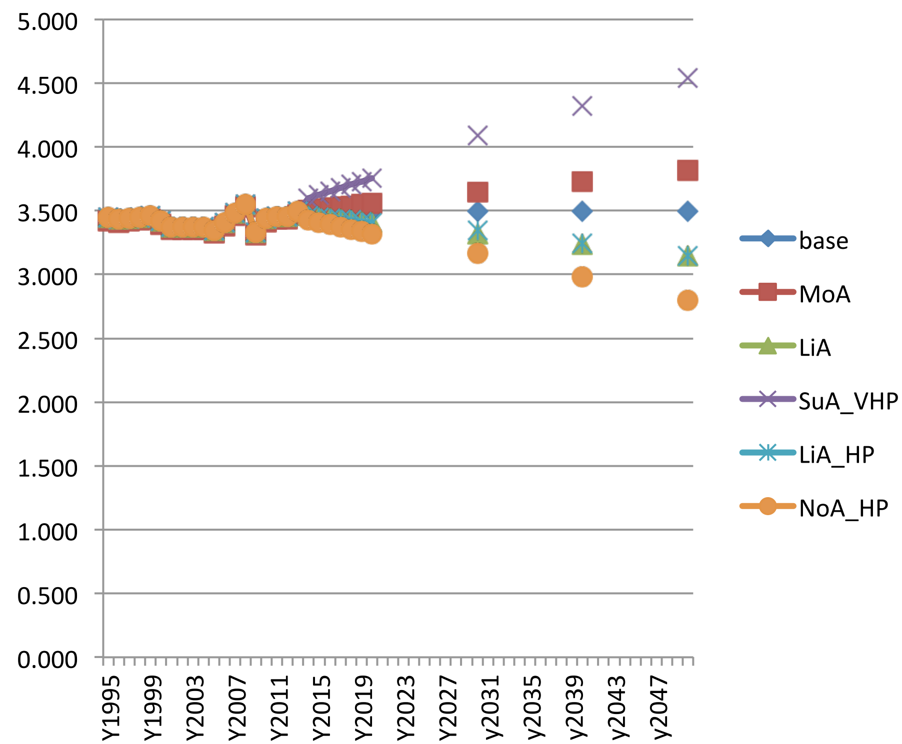
Production quantities and crop cultivation areas in the baseline scenario and reality (official agricultural statistics, www.mmmtike.fi); comparing 5-year average 2008-2012. Grassland area is smaller in DREMFIA than in reality, since horses, lambs and reindeers (users of roughage) are not included.

Lehtonen, H. 2001. Principles, structure and application of dynamic regional sector model of Finnish agriculture. Academic dissertation. Systems Analysis Laboratory, Helsinki University of Technology. Publications 98. Agrifood Research Finland, Economic Research (MTTL). Helsinki. 265 p. http://lib.tkk.fi/Diss/2001/isbn9512256894/

Lehtonen, H. 2013. Sector-level economic modeling as a tool in evaluating greenhouse gas mitigation options. Acta Agriculturae Scandinavica, Section A – Animal Science, Vol. 62, No. 4, 326-335. http://dx.doi.org/10.1080/09064702.2013.797011.

N Fertilisation (left, kg/ha) and yield of barley (right, tons/ha), Southern Finland, support region B

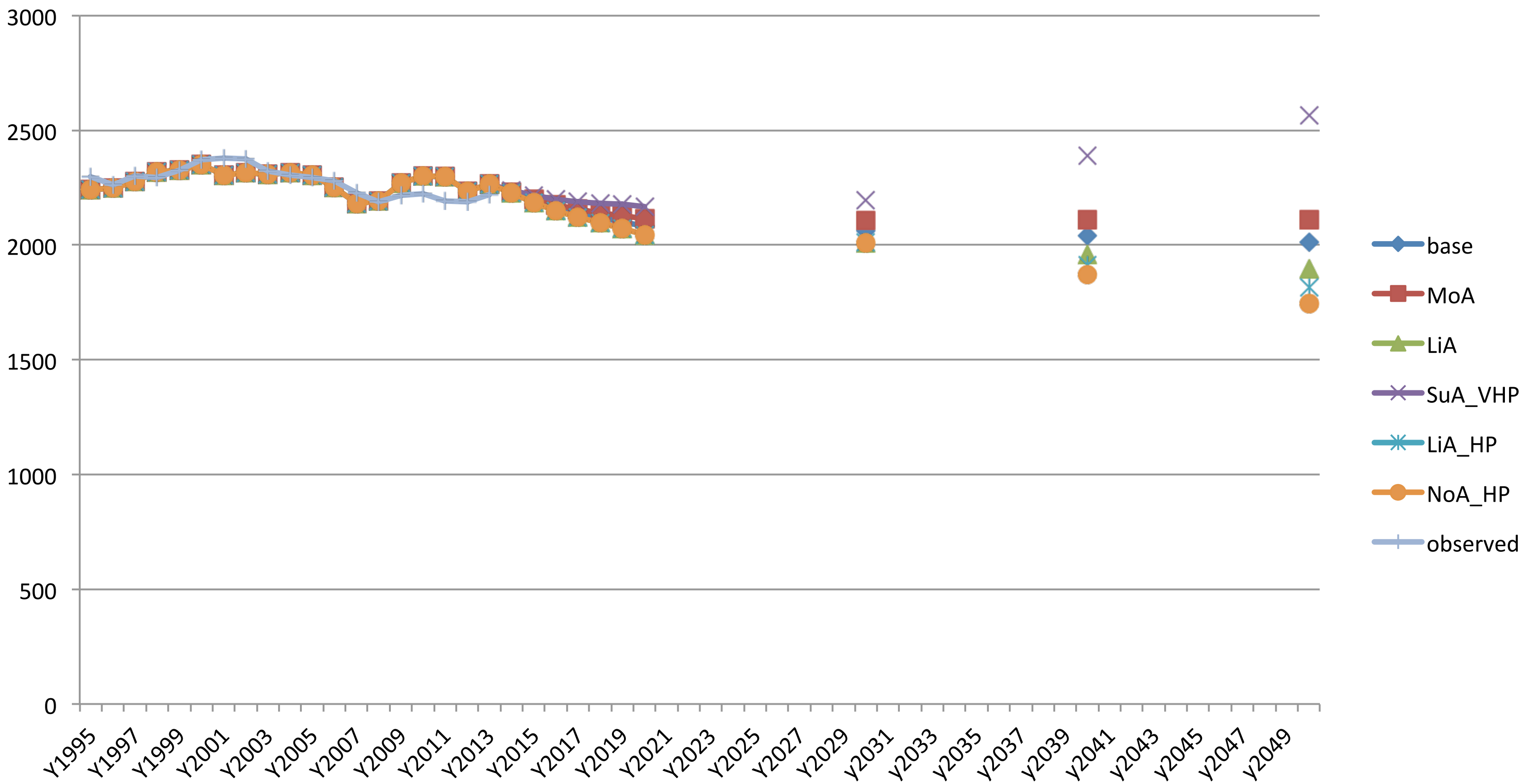




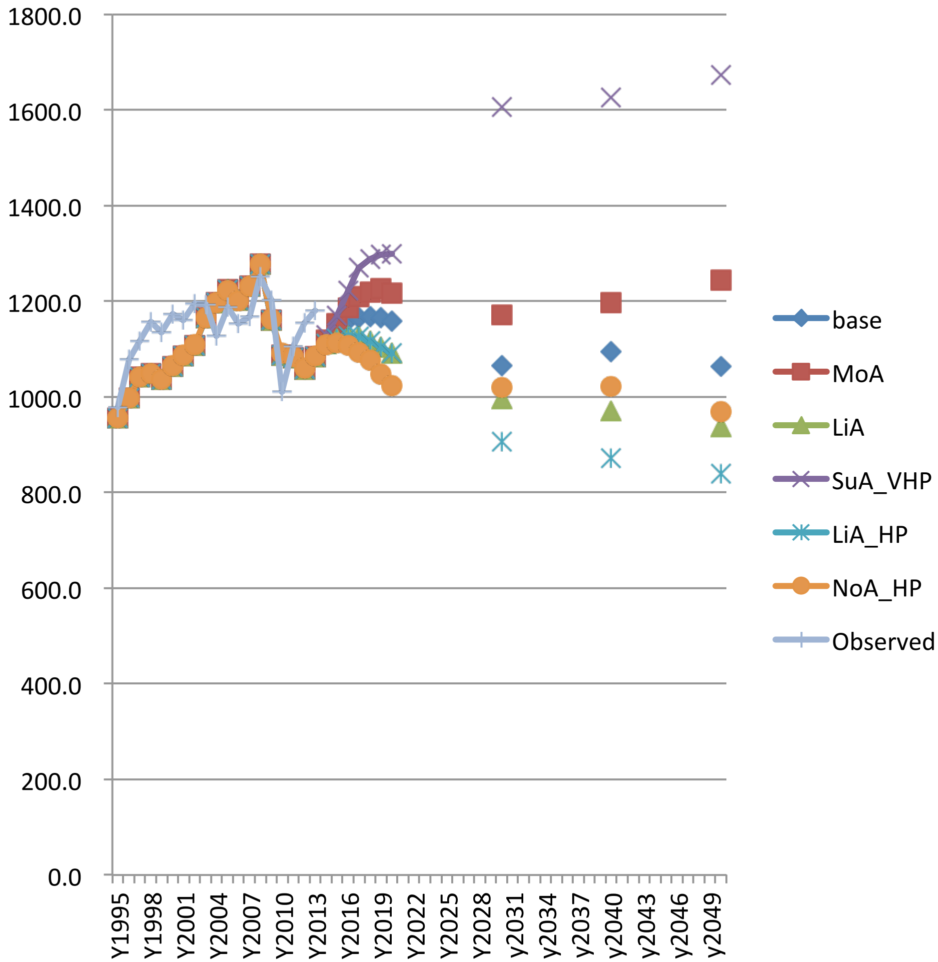
Livestock production not easily changed!

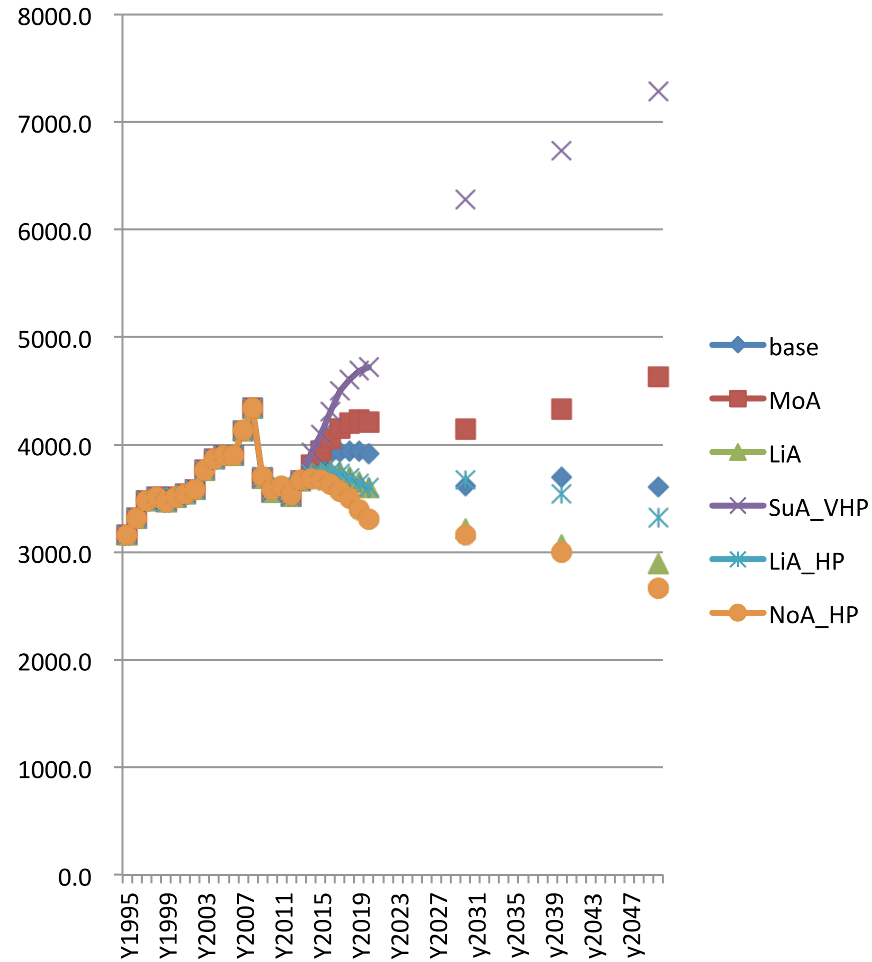
- Dairy and beef production is stabilized by EU and national coupled payments
  - there are budgetary limits for these production-linked subsidies
- Most optimistic scenario (SuA_HP): Dairy milk production increases **at most by 12% (w.r.t.2013)**
  - grassland area decreases because of 30% higher grass yields in the successful adaptation scenario
- Pig and poultry meat production are only slightly affected by the yield and price scenarios!
  - relatively high marginal costs of production
- For example: 5-10% less beef and milk is produced, and 5-10% less grass forage is needed, if -10% lower yields actualize

Milk production (1000 litres) stable, due to coupled support and (existing) high value added products



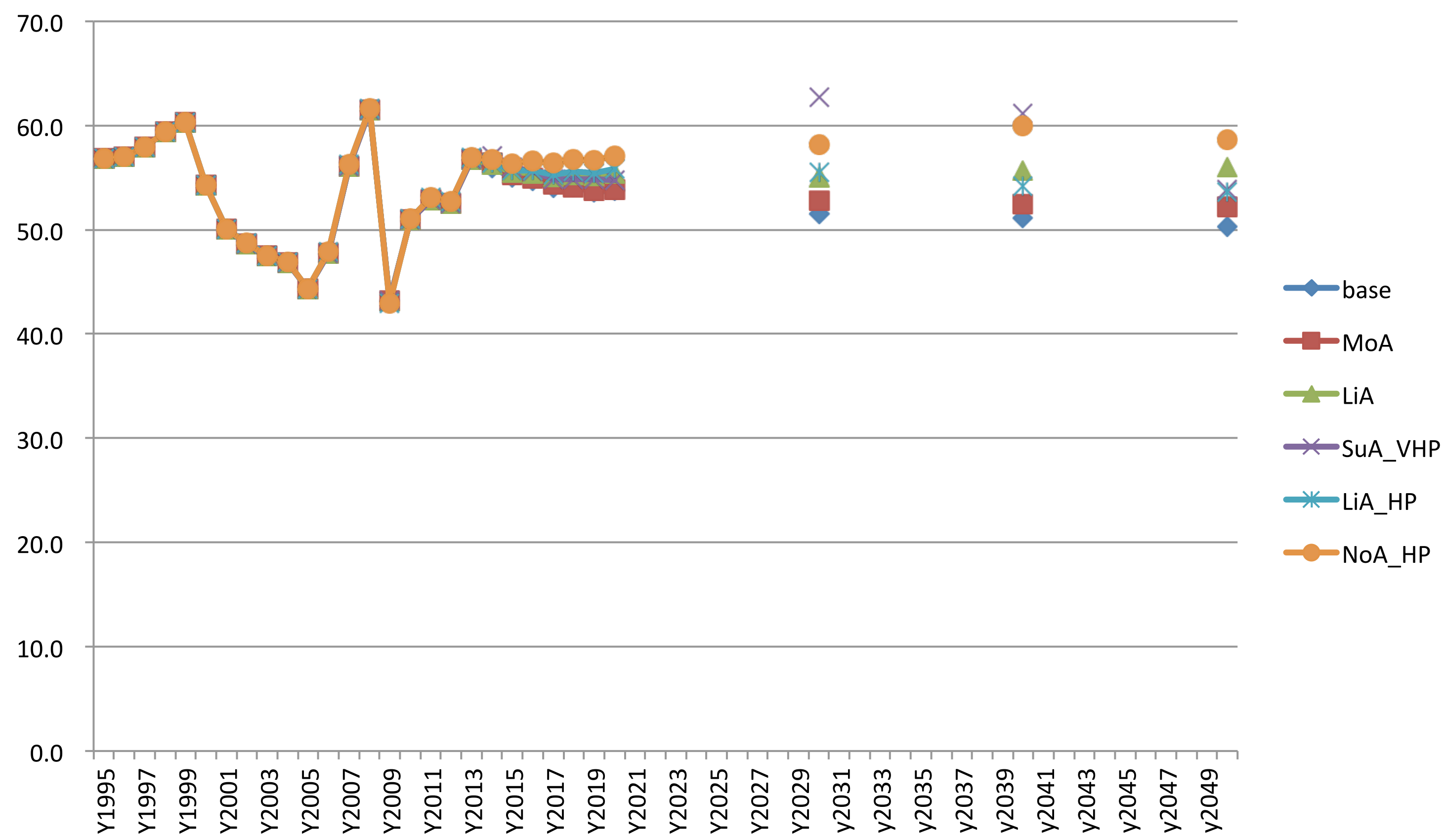
Cereals area (1000 ha, left), total cereals production (1000 tons, right)





Nitrogen balance increasing, if no increase in NUE

- high prices – stagnant / decreasing yields may trigger significantly increasing nitrogen balance!



Most "upsetting" results

- In our very optimistic successful adaptation scenario mainly cereals production expanded – little market /subsidy regulation, abundant land resources
- Harvested grass output changed only slightly => grass area down by 25%
- Dairy production increased 12%, beef 2%, pork 12%, and poultry production 3%
- Overall farm income increased > 90% in the successful adaptation scenario
  - This is mainly because of decreased production costs per unit produced, not only because of increased production

- **Farm income** increased by 14% in the moderate adaptation scenario (yields +10%)
- **… d**ecreased by 12% in the little adaptation scenario (yields -10%), until 2050
- Significantly increasing cereals production in moderate and successful adaptation scenarios is explained by abundant farmland resources and relatively little regulated cereals markets
- high feed / timeliness costs, high opportunity cost of labor and budgetary constraints in national subsidies stabilize livestock production close to the current levels if little change in crop yields

Conclusions

- Finnish agriculture seems to cope well with slightly decreasing yields, due to abundant (farm)land resources
- Avoiding decreases in crop yields is important for agricultural income in the long-term, even if livestock production in also maintained by national subsidies
- Decreasing yields will result in increasing nutrient surplus
  - …and most likely in increased nutrient leaching
- Increasing crop yields, even slightly, would significantly decrease nutrient surplus and increase farm income
- Significant increases in crop yields and prices, however, are required for any significant increase of production in Finland
- Cereals production would increase relatively more than livestock production, in the case of high future prices

Kiitos!
Thank you!

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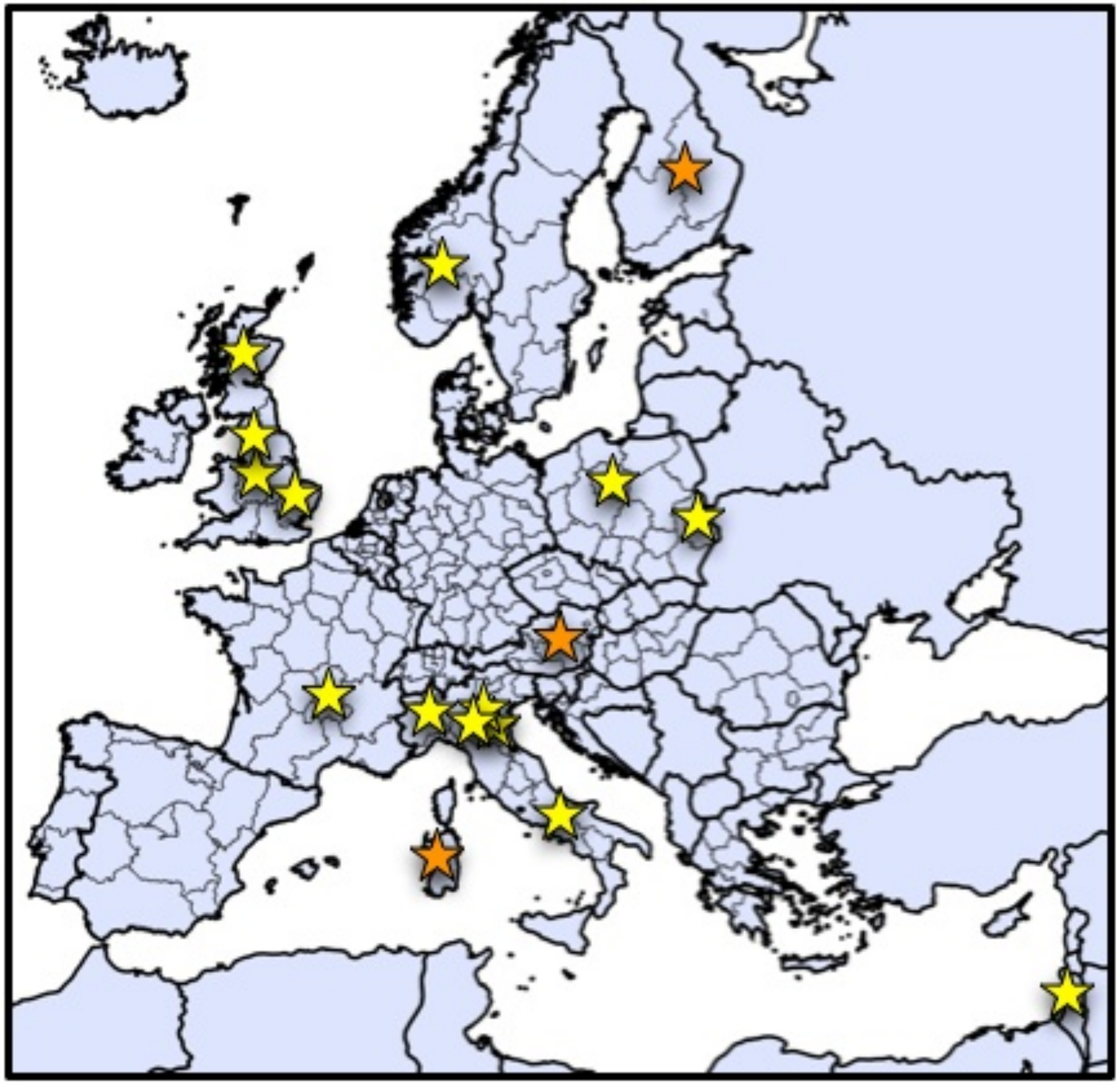

http://macsur.eu/index.php/regional-case-studies/