Key opportunities & challenges in nutrient recycling for the Baltic Sea Region

Arno Rosemarin
Karina Barquet
SEI

SEI Stockholm Environment Institute

2020-09-30

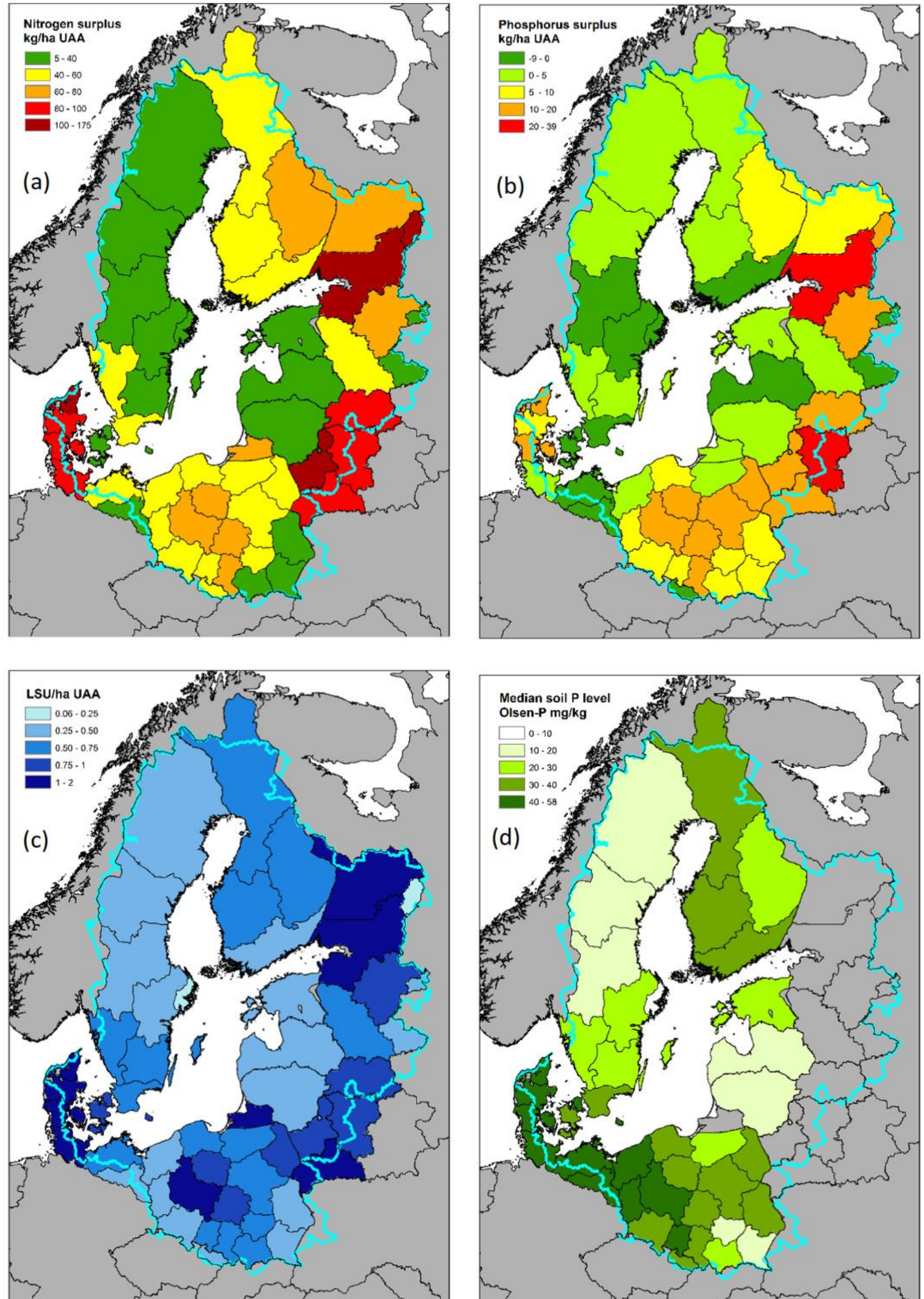
Biophysical Challenges

- BSR phosphorus load exceeds HELCOM recommendations by >40%
- P-driven cyanobacteria blooms fix as much nitrogen as the anthropogenic load
- Intensive animal farms - nutrient hotspots requiring more attention
- Continued loading from legacy P from previous decades of excessive fertilizer use
- Enclosed brackish sea with 30-40 yr retention time and anoxic benthic zones

N & P surpluses

livestock densities

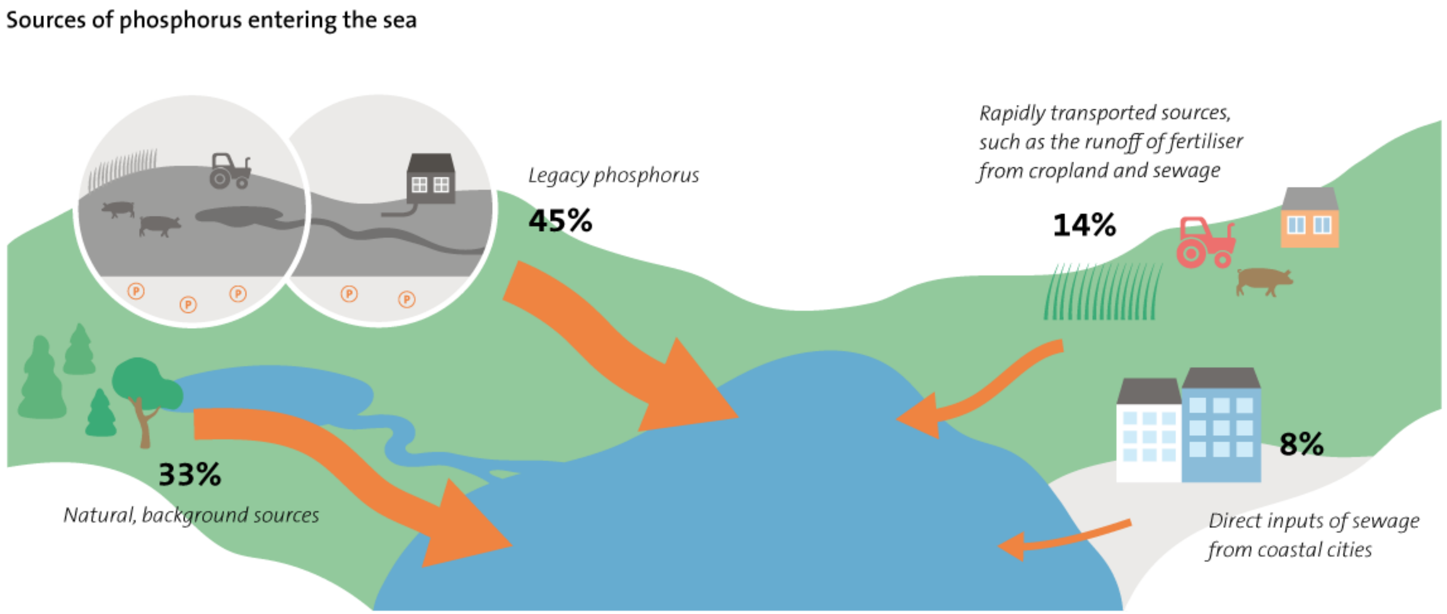
soil P levels



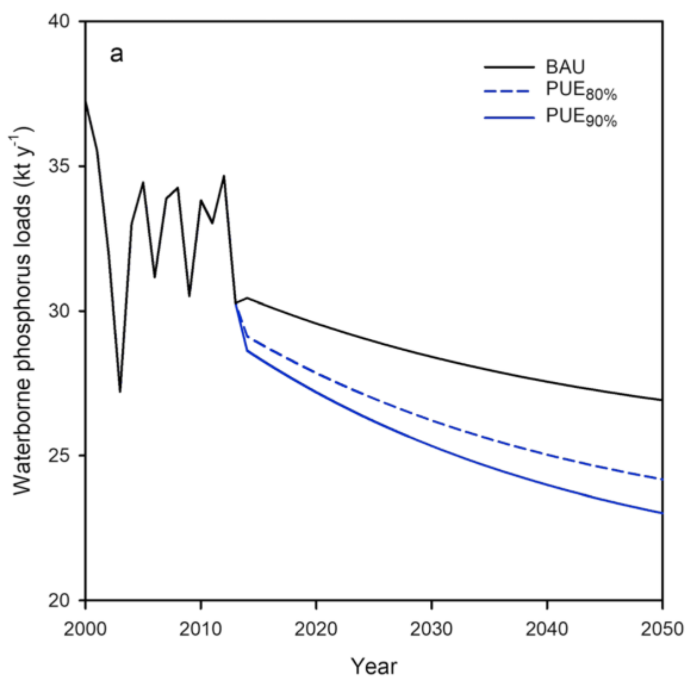
Svanbäck et al 2019

surpluses related to animal densities

Blaming legacy P could lead to complacency



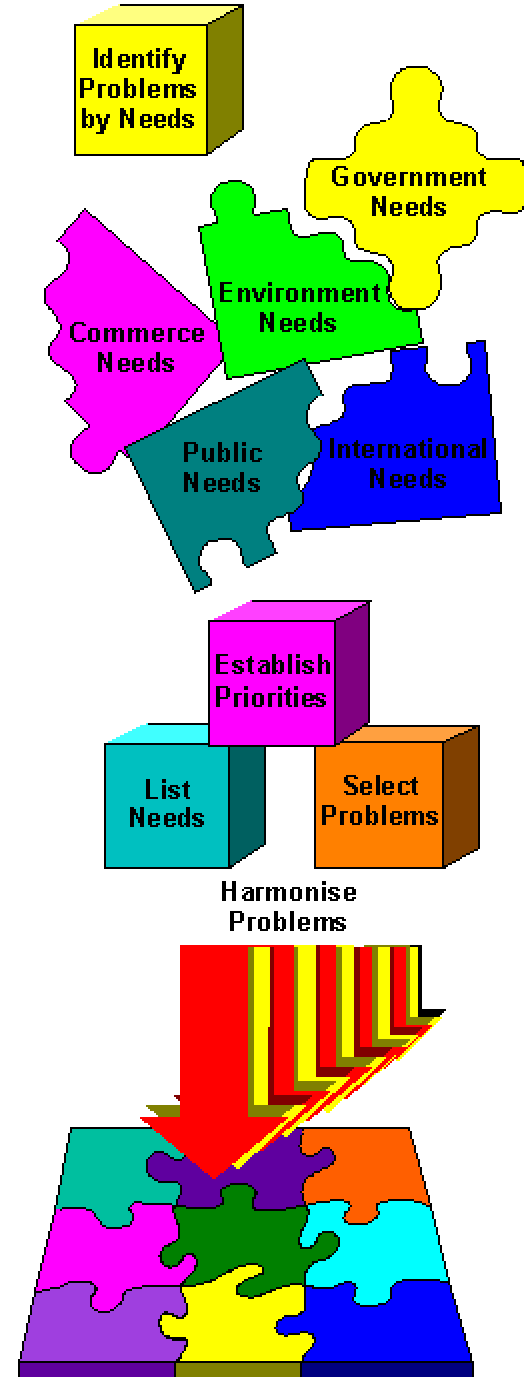
McCrackin et al 2018

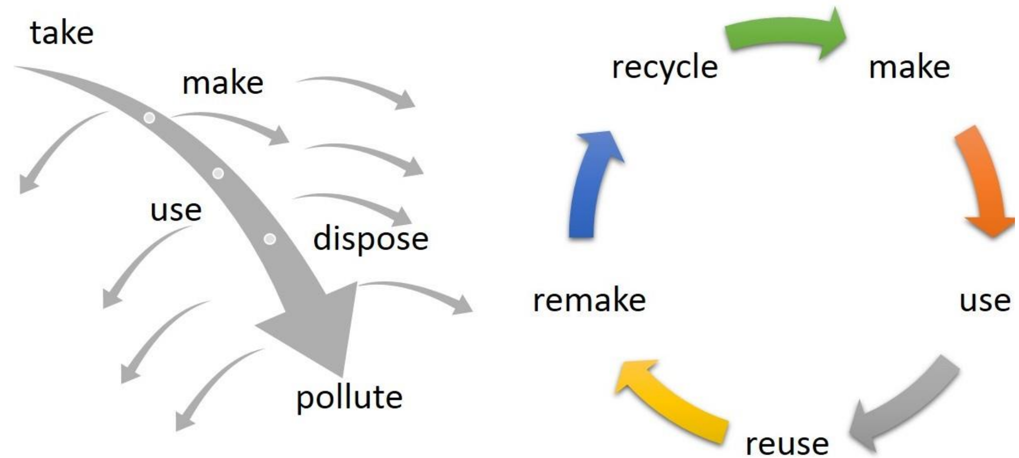


- Complacency would just increase the legacy P store
- Need to come down to P-loading levels that will decrease and eliminate the annual blue-green blooms

Policy challenges

- Lack of policy harmonisation & coherence
- EU Wastewater Directive
  - wastewater and sludge need to be brought into the fertilizer market
  - sludge needs a safety certification system
- EU Nitrates Directive
  - phosphorus left unmanaged
  - manure N/P ratios left unmanaged
- National regulations for manure phosphorus vary widely and don’t exist for several countries
- Application of EU Water Framework Directive to farming practices unclear
- EU CAP subsidies to farmers have led to nutrient surpluses
- HELCOM recommendations not always adapted into national regulations



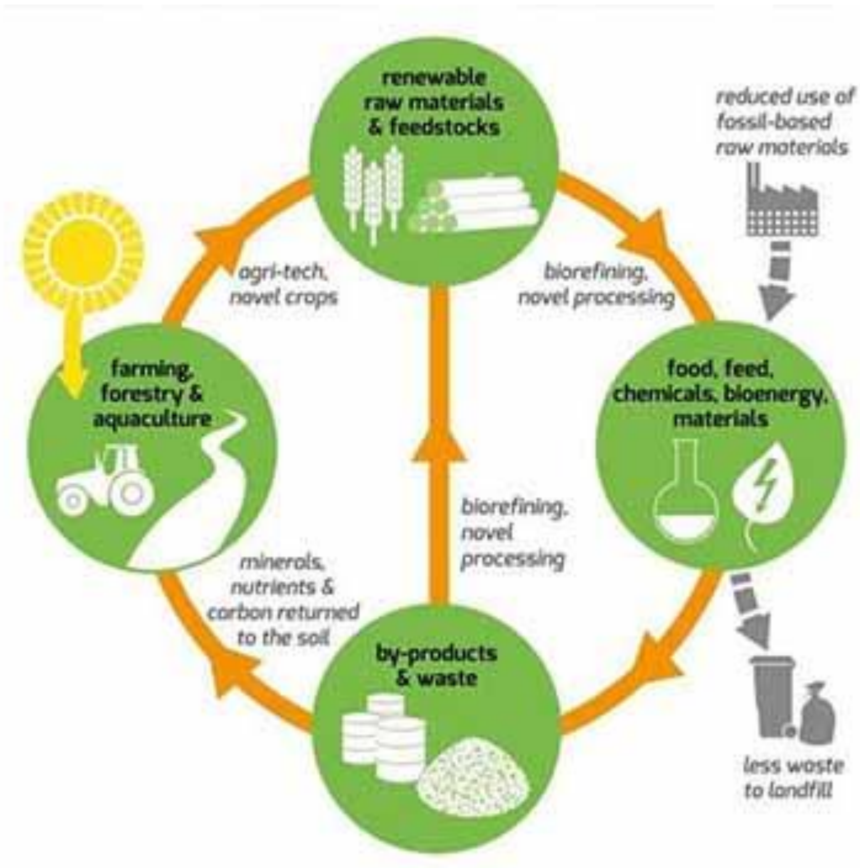


Policy challenges

- Linear and "silo" thinking impedes progress towards circularity
- Contrasting paradigms: wastewater sees nutrients as pollutants; agriculture sees them as a resource
- Circular nutrient economy has not yet taken root
- Pricing of conventional fertilizer makes reuse products less competitive
- Intrinsic value of EUSBSR "Saving the Sea" inadequately communicated to the public
- EUSBSR requires a clear action strategy linked to flagship project recommendations

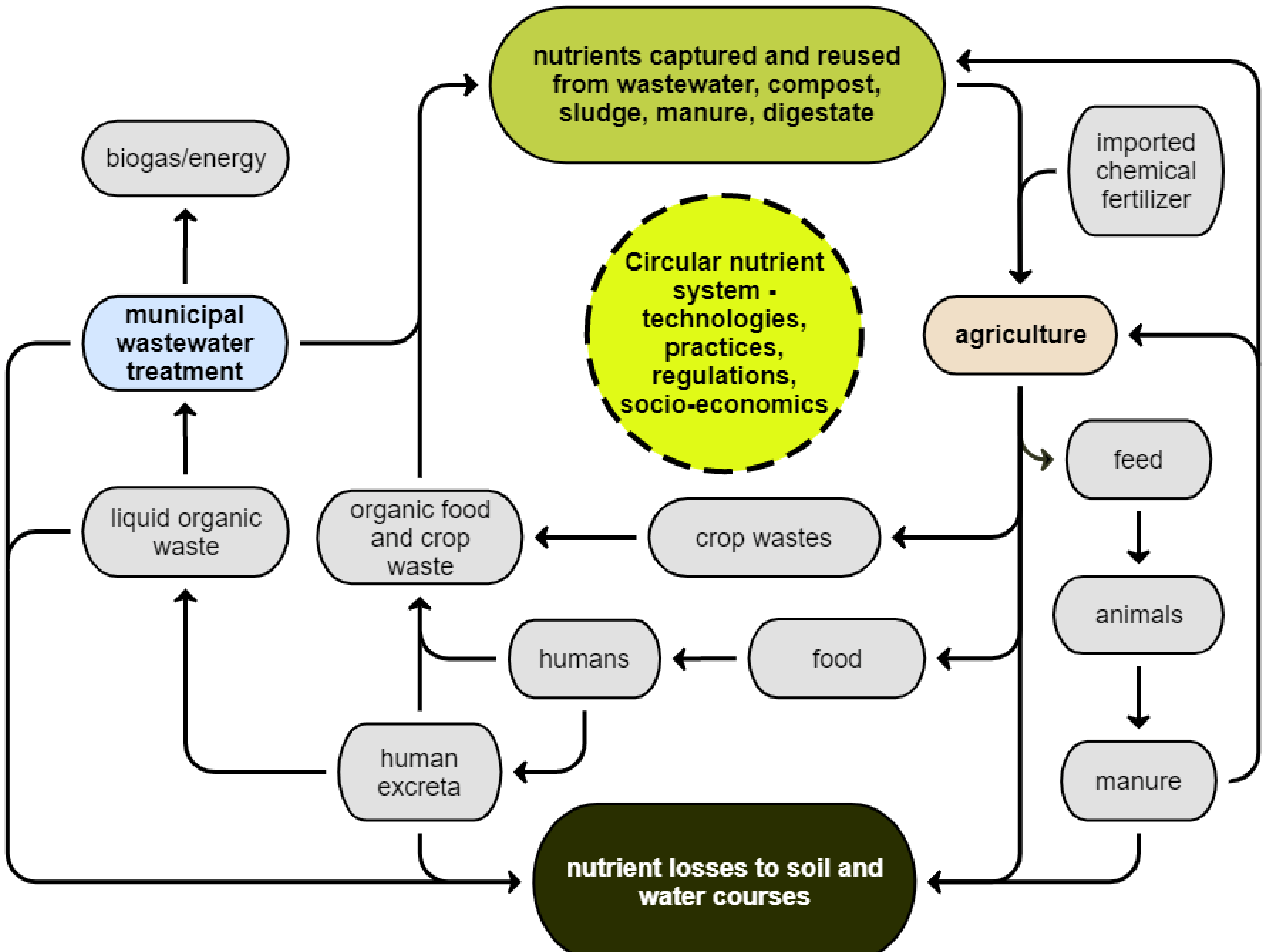
Opportunities/drivers for recycling nutrients

- Technologies & practices exist integrating C, N & P capture/reuse
- New bioeconomy business models integrating energy and nutrient systems
- Retaining sovereign P (P is on EU list of Critical Raw Materials)



Bioeconomygame.com

Agriculture & wastewater components comprising the circular nutrient system



Capture & reuse of wastes

turning them into energy & fertilizer resources

Starting materials

- manure, crop residues, digestates (liquid and solid), wastewater and sludge

Priority factors

- bioavailability as fertilizer
- transportability to markets
- storage without losses of volatile N and C or water-soluble N and P

Technologies at hand

- **anaerobic digestion** of wet matter producing biogas & N & P capture
- **slurry acidification** to retain ammonia
- **aerobic composting** of dewatered matter mineralizes N, P & C increasing bioavailability as fertilizer
- **pyrolysis** of dried matter to retain C as biochar - also retains P
- **incineration** of dried matter to produce ash for P extraction (N & C are lost to the atmosphere)

Agriculture practices to retain nutrients on land

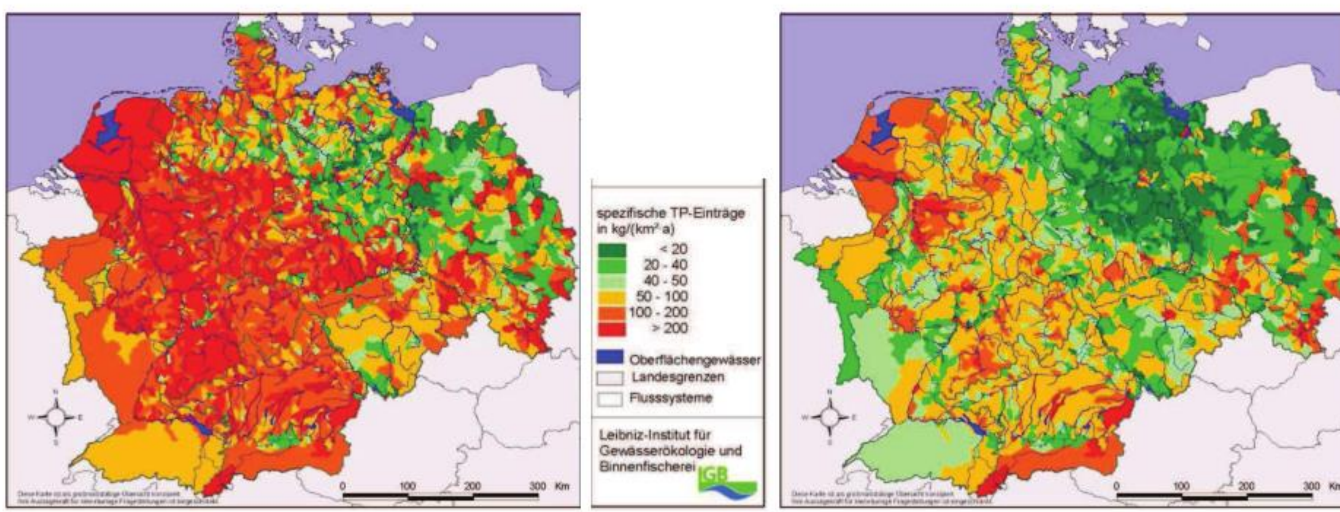
- planting of **buffer zones** to trap runoff
- **constructed wetlands** to absorb N & P in wastewater & runoff
- **sedimentation ponds** to trap suspended soil particles
- **contour ploughing** to reduce runoff
- **cover crops to** trap & fix N preventing losses to the air & water courses
- **planting of crops without manure** additions to reduce residual soil P levels

Phosphorus management in agriculture

- BSR **P-indices** development
  - **P-based manure application**
  - **P-loss risk maps** for BSR croplands & fields
- BSR region-wide **norms for P fertiliser use** for the relevant crops
- BSR region-wide **tool for farmgate P balancing** (feed, fertilizer, manure, soil, crops)
- **regional and national policies and multi-level governance** to manage phosphorus

Spezifische Phosphoreinträge aus den Teilgebieten im Zeitraum, 1983 - 1987

Spezifische Phosphoreinträge aus den Teilgebieten im Zeitraum, 2003 - 2005



Marginal costs to reduce emissions

Marginal costs for N reductions

Calculated marginal costs per kg N reduction to the Baltic Sea from emission reduction measures at sources, Euro/kg N reduction to coastal waters.

	NOx	*Livestock reductions*	*Fertiliser reduction*	*Sewage treatment*	*Private sewers*
Denmark	25 – 42	36 – 65	1 – 154	15 – 35	54 – 60
Finland	27 – 43	30 – 59	1 – 42	15 – 45	54 – 77
Germany	47 – 80	56 – 68	1 – 44	15 – 48	54 – 82
Poland	33 – 56	33 – 44	1 – 11	12 – 48	46 – 81
Sweden	23 – 40	23 – 52	1 – 50	15 – 79	54 – 81
Estonia	24 – 40	23 – 35	1 – 7	12 – 35	46 – 59
Lithuania	27 – 45	6 – 14	1 – 24	12 – 41	46 – 83
Latvia	37 – 37	22 – 43	1 – 17	12 – 49	46 – 70
Russia	28 – 64	22 – 41	1 – 44	12 – 67	46 – 115

Gren et al 2008

Need to follow up on these data and to use this approach to achieve further reductions

Marginal costs for P reduction

Calculated marginal costs for phosphorus reductions to the Baltic Sea from emission reduction at sources, Euro/kg P reduction to coastal waters.

	P free detergents	*Livestock reductions*	*Fertiliser reductions*	*Sewage treatment*	*Private sewers*
Denmark	11 – 46	2530 – 4810	1 – 10920	61 – 135	255 – 260
Finland	15 – 52	1020 – 1730	1 – 1190	61 – 180	255 – 345
Germany	27 – 134	4300 – 6000	1 – 9950	61 – 330	255 – 637
Poland	18 – 29	497 – 590	1 – 550	41 – 140	215 – 345
Sweden	11 – 100	1190 – 4540	1 – 4140	61 – 250	255 – 480
Estonia	17 – 30	775 – 920	1 – 280	41 – 138	215 – 335
Lithuania	14 – 20	120 - 260	1 – 160	41 – 126	215 – 306
Latvia	18 – 36	640 – 650	1 – 293	41 – 147	215 – 360
Russia	13 – 45	960 – 2080	1 – 2021	41 – 220	215 - 535

Gren et al 2008

Conventional vs reuse fertilizers

- Conventional fertilizers - relatively cheap & not used efficiently
- Their costs don't account for externalities
- They are priced based on commodities eg P-rock, methane (for ammonia production), potash, sulfuric acid, etc.
- Reuse products account more for externalities and c annot compete with conventional fertilizers

Economic tools to promote nutrient capture and reuse

A technology's economic feasibility

- determined by cost, market demand, price for recovered & competing products, transportability & levels of energy consumption

Economic tools

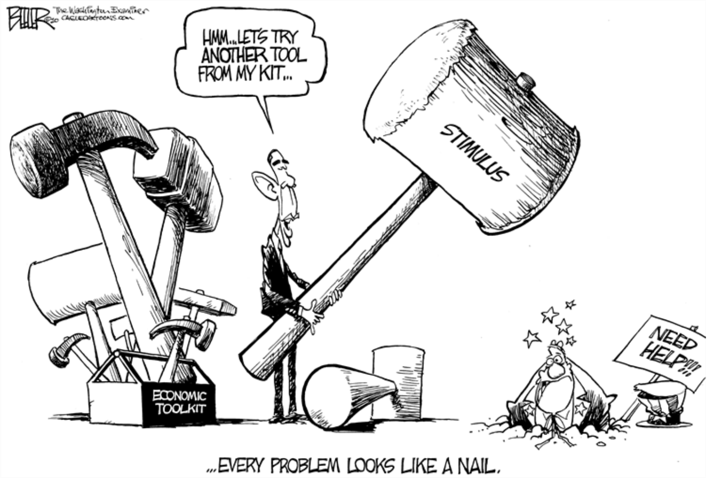
- Include quotas (tradable & non-tradable), fixed & volume-based fees or taxes & subsidies (the new CAP?)

It's an ethical, political, public/private choice

- local circumstances and priorities

Combining different measures & tools

- To provide more sustainable solutions for all parties



Opportunities but with challenges

- EU Circular Economy package
- EU Farm to Fork Strategy
- European Green Deal
- EU Integrated Nutrient Management Action Plan
- New EU Fertilising Products Regulation (STRUBIAS and cadmium regs)
- Nitrates Directive / recycled nutrient products from manure (SAFEMANURE)
- Common Agricultural Policy – environmental measures
- Best available techniques (BAT) BREFs (Industrial Emissions Directive)
- Best environmental management practices (BEMPs)

SEI

Stockholm
Environment
Institute