Fertilizer recommendations and nutrient balance calculations: experience and tools in Estonia

Alar Astover, Karin Kauer
Chair of Soil Science

LIFE IP CleanEST workshop “Nutrient balance calculations for sustainable farming and water protection”
20-21. April 2023, Tartu

Project number: LIFE 17IPE/EE/000007

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Outline

- Short introduction of university
- Fertilizer recommendations
- Nutrient balance/budget indicators in agriculture
- Examples from Estonia
  - National, Farm Gate, Field level
  - Field level NPK balance calculation tool

Eesti Maaülikool in brief

- Tartu Veterinary School, founded in 1848
- Faculty of Agriculture in University of Tartu, incl. departments of agronomy and forestry, founded in **1919**
- Estonian Academy of Agriculture, founded in **1951**
- Estonian Agricultural University 1991 - 2005
- Since 2005 **Eesti Maaülikool,** Estonian University of Life Sciences

Mission

The University creates and shares knowledge to the promotors of bio-economy for the best of Nature and Man.

Rankings:

- *Times Higher Education* ranking: **801 and 1,000**.
- *QS World University Rankings* by Subject **51–100** in the field of **agriculture** and **forestry** in the world in recent years
- Top 50 in 2019, 48th in 2020, 68th in 2022, **37th** in 2023.

Accreditations (International)

- Science – positively in 2017 (7yrs)
- Institutional, including studies – passed spring 2022, full (7yrs)

Number of students (March 2023): 2700

Academic staff: ca 500

Basic structure: 3 institutes

Institute of Agricultural and Environmental Sciences	Institute of Veterinary Medicine and Animal Sciences	Institute of Forestry and Engineering
Crop science and plant biology	Animal breeding and biotechnology	Silviculture and forest ecology
Horticulture	Animal nutrition	Forest and land management and wood processing technologies
Plant health	Aqaculture	
Soil science	Veterinary biomedicine and food hygiene	Rural building and water management
Landscape and environmental management	Clinical veterinary medicine	
Landscape architecture	Food Science and Technology	Biosystems engineering
Biological diversity and nature tourism		Energy application engineering
Hydrobiology and fishery	Rural economics	

RESEARCH CENTRES AND FIELD BASES

Chair of Soil Science

- Experiments from lab to field and jointly with farmers and other companies
- Soil quality, crop productivity, environmental impact
  - Field experiments (mineral and organic fertilizers), also in farmer fields
  - Mini lysimeters experiment
  - Pot experiments in controlled conditions

Fertilization recommendations based on soil data

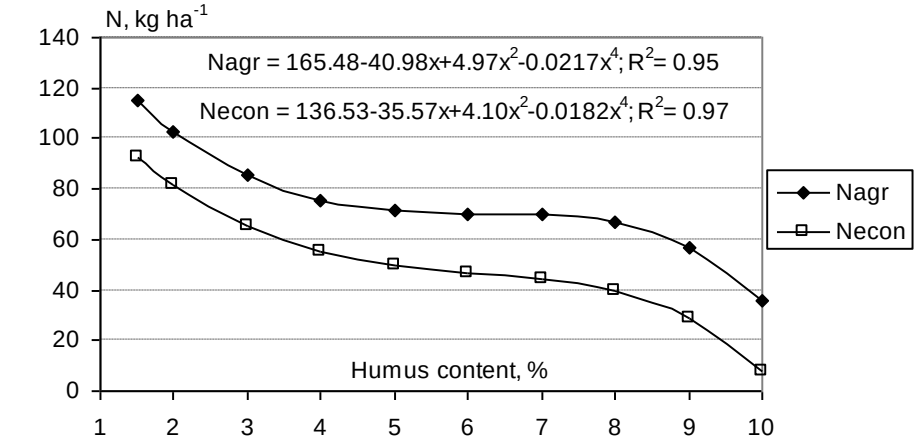
- Farmers can have recommendations for fertilisation based on soil data (lab analysis + soil map + crop specifics and yield goal)

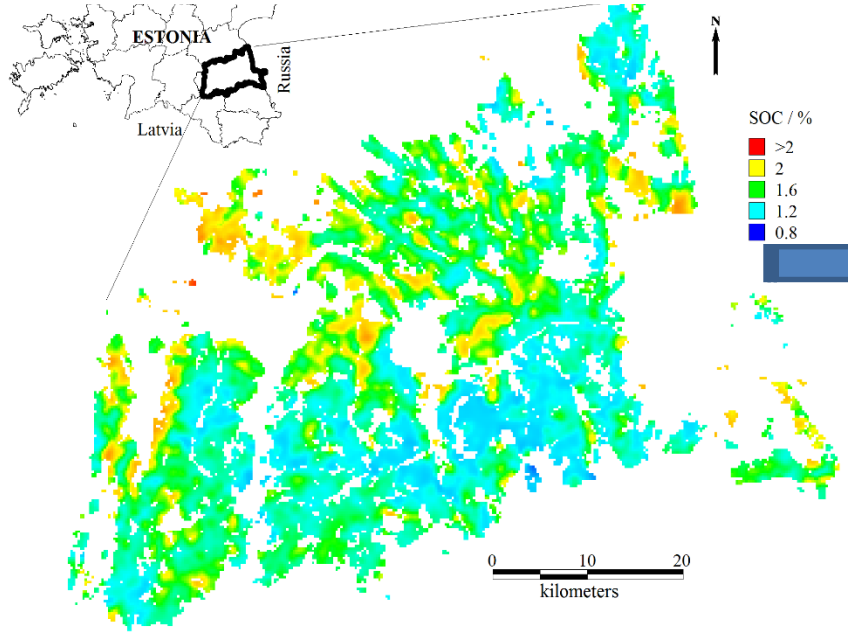
Example: Phosphorous fertiliser requirement (kg P/ha) for wheat, expected yield 5 t/ha.

One piece of puzzle for precision farming

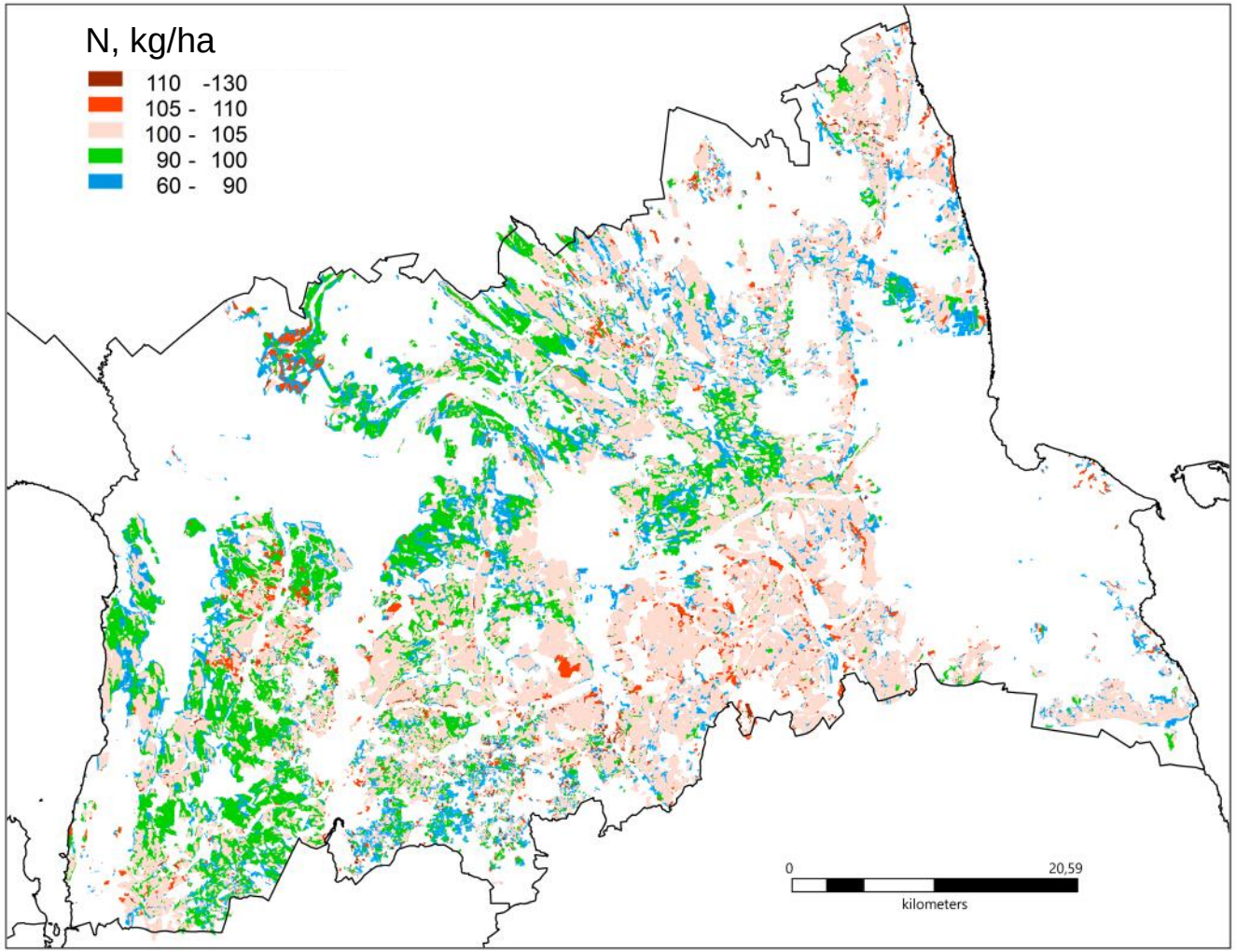
„Big Data“ in agriculture

Agronomic and economic optimum of mineral N fertilizer rate for barley depending on soil humus concentration





Agronomic optimum N rate (kg/ha) for spring barley (with addition $P_{27}K_{60}$)



National/state fertilization programme - how farmers can evaluate soil condition?

- Re-established in 2002
- Purpose is to support efficient use of fertilizers by farmers
- What is measured?
  - pH, content of P, K, Ca, Mg, soil organic carbon
- Results are benefitial to:
  - Farmers- ferilization and lime application recommendations are composed based on the laboratory data
  - Policy makers- we get comprehensive overview about the soil condition
- Programme is mandatory, if CAP environmentally friendly farming or organic farming support is applied for

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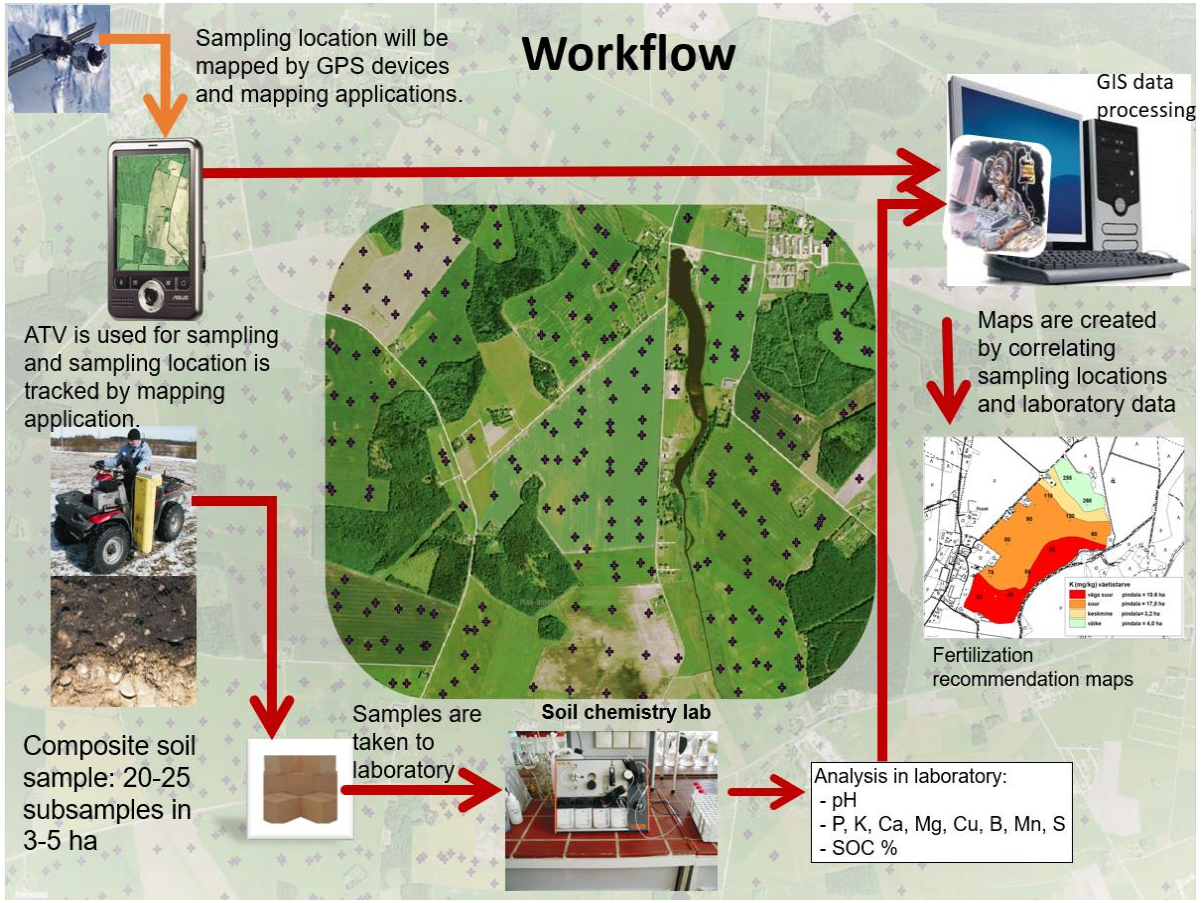


Penu, Pihlap, Kikas 2023

Fertilizer recommendation maps

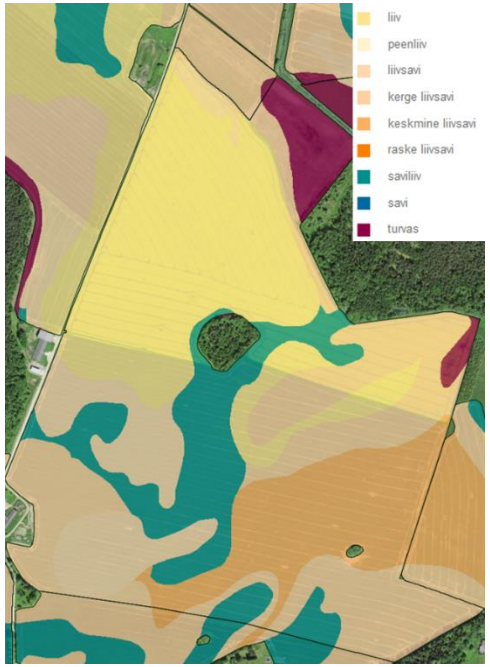
Input data

Soil sample lab results

Proov_nr	pH	P	K	Ca	Mg	Cu	Mn	B	OrgC	tootja	asutus
1 204 732	5,9	98	118	1 117	80	0	0	0	0		
1 204 733	5,7	115	106	884	68	0	0	0	0		
1 204 734	5,6	134	110	300	62	0,6	113	0,27	4,1		
1 204 735	5,7	111	167	1 196	79	0	0	0	0		
1 204 736	5,6	58	145	1 210	104	0	0	0	0		
1 204 737	5,1	72	153	874	81	0	0	0	0		
1 204 738	6,6	40	139	1 468	291	0,8	132	0,57	1		
1 204 739	5,2	55	139	815	107	0	0	0	0		
1 204 758	6,8	34	123	1 973	324	0	0	0	0		
1 204 759	5,7	50	127	1 117	91	0	0	0	0		
1 204 760	5,3	31	136	919	77	0	0	0	0		
1 204 761	5,4	40	128	1 046	97	0,5	104	0,31	1,3		
1 204 762	5,7	50	139	999	101	0	0	0	0		

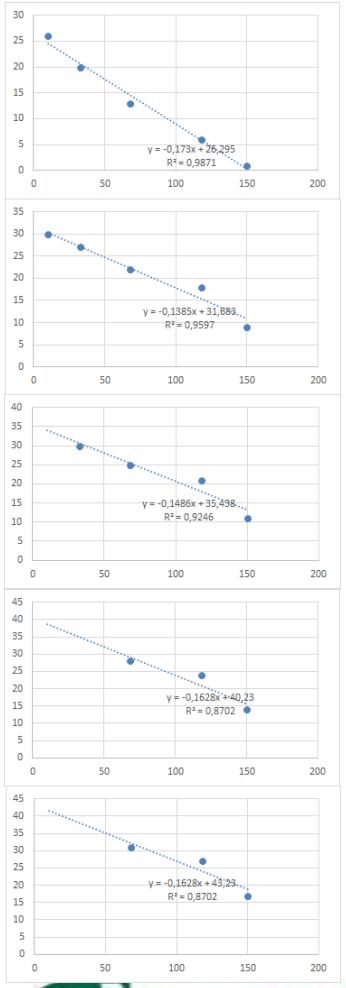
+

Soil texture



+ Crop +

Models by replacement approach



Penu, Pihlap, Kikas 2023

20. April 2023

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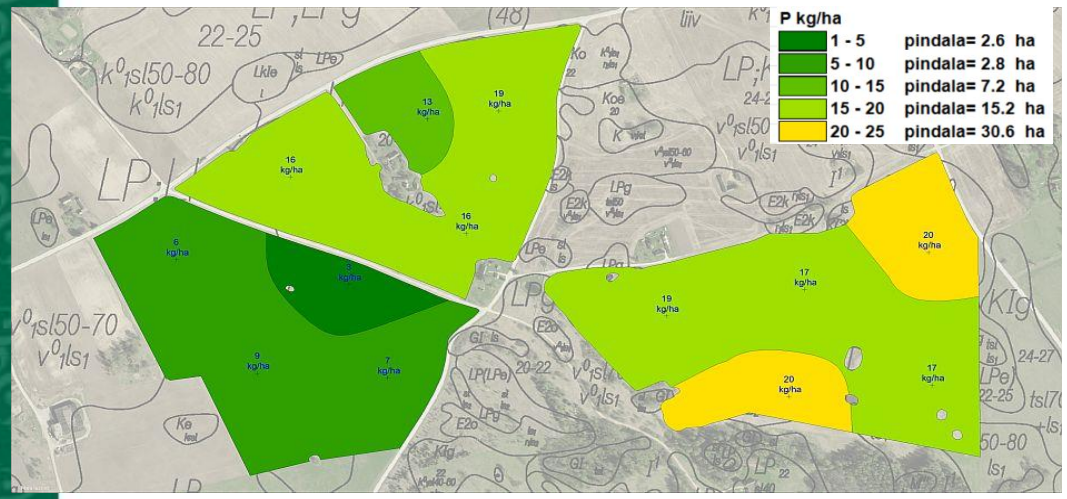
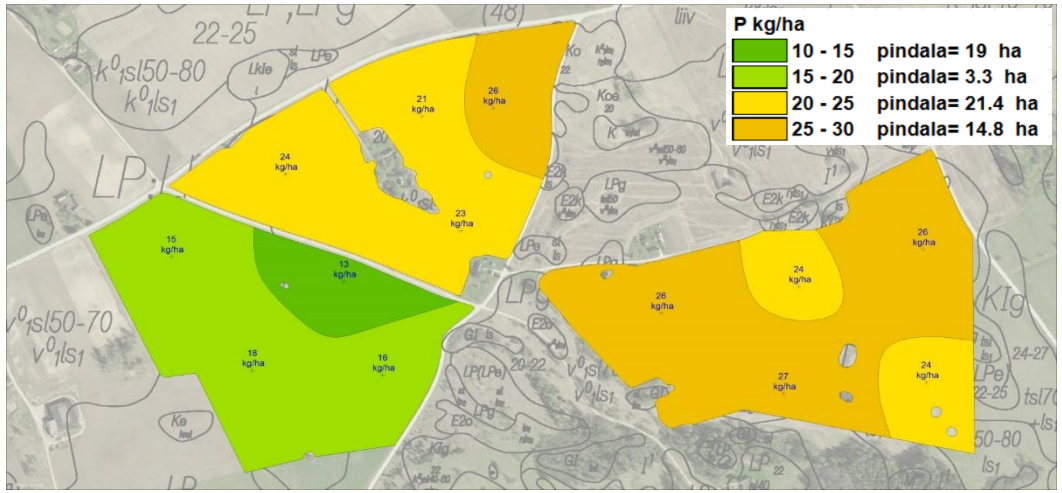
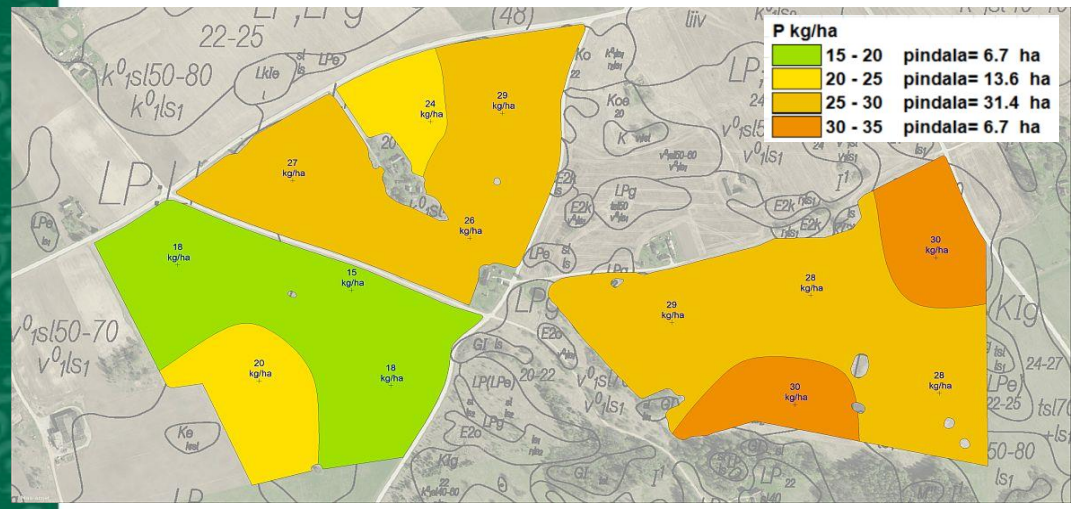
Summer wheat, target yield 3 t/ha



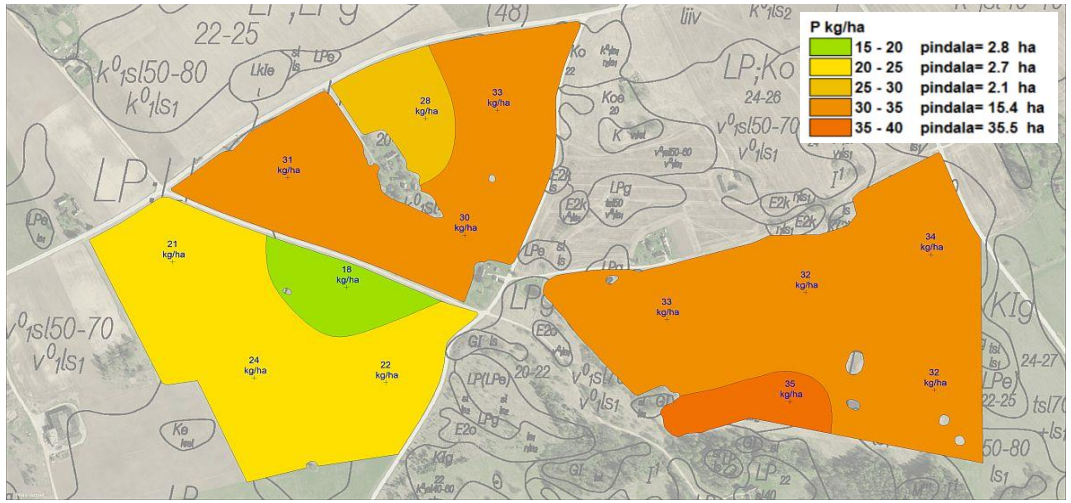
Summer wheat, target yield 4 t/ha



Summer wheat, target yield 5 t/ha



Summer wheat, target yield 6 t/ha



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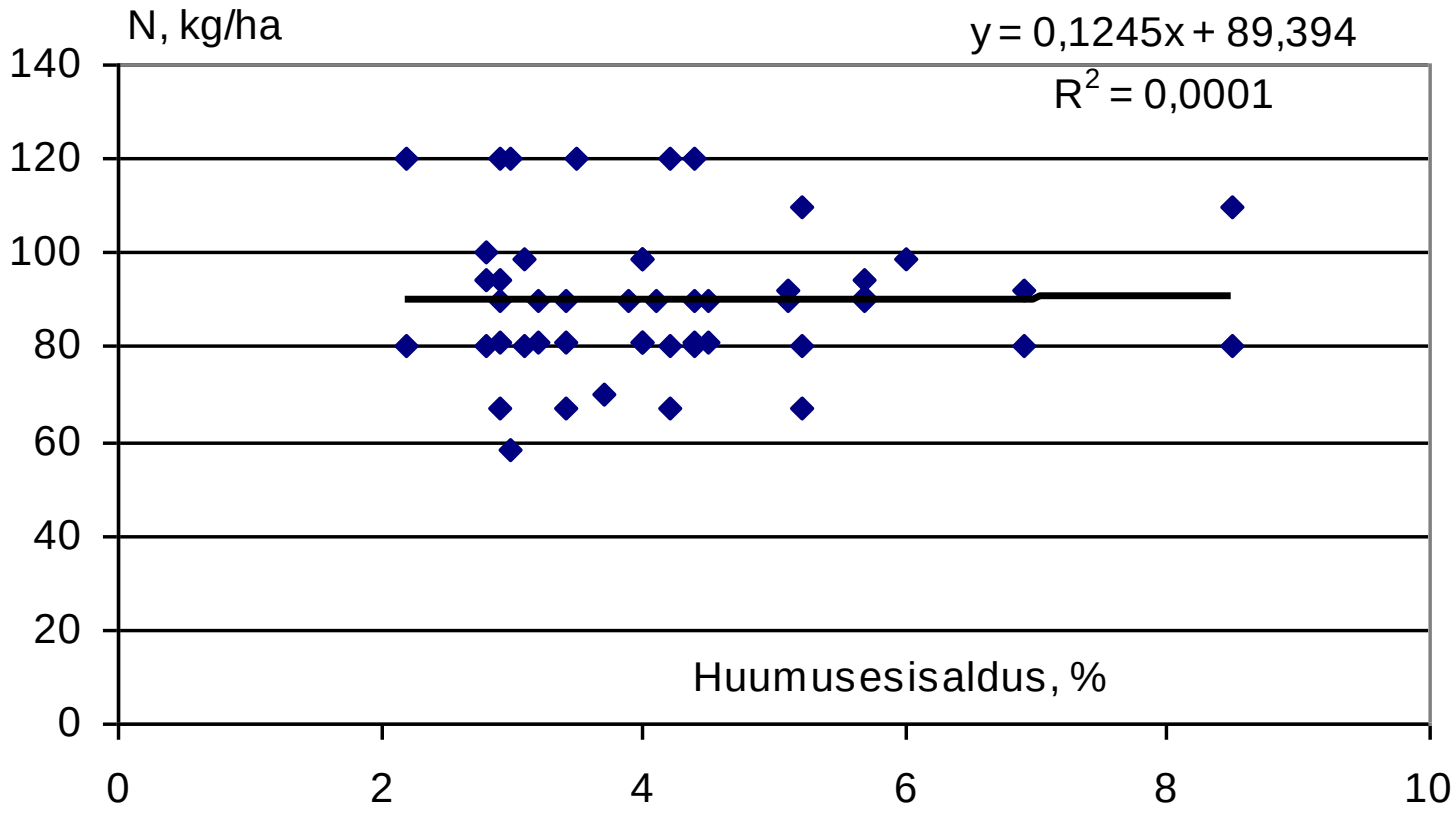
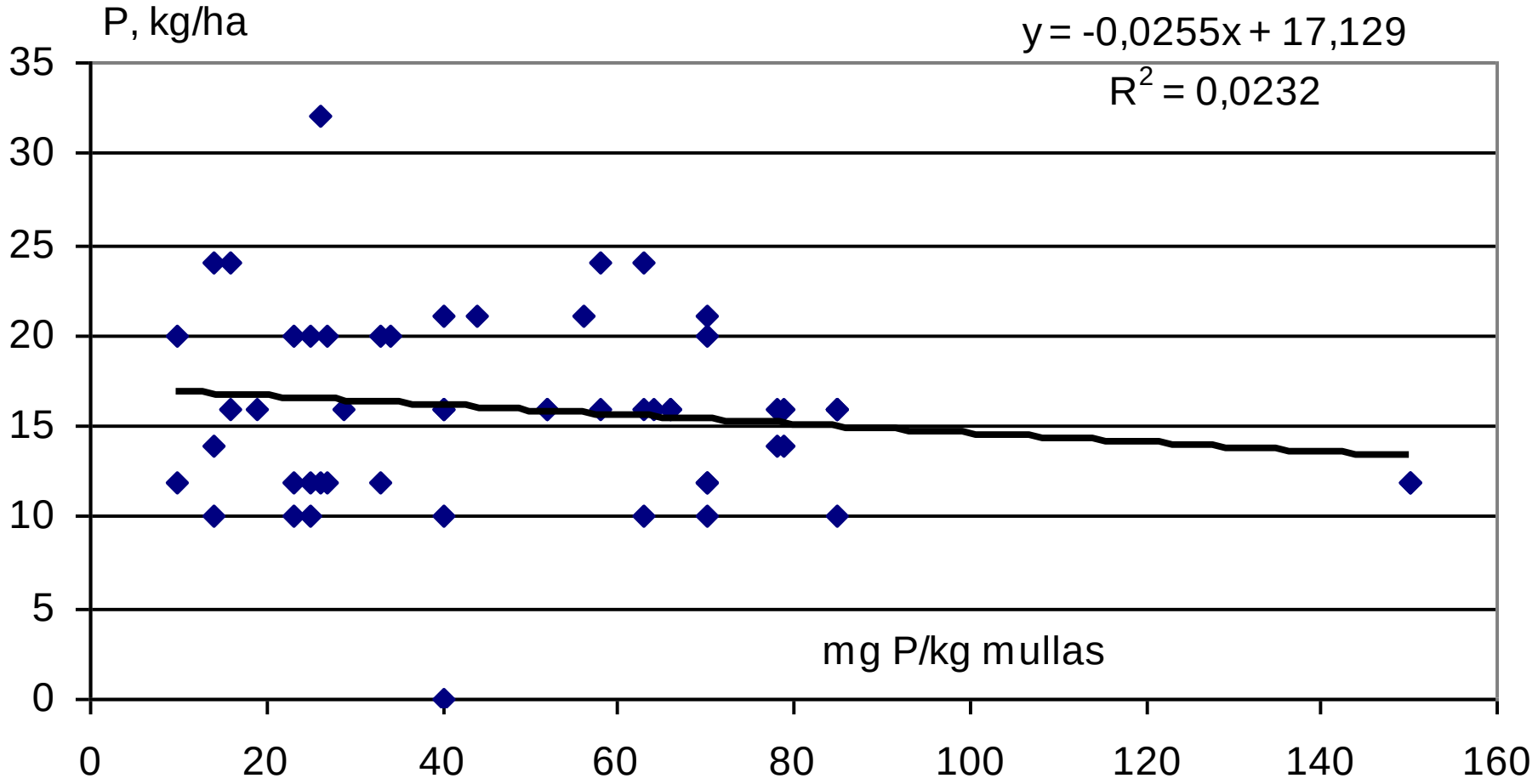
- Some commercial service providers as well
  - Agricon (lab and knowledge from Germany)
  - Yara (lab in UK)
  - …

Example from real cereal farm practice: N use depending on soil humus (Corg*1.72)

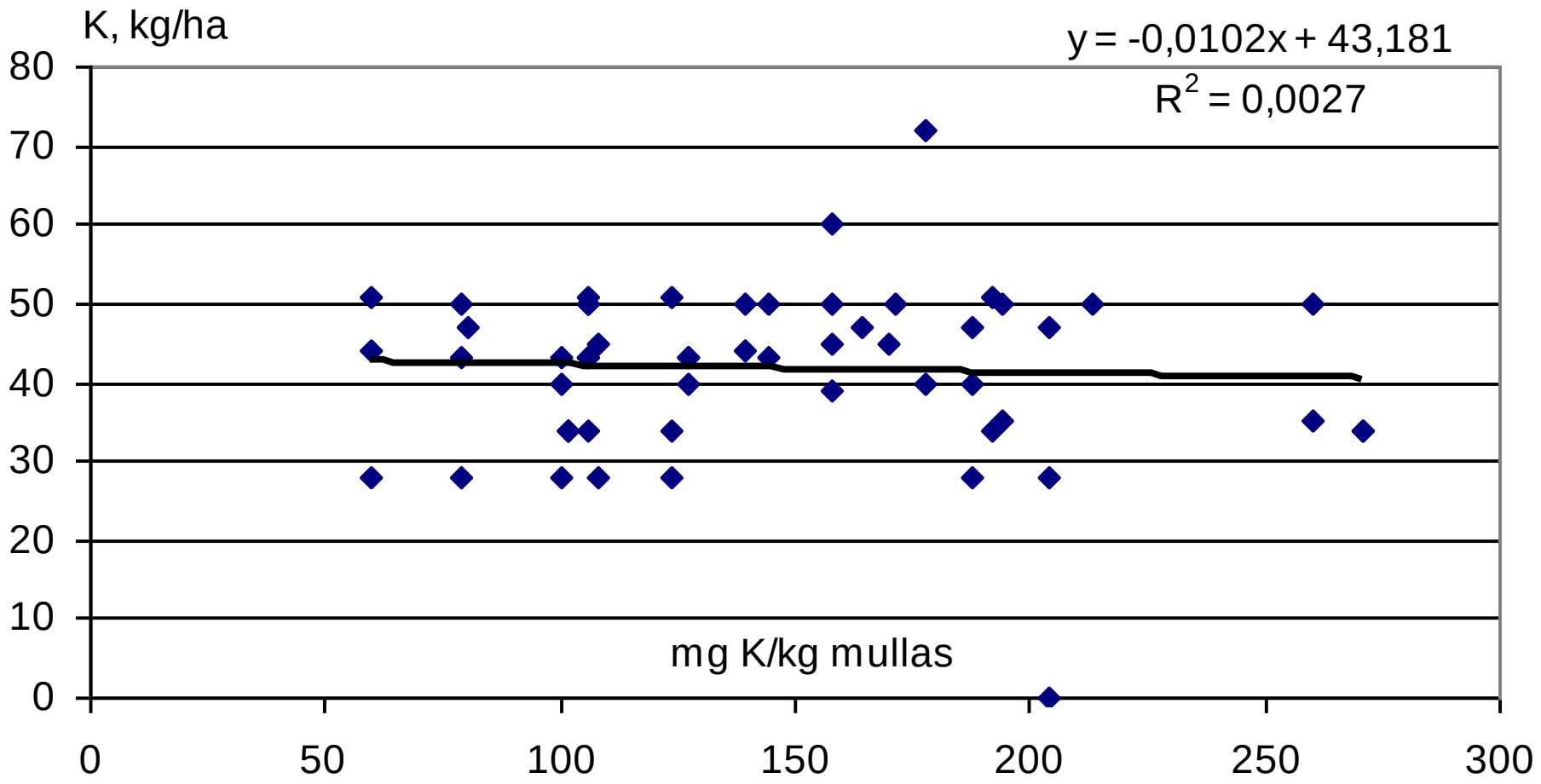
Fertilizer use by crop and yield target and soil not considered at all (hard to estimate how dominant in general)



Same farm:
P use depending on soil extractable P-content

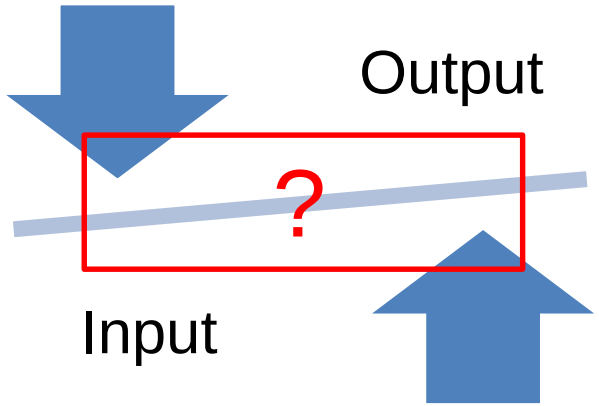


Same farm:
K use depending on soil extractable K-content



Why nutrient balance indicators can be useful:

- Nutrient management planning and optimizing fertilizer use
- Soil quality and fertility
- Potential environmental impact of agriculture – assessment and measures for protecting soil, water and air. Policy instrument.



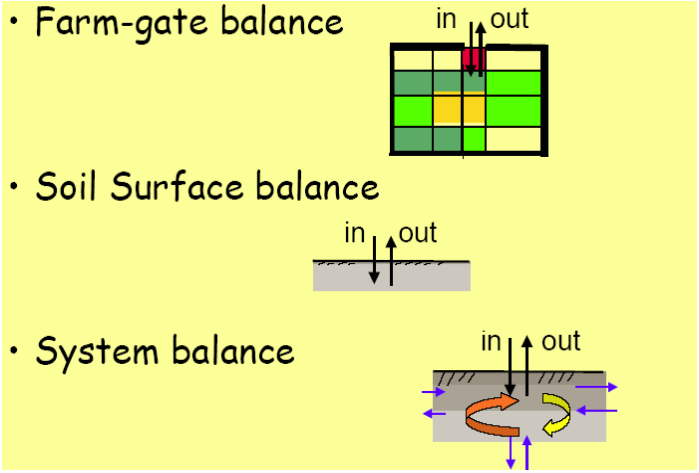
http://sp.life123.com/bm.pix/how-to-milk-cow.s600x600.jpg

- **Farm-gate balance** – boundary as legal body and calendar year.

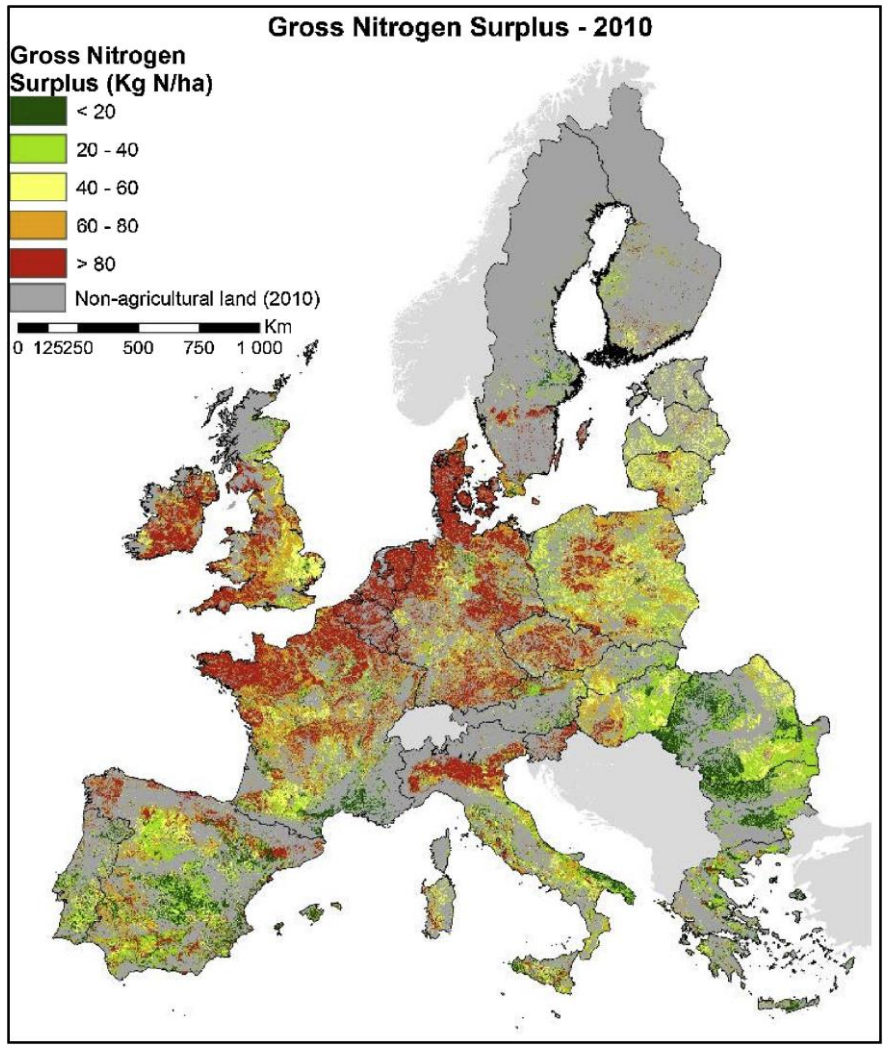
- **Soil (surface) balance** – land/soil surface as system border.

Spatial scale from national (OECD/Eurostat), regional to field.

- **System balance** – (soil) internal fluxes taken into account also (mostly by modelling).

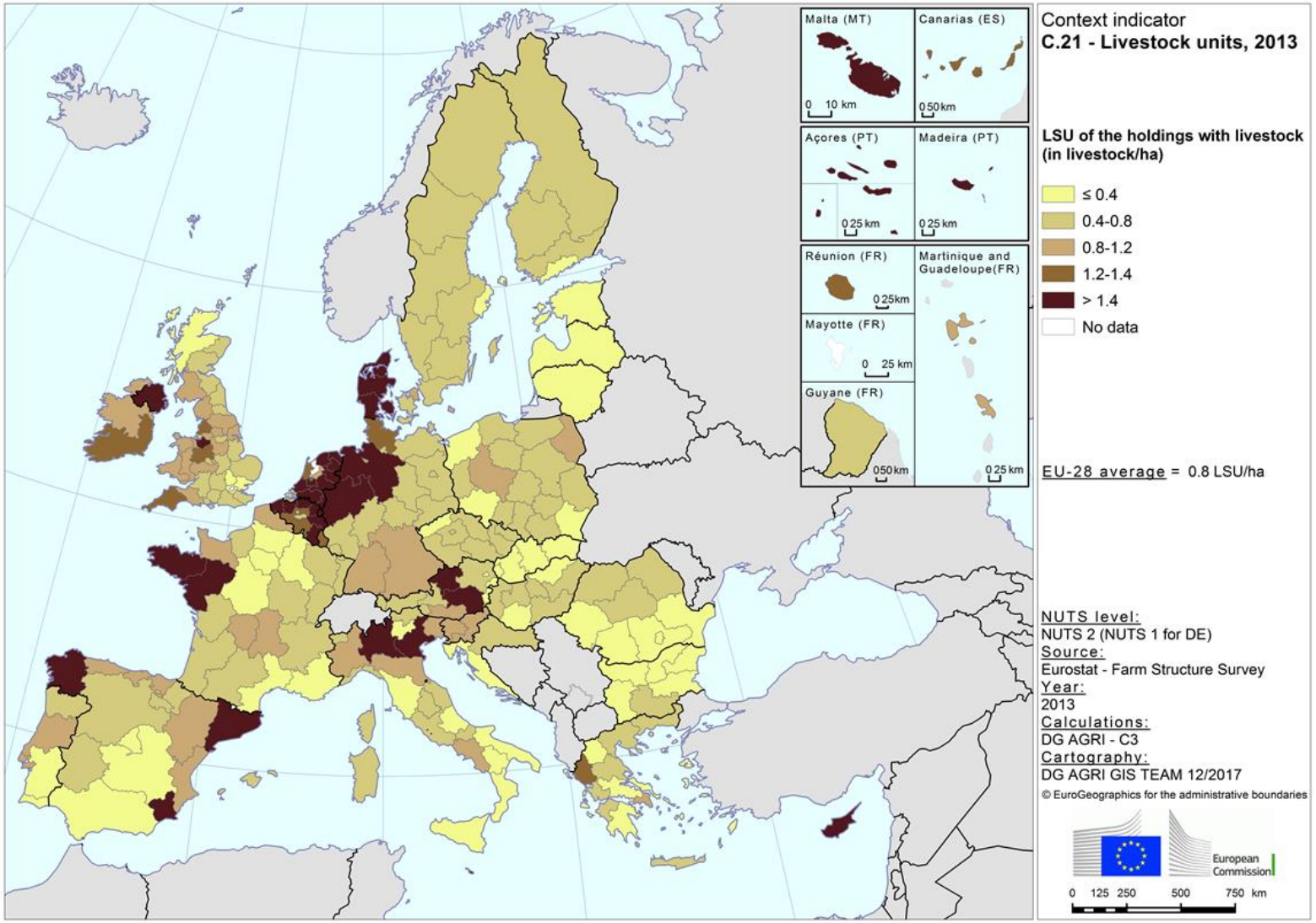


Nitrogen budget/surplus in European agricultural land, kg/ha



Rega et al 20198; https://doi.org/10.1016/j.landusepol.2019.05.005

- Surplus in “nice” way correlated with livestock density



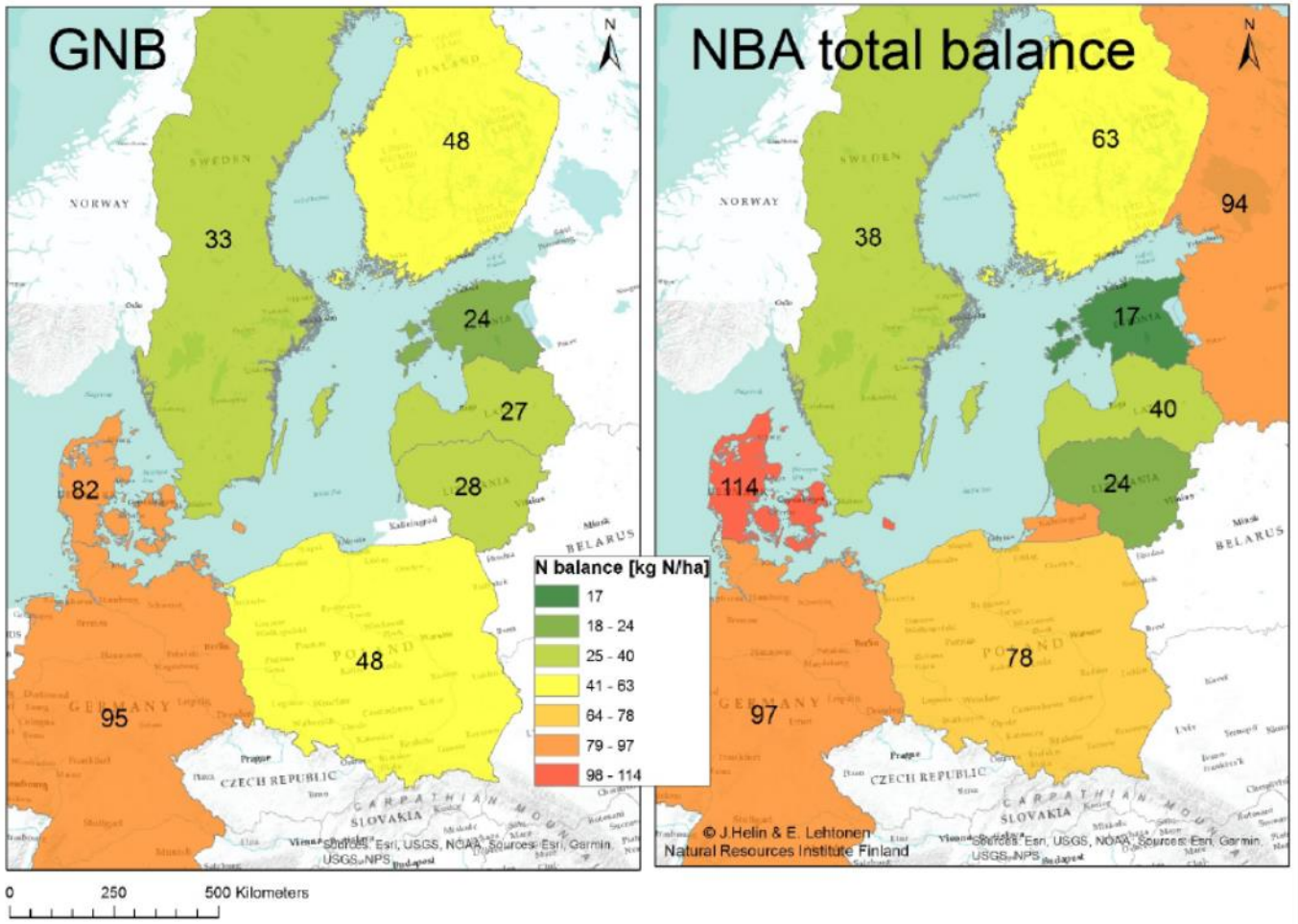
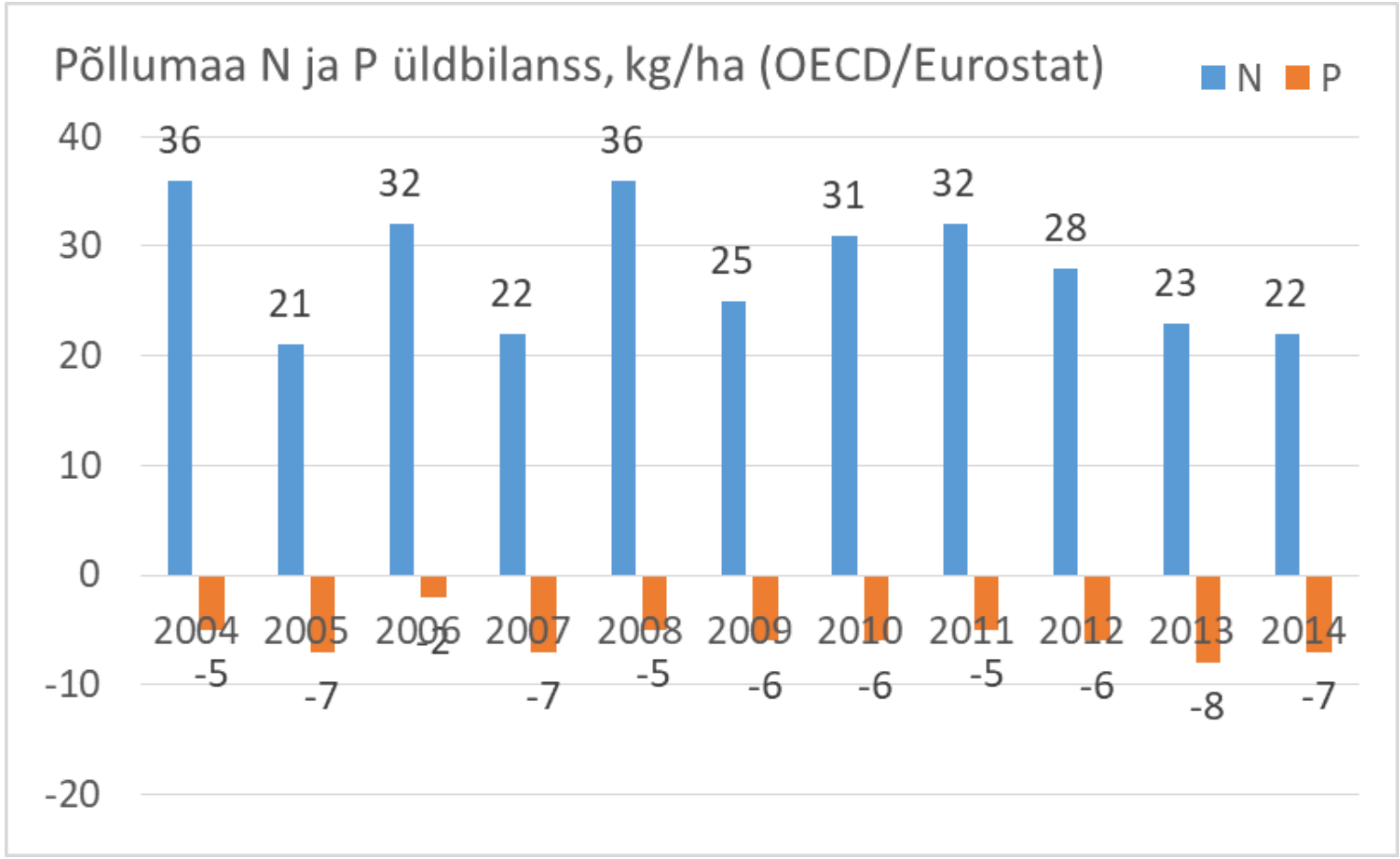


Figure 3: Gross Nitrogen Balance (GNB) according to OECD/Eurostat and total balance according to the NBA currently used in Germany as a five-year average of 2012-2016 (RU only Leningrad region)

Kuka et al. 2019

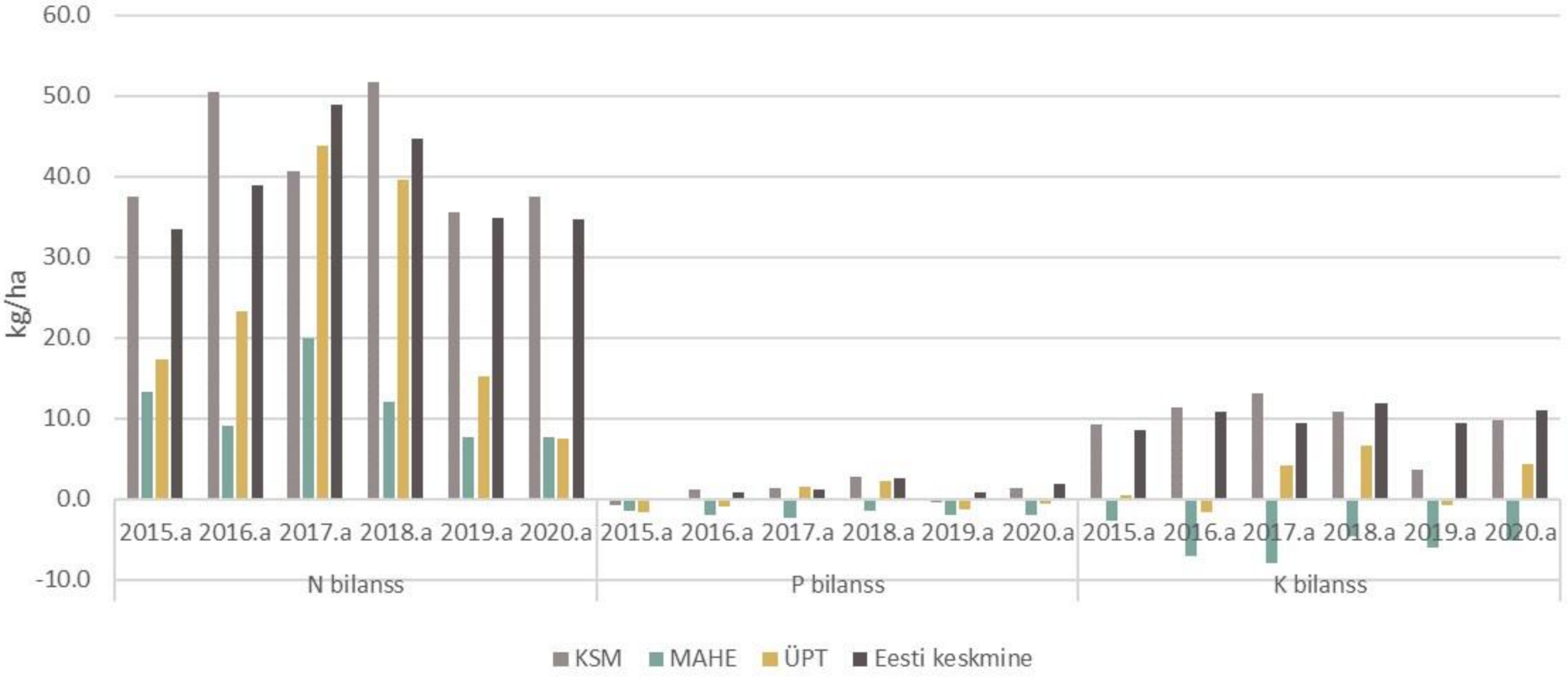
Manure Standards

National level - Estonia



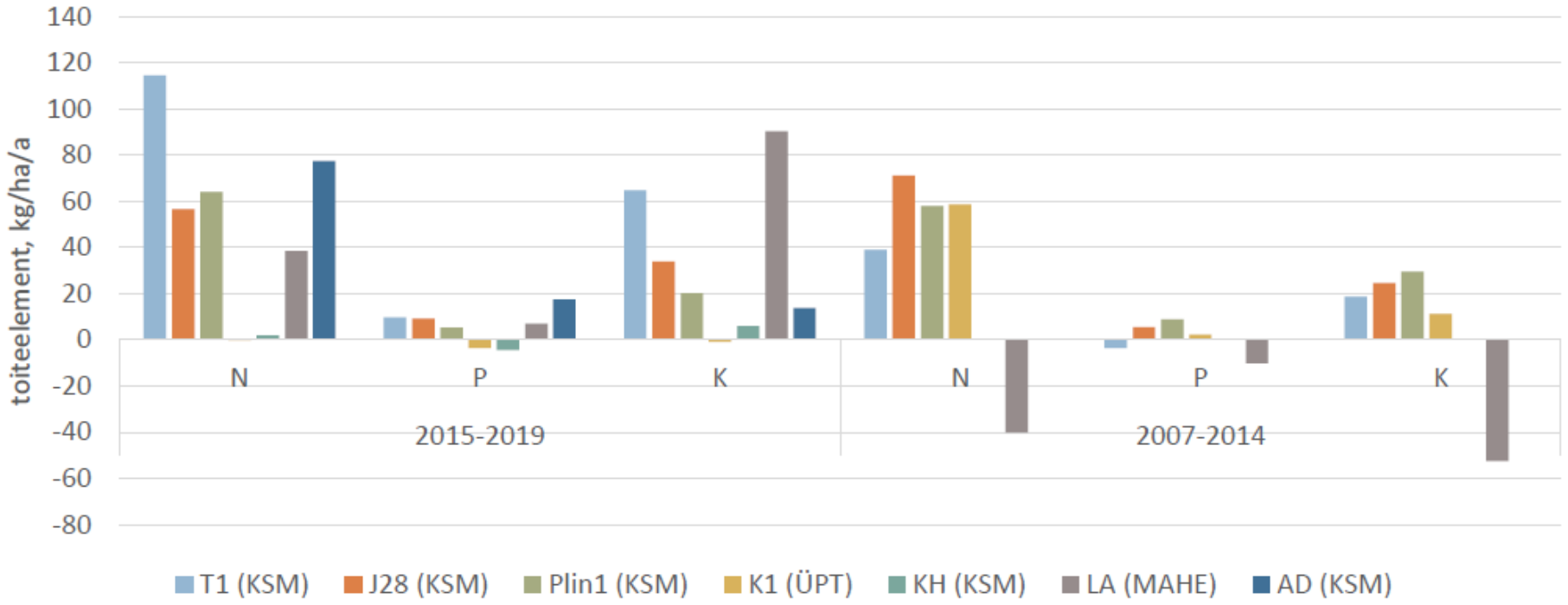
Source: https://stats.oecd.org/

Farm gate balance – Estonian farms (FADN)



https://pmk.agri.ee/et/keskkonnaseire/taluvarava-toiteelementide-uuringust

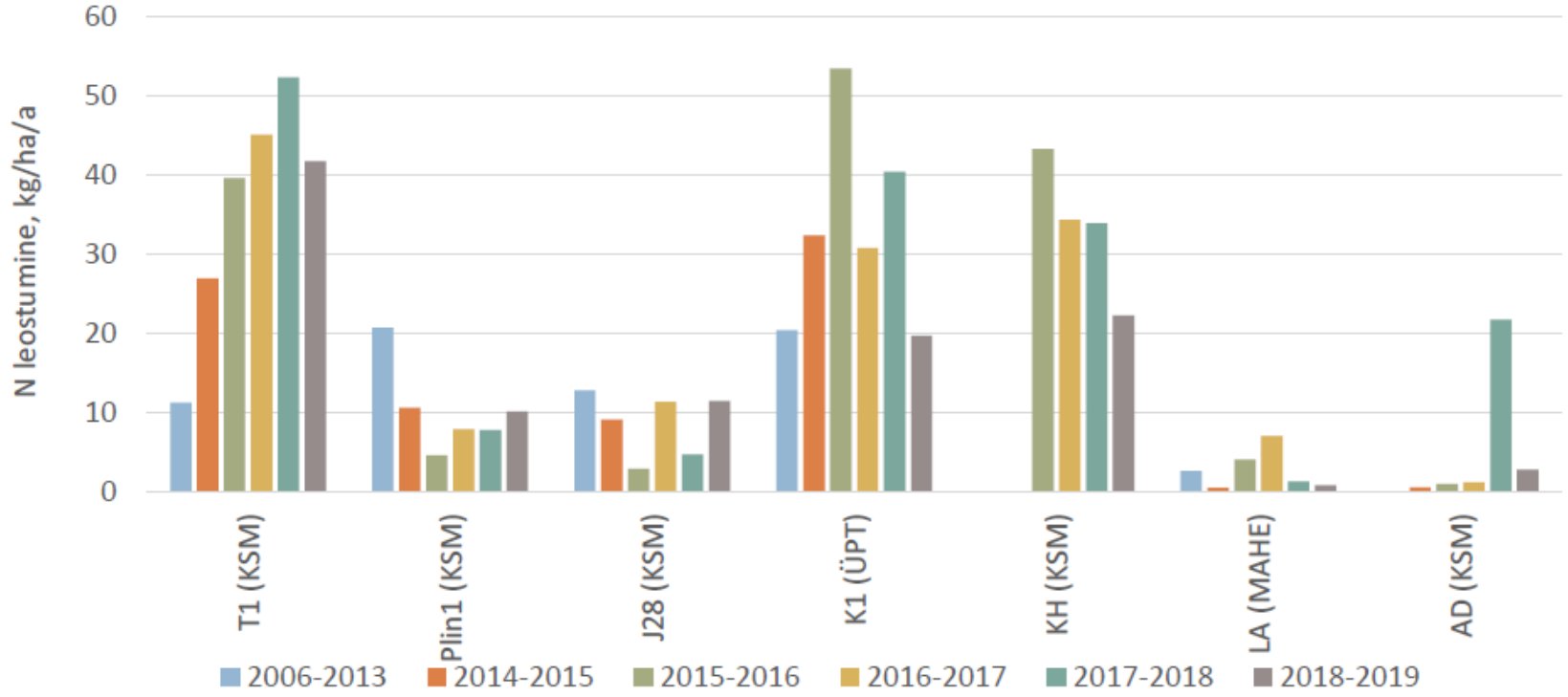
Monitoring fields – run-off by drainage
Field NPK balance



Joonis 21. Taimetoiteelementide üldbilanss seirepõldudel (T1, J28, Plin1, K1, KH, LA, AD) perioodide 2007-2014 ja 2015-2019 keskmisena

PMK, 2019

Monitoring fields – run-off by drainage
N leaching, kg/ha/y



Joonis 18. Lämmastiku aastane leostumine seirepõldudelt (T1, Plin, J28, K1,KH, LA, AD) referentsperioodil 2006-2013 ja aastatel 2014-2019

PMK, 2019

Field level nitrogen, phosphorus and potassium balance calculator

- Currently in Excel
- Updates and integration to online version (“big data”) in progress
- Time boundary – crop growing cycle (not calendar year)

- Published guideline “Nutrient balances – guideline for field level nitrogen, phosphorus and potassium balance calculator” for agricultural producers/advisors
- Stakeholders involved (farmers, KeM, EPKK etc)
- Introduced in newsletters and in dedicated seminars

Taimetoiteelementide bilansid – põllupõhise lämmastiku, fosfori ja kaaliumi bilansikalkulaatori juhendmaterjal. Alar Astover, Karin Kauer. Eesti Maaülikool, 2022.

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	A	B	C	D	E	F	G	H	I	J	AJ	AK	AL	AM
1											Kaalutud keskmine			
2											0	-7	-55	
3	Arvuta rida		Lisa	Kustuta	Puhasta rida			Saak			Bilanss (kg/ha)			Hinnangud bilansi tulemusele
4	Põllu number	Põllu nimi	Põllu-massiiv	Kultuur	Pind (ha)	Aasta	Külvise-norm (kg/ha)	Saagikus (kg/ha)	Koristatav saagiosa	Proteiini % kuiv-aines	N	P	K	N
5	Teraviljad													
6				suvinisu	1		200	5000	terad	14,7	23	-2	2	Suure N-tarbega mullal tasakaalus bilanss. Oled jätkusuutlik.
7				suvinisu	1		200	5000	terad ja põhk	14,7	9	-6	-37	Suure N-tarbega mullal tasakaalus bilanss. Oled jätkusuutlik.
8	Muud													
9				taliraps	1		8	3200			30	14	98	
10	Kaunviljad													
11											0	0	0	
12	Heintaimed													
13				liblikõieliste ja kõrreliste segu	1			10000	märgsilo kuni loomiseni		-63	-33	-284	Suure N-tarbega mullal tugevasti negatiivne bilanss. Saagi moodustumine mulla orgaanilise aine N arvelt.

pollumeheteataja.ee/uudis/2021/06/08/taimetoiteelementide-tasakaal-pollumullas-tagab-hea-saagi/

ESILEHT TEEMAD LIITUDE UUDISED VÄLJAANDED KOLLEEGIUM TOIMETUS

Taimetoiteelementide tasakaal põllumullas tagab hea saagi

Alar Astover, Eesti Maaülikooli mullateaduse professor — juuni 2021 Taimekaitse, Põllumehe Teataja juuni 2021

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Inputs and output in calculation tool

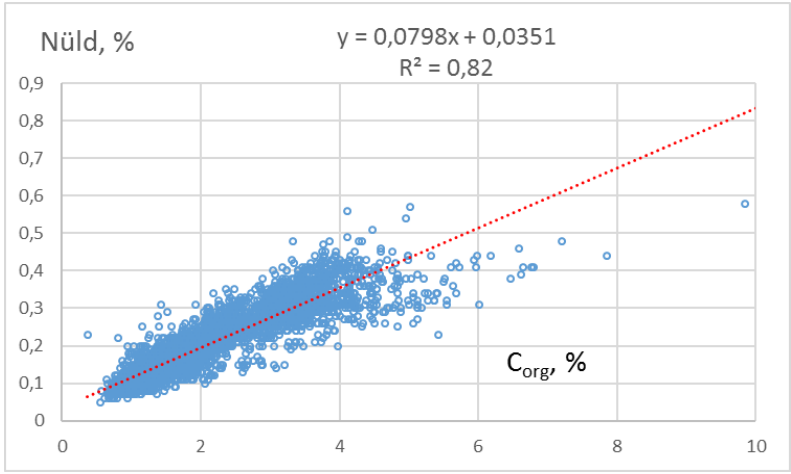
- Output – removal with harvest
  - Yield quantity (main crop, by-product, “easy” with main crops, higher uncertainty for grassland)
  - Yield quality (especially *N/protein content varies*)
- Inputs
  - Fertilisers (mineral, *organic*)
  - N_2 *fixation by legumes/bacteria* (depends on biomass yield, not fixed rates by crop type)
  - Seeds (for selected crops)

Indicator value is transferred to qualitative “message” (requires soil data)

- N balance value assessed by soil Corg classes

Corg classes	Corg % >=	Corg % <
1		1,2
2	1,2	2,2
3	2,2	3,2
4	3,2	5
5	5	100

Soil Ntot depending on Corg value (soil monitoring dataset n=6521)



- P and K soil classes by Mehlich-3 analysis method

- Lets look inside…

- Challenges and discussion points
  - Harmonization (EU, HELCOM, …)
  - Context-specific interpretation
  - Stakeholder (farmer) involvement (support and/or penalty's)
  - …

Alar Astover, professor, Head of Chair
Chair of Soil Science
E-mail: alar.astover@emu.ee

Euroopa Maaelu Arengu Põllumajandusfond: Euroopa investeeringud maapiirkondadesse

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