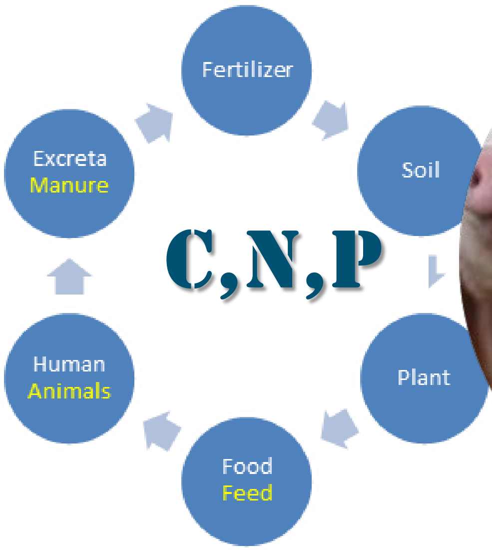
Assessment of global nutrient use
&
estimation of nutrients in manure

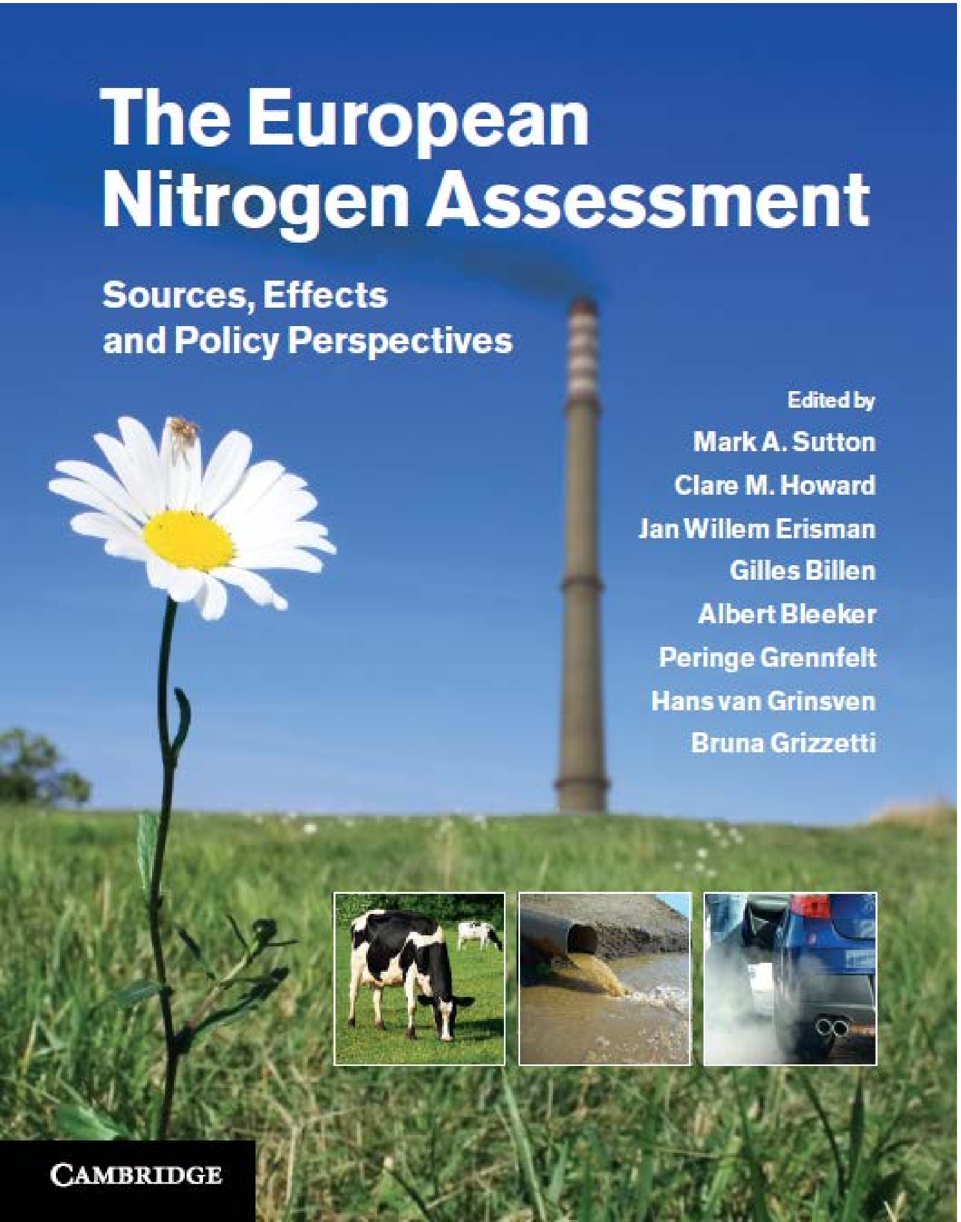
Oene Oenema & colleagues
Wageningen University



WAGENINGEN UR
For quality of life

EAAP Meeting,
Nantes, France, 26-30 August 2013

Nitrogen is in the news



COMMENT

ENVIRONMENT Worse than Deepwater would be an Arctic oil spill p.162

BIOTECHNOLOGY Biohackers take biology into the garage p.167

ECOLOGY Libyan revolution might protect bluefin tuna, with trawlers grounded p.169

OBITUARY Simon van der Meer, who enabled the discovery of W and Z particles p.170

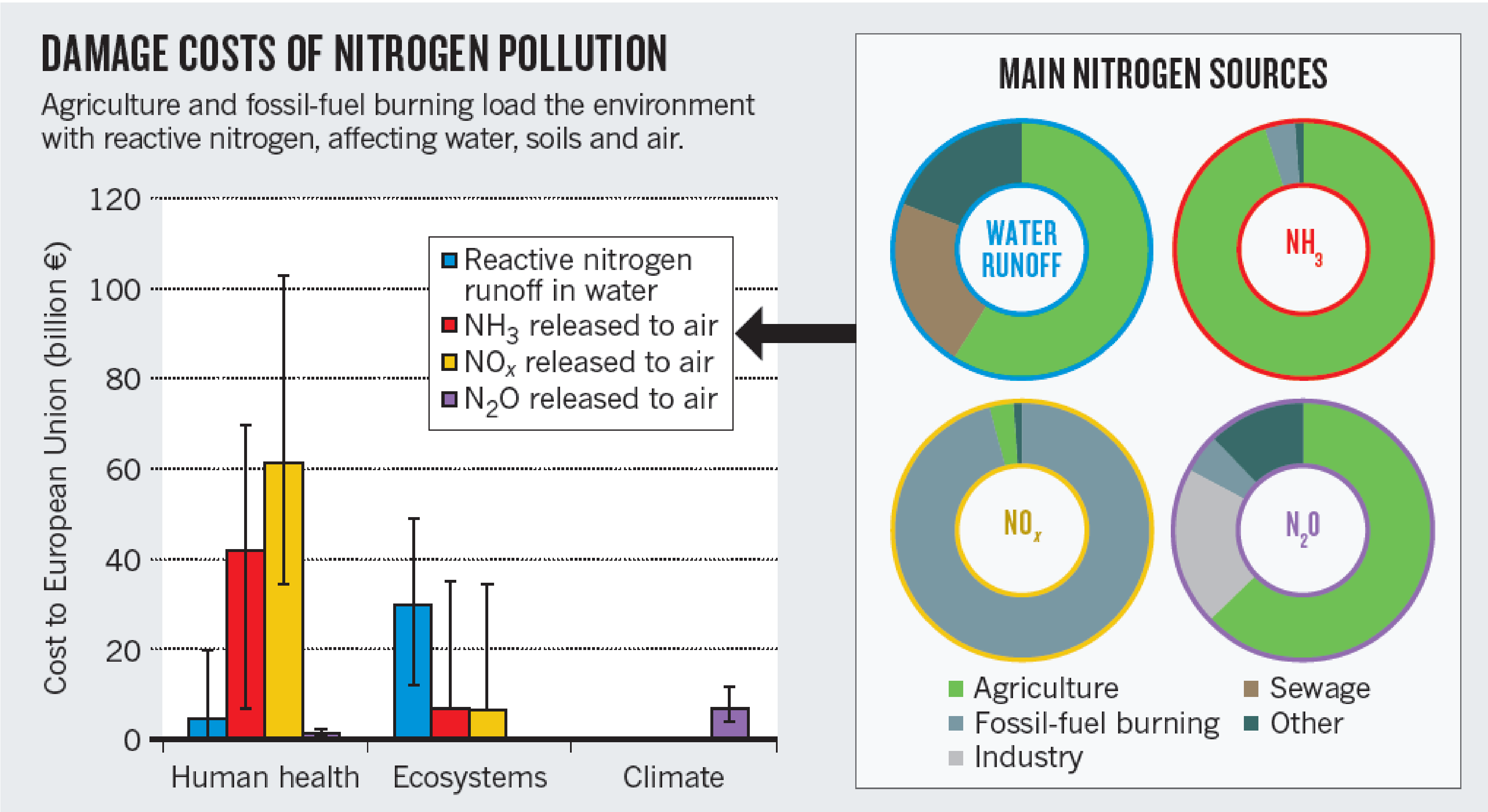
Applying liquid manure more precisely than this would be cleaner, reduce odour and emit less ammonia.

Too much of a good thing

Curbing nitrogen emissions is a central environmental challenge for the twenty-first century, argue **Mark Sutton** and his colleagues.

ENA Authorship: 200 experts,
21 countries & 89 organizations
Scientifically independent process

Nitrogen Damage Costs & Sources



EU Damage cost: 70 - 320 billion € / year

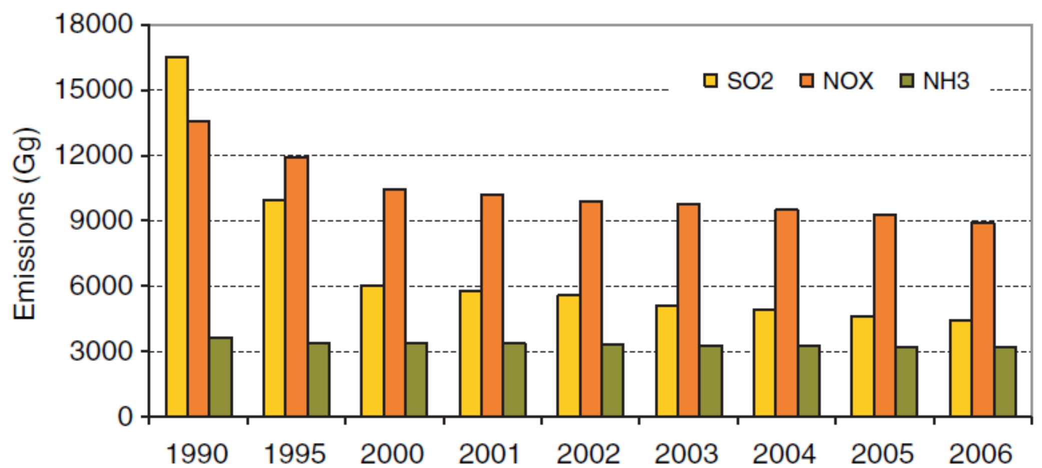
Nature 14 April 2011

Effectiveness EU environmental policies

Decreases in emissions since 1990:

SO_2 to air	~80 %
NO_x to air	~40 %
NH_3 to air	~10 %
N_2O to air	~10 %
N and P to surface water*)	~40 %

*) reductions mainly from industry and households



WAGENINGEN UR
For quality of life

UN says fertiliser crisis is damaging the planet

Scientists urge rich world to halve its meat consumption

The shape of nitrogen to come

An analysis reveals the huge impact of human activity on the nitrogen cycle in China. With global use of Earth's resources rising per head, the findings call for a re-evaluation of the consumption patterns of developed societies.

MARK A. SUTTON & ALBERT BLEEKER

Although Earth's atmosphere consists of nearly 80% dinitrogen ...

NO_x to the formation of ground-level ozone, which causes crop losses; increased emissions of nitrous oxide (N_2O), a greenhouse gas; and ...

Nature doi:10.1038/nature11954

More environment-friendly nutrient use could save $170bn a year

18 Feb 2013: *Independent , Guardian, Herald Tribune, Times of India* and **300 articles worldwide**

Our Nutrient World

The challenge to produce more food and energy with less pollution

Sutton et al. 2013

Prepared by the Global Partnership on Nutrient Management in collaboration with the International Nitrogen Initiative

Background

Plants need 14 nutrient elements (in addition to C, H, O):

N, P, K, Mg, Ca, S, Fe, Mn, Zn, Cu, B, Mo, Cl (Ni)

Animals and humans need 22 nutrient elements:

N, P, K, Mg, Ca, S, Fe, Mn, Zn, Cu, Mo, Cl, Co, Na, Se, I, Cr, Ni, V, Sn, As, F

Uneven distribution of nutrients on the globe:

1. Shortages lead to poor growth & development
2. Surpluses lead to pollution & ecosystem degradation
3. Easy accessible reserves are depleted

WAGENINGEN UR
For quality of life

Assessment of micro nutrient use & resources

Element	R/P [1])	Econ. [2])	Supply Risk [3])	Use in Agric. (%)	Recycling (%)
B	49	5.0	0.6	12	0
Co	77	7.2	1.1	< 1	24
Cu	43	5.7	0.2	< 1	32
Mo	40	8.9	0.5	< 1	30
Se	47	?	?	10	0
Zn	20	9.4	0.4	< 1	27

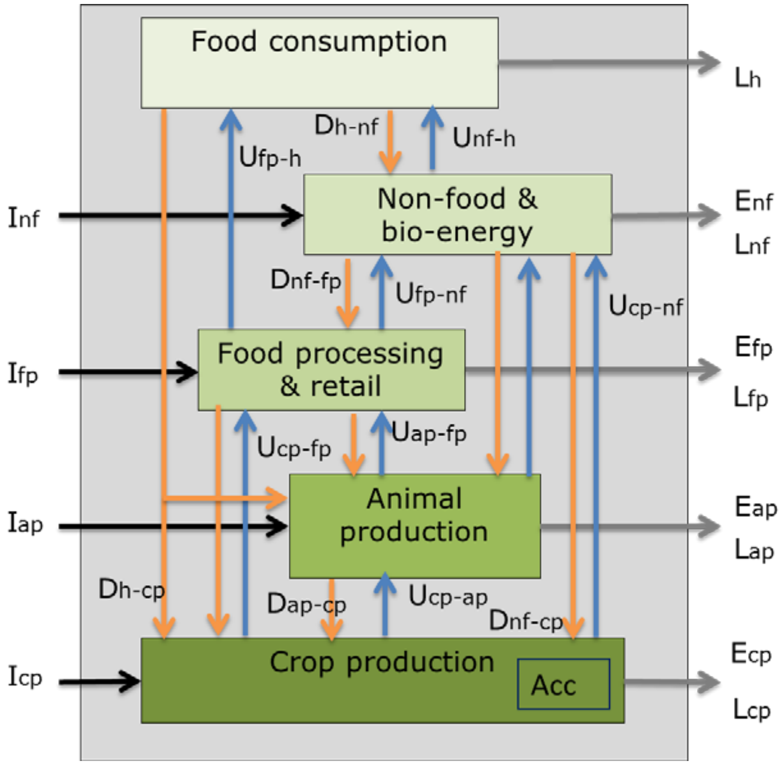
1) R/P = Reserves (known) / Production (annual)
2) Economic importance, with 10 most important
3) Supply risk is high if value >1 and low when value is <1

WAGENINGEN UR
For quality of life

Chardon & Oenema, 2013

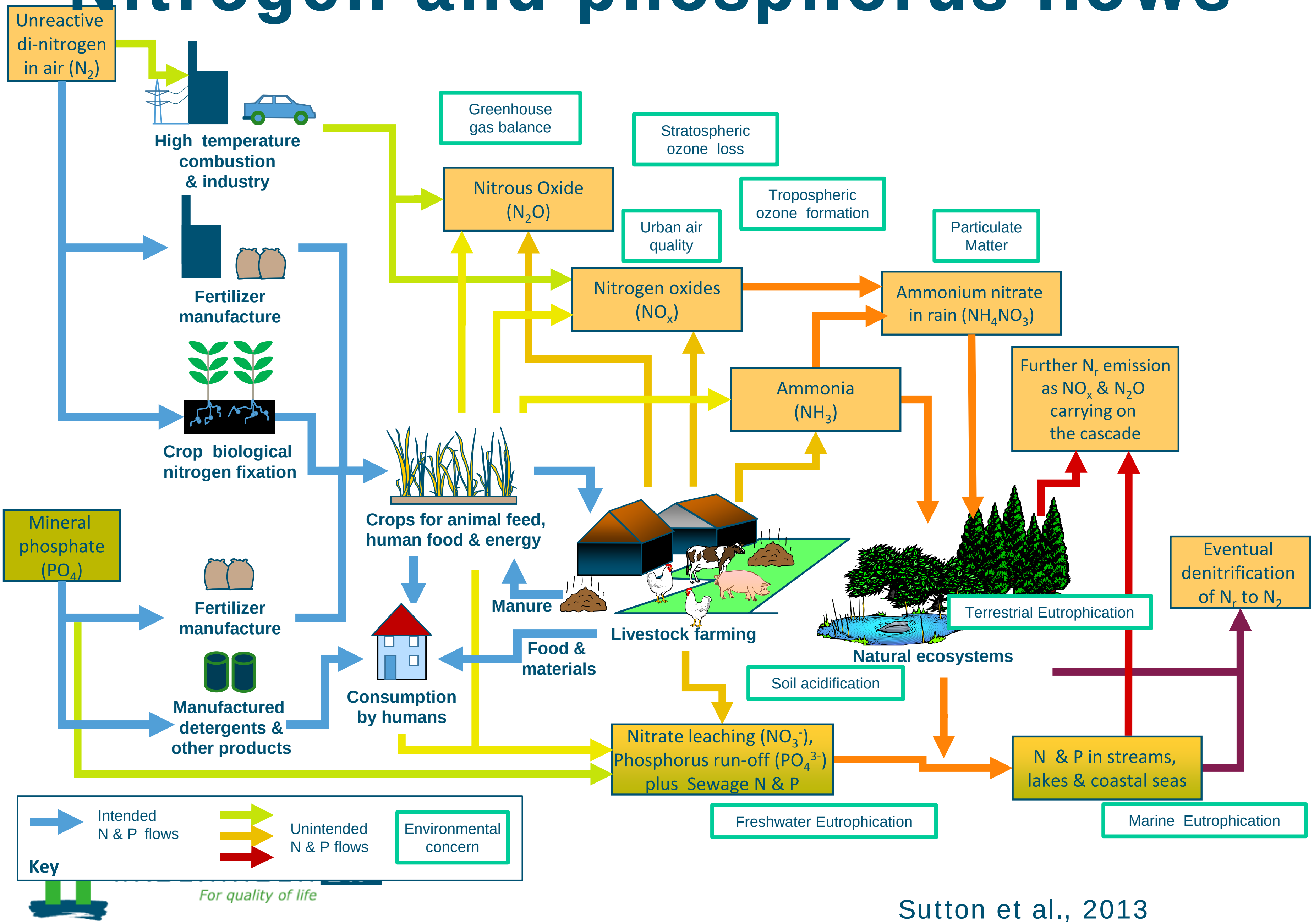
‘Food has high nutrient cost’

In total, 4 to 12 kg of “new” nitrogen and 4 to 12 kg of “new” phosphorus are needed to get 1 kg of nitrogen and 1 kg of phosphorus in food of consumers.



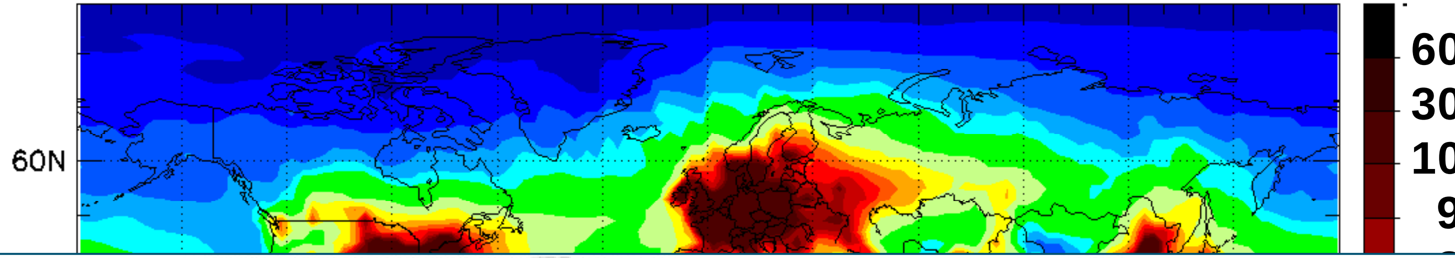
Ma et al., 2010, 2012, 2013
Van Dijk et al., 2013

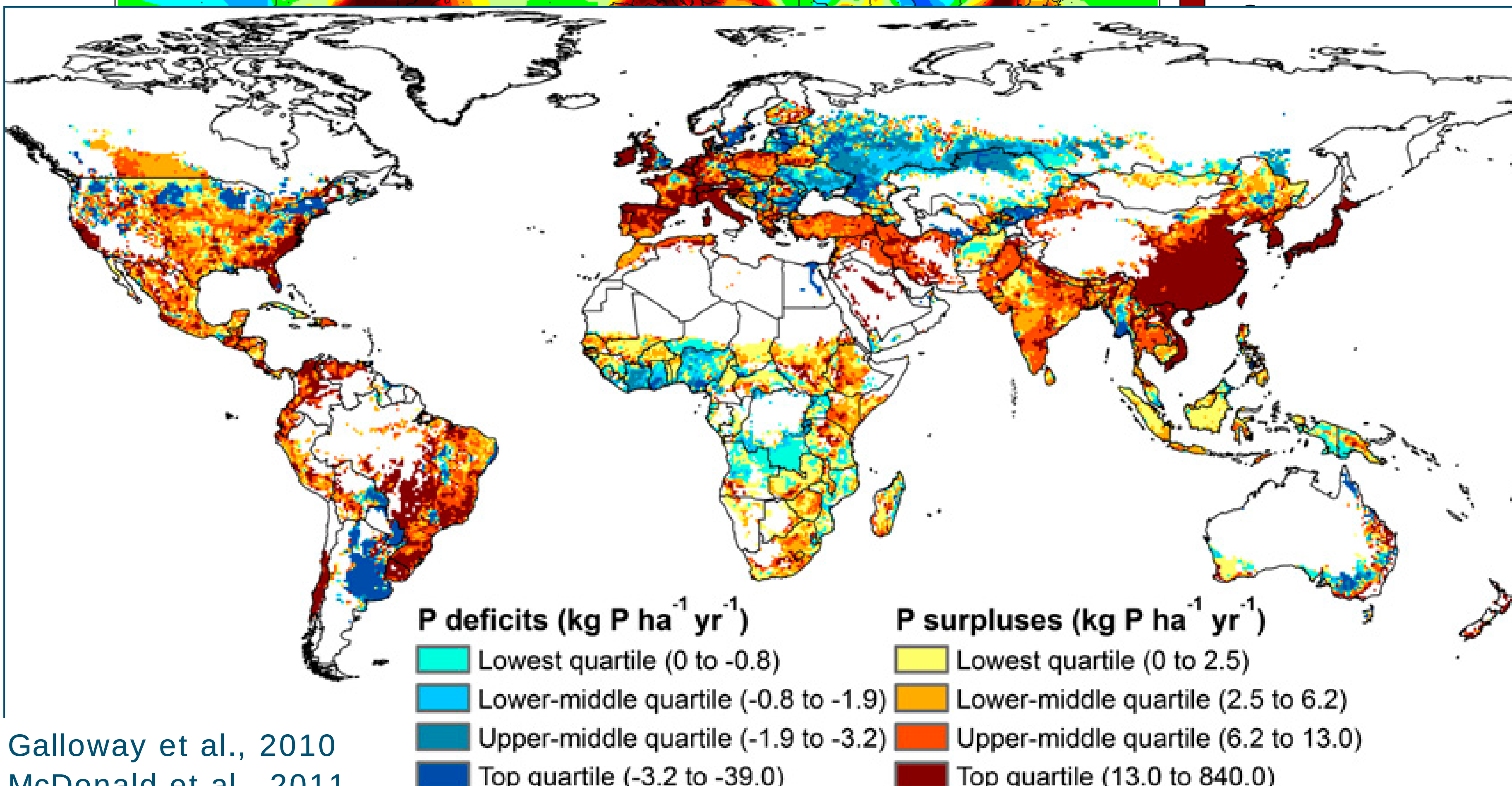
Nitrogen and phosphorus flows



Sutton et al., 2013

Nutrient pollution is a global problem

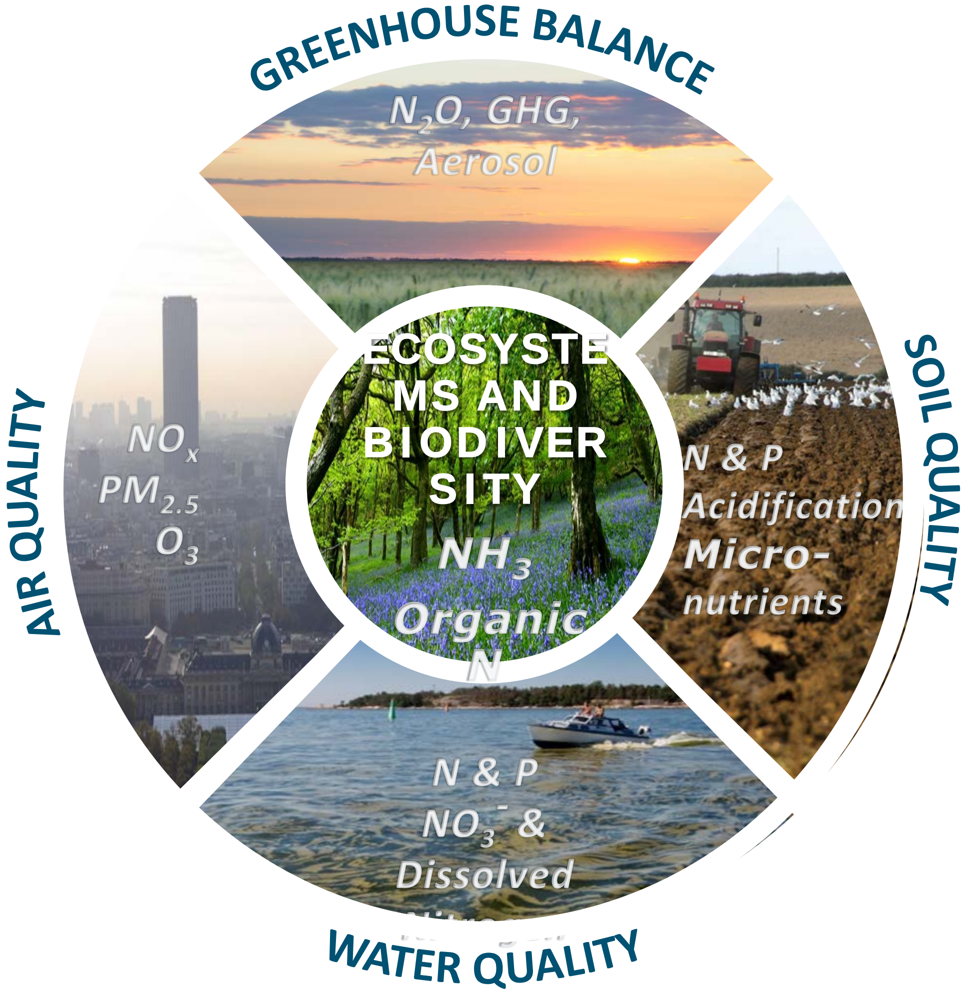




Galloway et al., 2010
McDonald et al., 2011

The five key threats of excess nutrients

Water quality
Air quality
Greenhouse balance
Ecosystems
Soil quality



Sutton et al., 2013

Challenges

Producing more safe nutritional food with less pollution

- Increasing nutrient use efficiency

WAGENINGEN UR
For quality of life

Global Partnership on Nutrient Management
GPNM

Ten key actions nutrient management

Agriculture

1. Improving nutrient use efficiency in crop production
2. Improving nutrient use efficiency in animal production
3. Increasing the utilization of nutrients in animal manure

Transport and Industry

4. Low-emission combustion and energy-efficient systems
5. NO_x capture and utilization technology

Waste & Recycling

6. Improving food supply efficiency & reducing food waste
7. Recycling nutrients from waste water systems

Societal consumption patterns

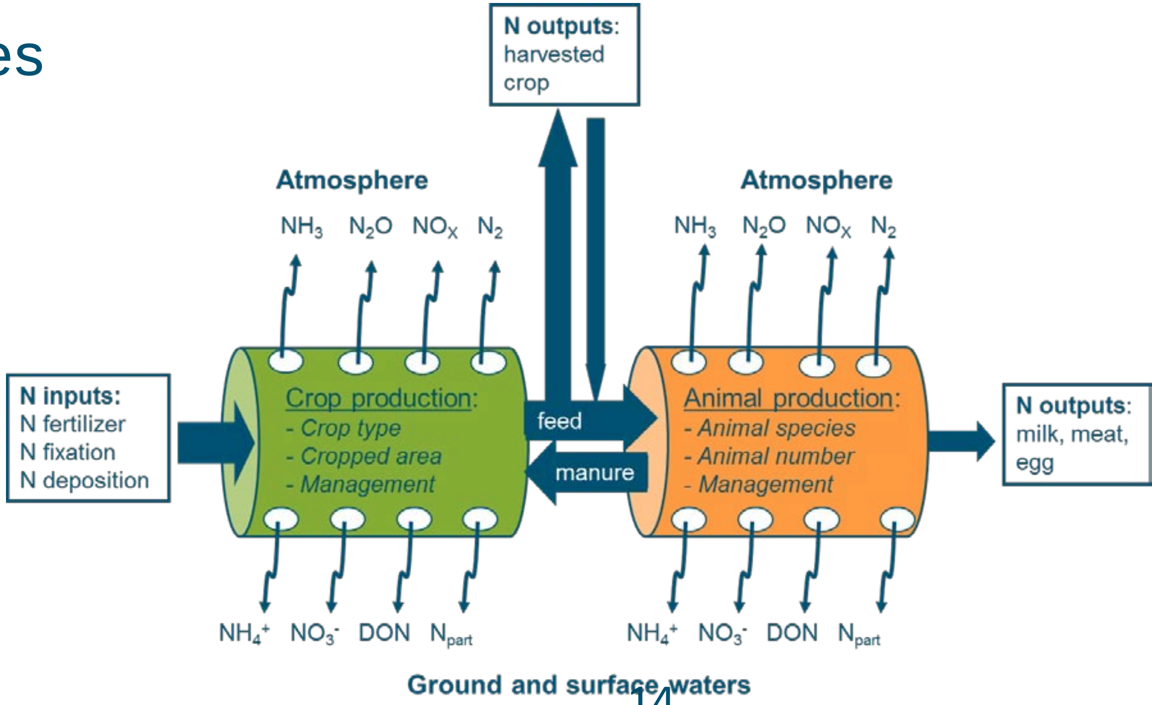
8. Energy and transport saving
9. Lowering the human consumption of excess animal protein

Integration

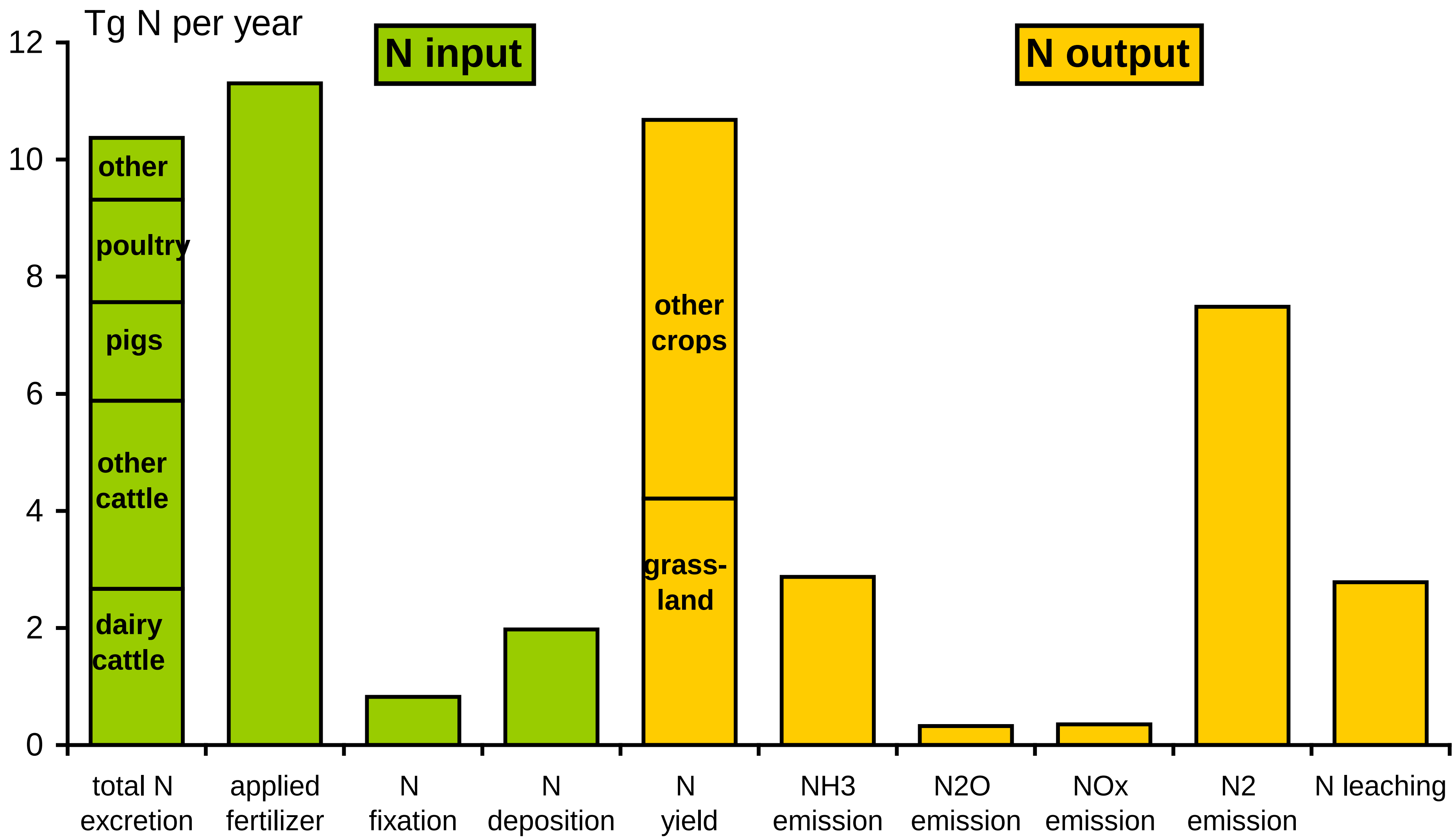
10. Spatial optimization and integration

Nitrogen and phosphorus in manure

- Large nutrient source
- Poorly quantified
- Poorly utilized, but with exceptions
- Relatively large losses

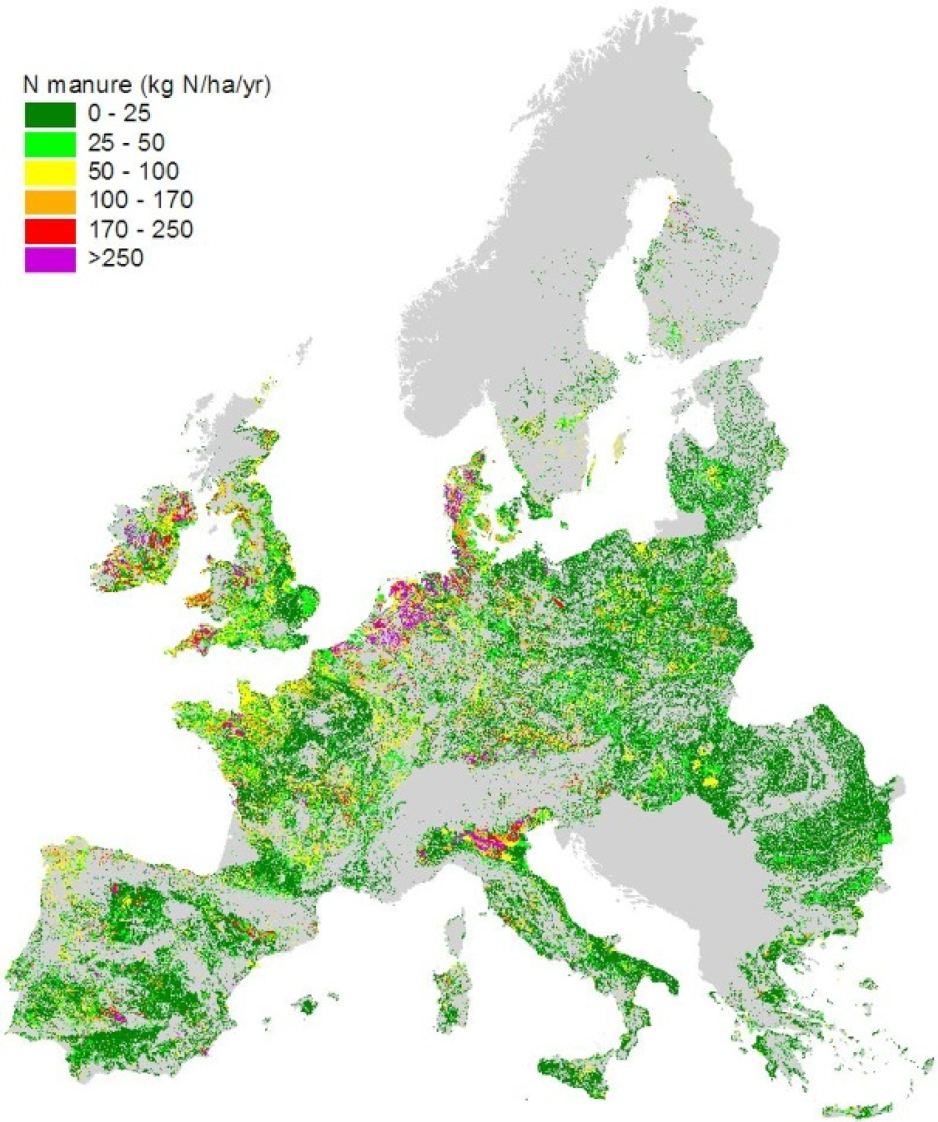


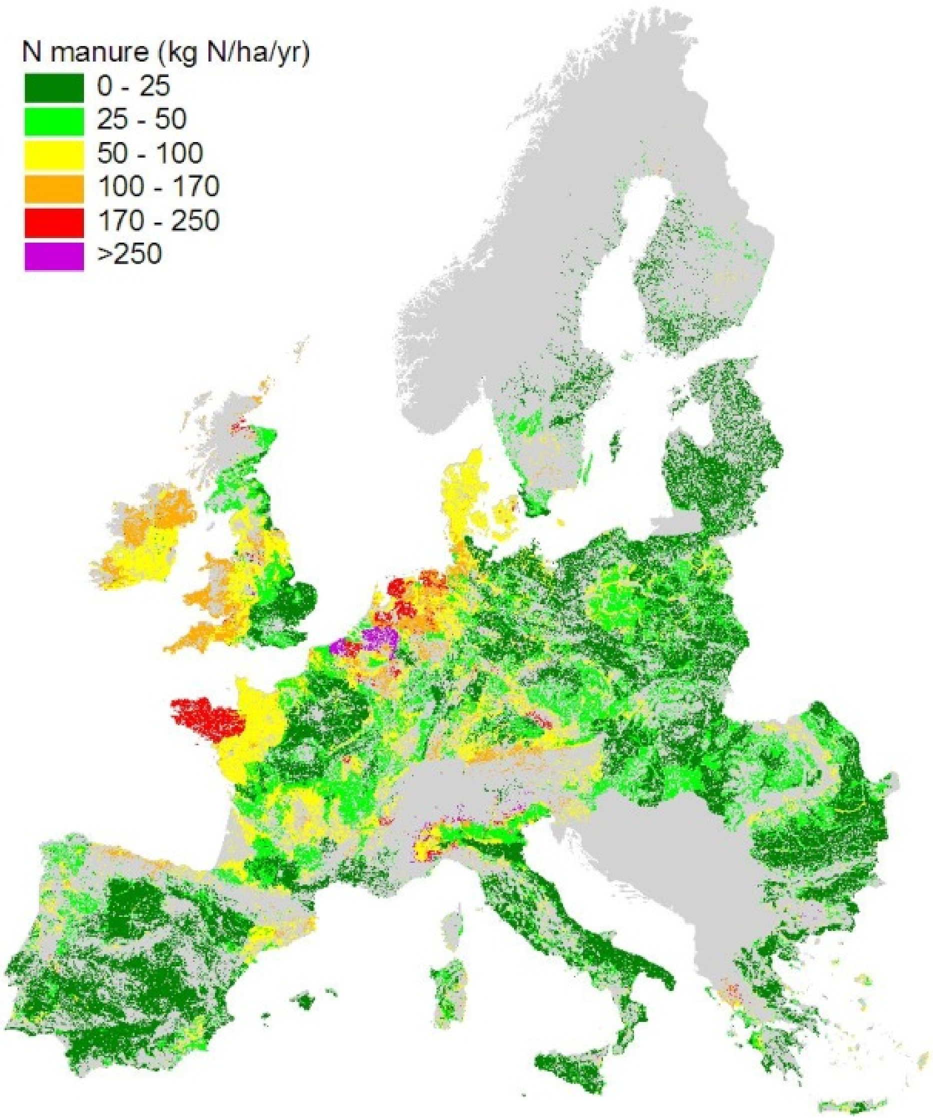
Nitrogen balance in Ag. in EU-27 2000-2008



Velthof et al., 2013

Two models, two outcomes





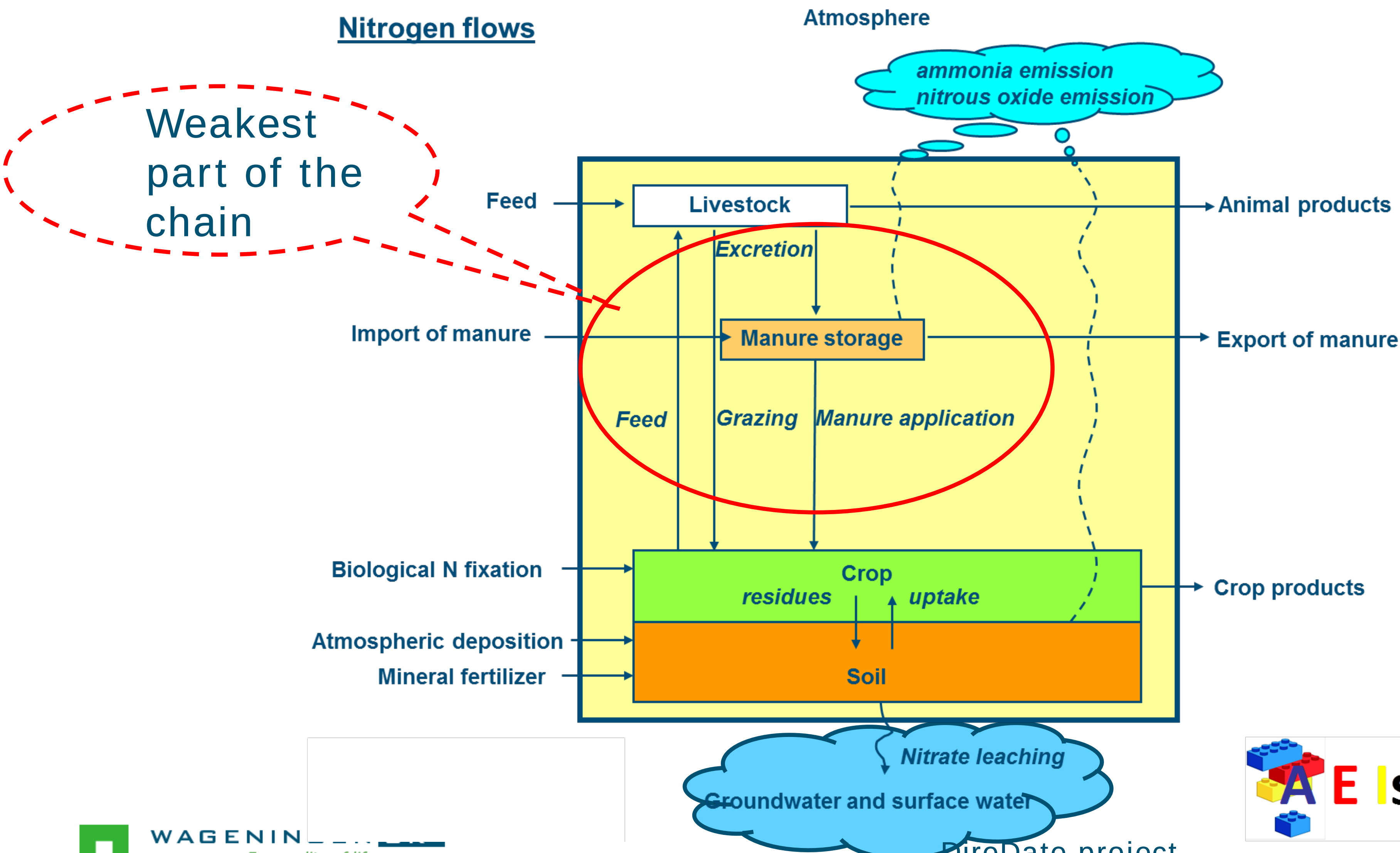
De Vries et al., 2011

Importance of monitoring

- EUROSTAT collects statistical data in EU-27 (e.g., FSS, SAPM) for estimating 28 agri-environmental indicators, for policy reporting.
- Monitoring and reporting is costly
- N and P excretion data are needed for 11 AEIs
- Member States often use different methods and approaches

WAGENINGEN UR
For quality of life

Streamlining data collection & processing



WAGENINGEN UR
For quality of life

DireDate project
Velthof 2011; Oenema et al., 2011

(Policy) Reports on animal excretion

- OECD/Eurostat reports on N and P Balances;
- Action Programmes under the Nitrates Directive;
- Inventories of GHG emissions under the UNFCCC;
- Inventories of NH3 emissions under the UNECE-CLRTAP;
- FAO Life Cycle Analysis (LCA) of livestock production;
- Model GAINS;
- Model CAPRI and EU project GGELS;
- Scientific literature

N excretion in UNFCCC Inventory Reports 2011

- Clear & complete reports
- Large variation (factor 2 – 3) between countries

Country	Dairy cows	Other cattle	Young cattle	Pigs (average)	Poultry	Horses	Sheep	Goat	Fur animals and rabbits
Austria	97.11	46.57	*	9.57	0.55	47.90	13.10	12.30	
Belgium	115.07	54.26	*	10.06	0.58	58.42	7.52	8.44	
Bulgaria	70.00	50.00	50.00	20.00	0.60	25.00	14.68	17.00	
Cyprus	*	*	*	*	*	*	*	*	
Czech Republic	144.83	70.00	*	20.00	0.60	25.00	20.00	25.00	
Denmark	138.12	47.82	*	8.40	0.53	39.56	15.32	16.37	
Estonia	102.10	44.38	16.71	12.88	0.60	25.00	16.00	25.00	
Finland	126.94	50.16	*	*	0.58	61.19	9.97	10.70	
France	100.00	57.51	*	16.46	0.60	25.00	18.34	25.00	
Germany	131.52	40.85	*	12.14	0.78	49.01	7.43	11.00	
Greece	100.00	45.36	*	16.00	0.60	40.00	10.68	12.00	
Hungary	114.14	48.27	*	8.07	0.60	60.00	20.00	18.00	
Ireland	85.00	48.87	*	8.53	0.31	44.00	6.31	9.00	
Italy	116.00	48.72	*	11.78	0.53	50.00	16.20	16.20	
Latvia	70.00	50.00	*	10.00	0.60	48.00	13.00	13.00	
Lithuania	99.25	57.58	*	12.31	0.60	25.00	16.00	16.00	
Luxembourg	102.00	68.00	39.98	11.87	0.74	62.86	17.00	17.00	
Malta	*	*	*	*	*	*	*	*	
Netherlands	127.00	82.80	39.68	8.87	0.65	49.23	6.70	9.94	
Poland	86.70	58.09	*	13.56	0.35	28.03	6.78	6.70	
Portugal	115.00	51.15	*	9.49	0.56	44.00	7.14	6.02	
Romania	70.00	50.00	*	20.00	0.60	25.00	16.00	25.00	
Slovakia	100.00	60.00	*	15.82	0.73	25.00	16.00	16.00	
Slovenia	110.57	42.29	*	11.92	0.60	25.00	20.00	25.00	
Spain	67.72	52.57	*	9.42	0.45	40.00	5.18	11.28	
Sweden	126.37	41.74	*	9.14	0.40	50.00	6.11	8.75	
United Kingdom	110.01	55.32	*	10.60	0.57	50.00	5.23	20.60	
Belarus	77.09	36.42	*	9.99	0.60	25.00	16.00	25.00	4.59
Croatia	70.00	50.00	50.00	20.00	0.60	25.00	16.00	25.00	
Norway	82.00	35.00	26.47	6.41	0.21	50.00	10.41	15.50	5.84
Russia	94.49	59.06	*	21.91	0.77	25.00	16.00	25.00	4.59 -12.09
Switzerland	110.23	80.00	33.45	9.18	0.54	43.70	8.47	10.21	
Turkey	82.58	45.09	*	6.80	*	*	13.50	16.49	
Ukraine	74.52	68.40	29.75	12.65	*	25.00	16.00	25.00	8.34

Velthof, 2013

WAGENINGEN UR
For quality of life

Methodologies used for Nitrates Directive

- Use of different methodologies
- Gross N excretion vs net N excretion
- Reports not always clear

Velthof, 2013

Country	Principle Methodology
Austria	Country specific net excretion
Belgium	As UNFCCC for Flanders: net excretion Gross excretion for Walloon
Bulgaria	N content and volume of manure***
Cyprus	N content and volume of manure
Czech Rep	N content and volume of manure
Denmark	N balance as UNFCCC; corrected for gaseous N loss
Estonia	N content and volume of manure
Finland	N balance.
France	N balance; corrected for gaseous N loss
Germany	Country specific gross excretion. Method not indicated
Greece	N content and volume of manure
Hungary	Country specific net excretion, based on literature
Ireland	N balance (as Nitrates Directive)
Italy	N balance
Latvia	N content and volume of manure
Lithuania	Net excretion based on N balance and gaseous N loss
Luxembourg	Not indicated
Malta	Not indicated
Netherlands	Same as UNFCCC, but other year. With correction for N losses
Poland	N content and volume of manure
Portugal	N content and volume of manure
Romania	Based on UNFCCC figures
Slovakia	N content and volume of manure
Slovenia	Country specific net excretion. Method not indicated
Spain	Country specific gross excretions. Method not indicated
Sweden	STANK model. Methodology not clear
UK	N balance.

WAGENINGEN UR
For quality of life

Comparison reported N excretion by cattle

- Differences between reports
- Background of differences not yet clear; some related to year effects
- Few gross N excretion data for Nitrates Directive

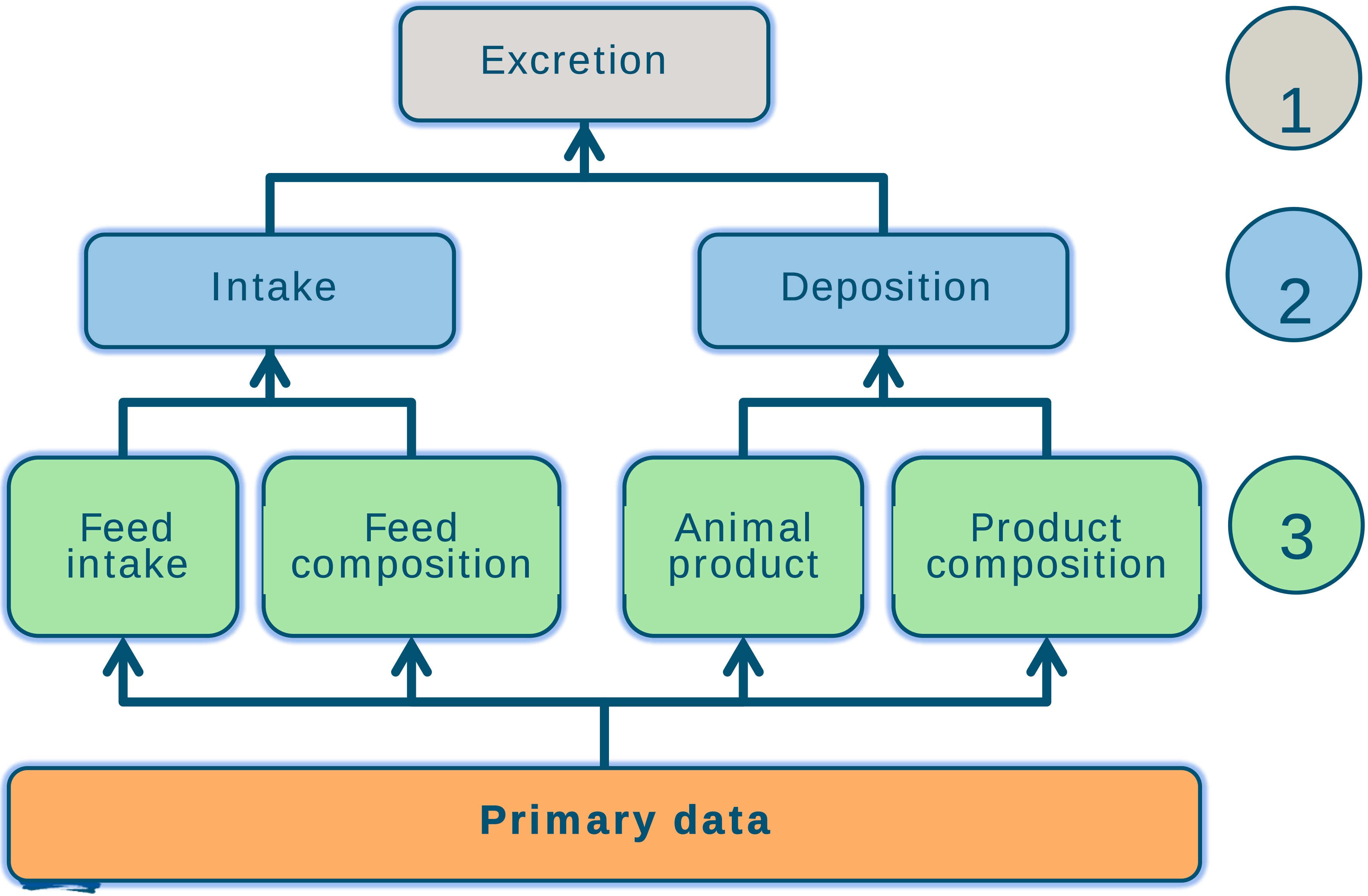
Comparison N excretion different sources: dairy cattle

Country	GAINS 2010	NIR 2011	CAPRI	Gothenborg	Nitrates Directive	Eurostat/OECD
	Dairy cows	Dairy cows	Dairy cows	Dairy cows	Dairy cows	Dairy cows
Austria	106.0	97.1	90.0	97.0		97.4
Belgium	117.7	115.1	95.0			109.0
Walloon				120.5		111.4
Flanders				97.0	97.0	105.9
Bulgaria	75.3	70.0	116.0			
Cyprus	103.1	*	134.0			106.7
Czech Republic	131.1	144.8	114.0			105.3
Denmark	131.8	138.1	194.0	138.0		129.4
Estonia	113.0	102.1	122.0			62.1
Finland	120.6	126.9	92.0	121.9		
France	112.1	100.0	105.0			124.7
Germany	130.1	131.5	106.0	113.7	100 - 149	
Greece	111.1	100.0	97.0			
Hungary	146.5	114.1	149.0			125.0
Ireland	104.8	85.0	88.0		85.0	108.9
Italy	111.7	116.0	97.0	116.0		94.0
Latvia	87.9	70.0	139.0			70.0
Lithuania	95.0	99.2	99.0		120.0	
Luxembourg	114.3	102.0				71.0
Malta	98.0	*	155.0			102.7
Netherlands	146.8	127.0	119.0	130.2	99 - 131	134.5
Poland	80.8	86.7	91.0			70.0
Portugal	101.9	115.0	121.0	111.7		111.7
Romania	67.5	70.0	96.0			
Slovakia	134.6	100.0	119.0			105.0
Slovenia	110.1	110.6	85.0			113.0
Spain	70.8	67.7	108.0	67.7	89.0	103.3
Sweden	132.2	126.4	180.0	125.0	117 - 139	117.0
United Kingdom	133.3	110.0	142.0			117.0
Belarus	55.0	77.1				
Croatia	55.0	70.0				
Norway	82.0	82.0		82.0		84.8
Russia	55.0	94.5				
Switzerland	107.0	110.2		115.0		115.3
Turkey	66.5	82.6				
Ukraine	55.0	74.5				

WAGENINGEN UR
For quality of life

Velthof, 2013

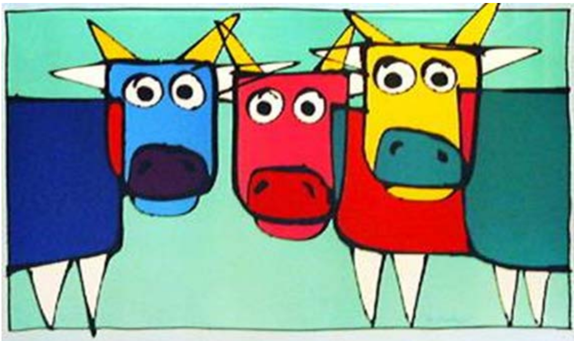
Towards a common methodology; 3 ‘tiers’



Conclusions

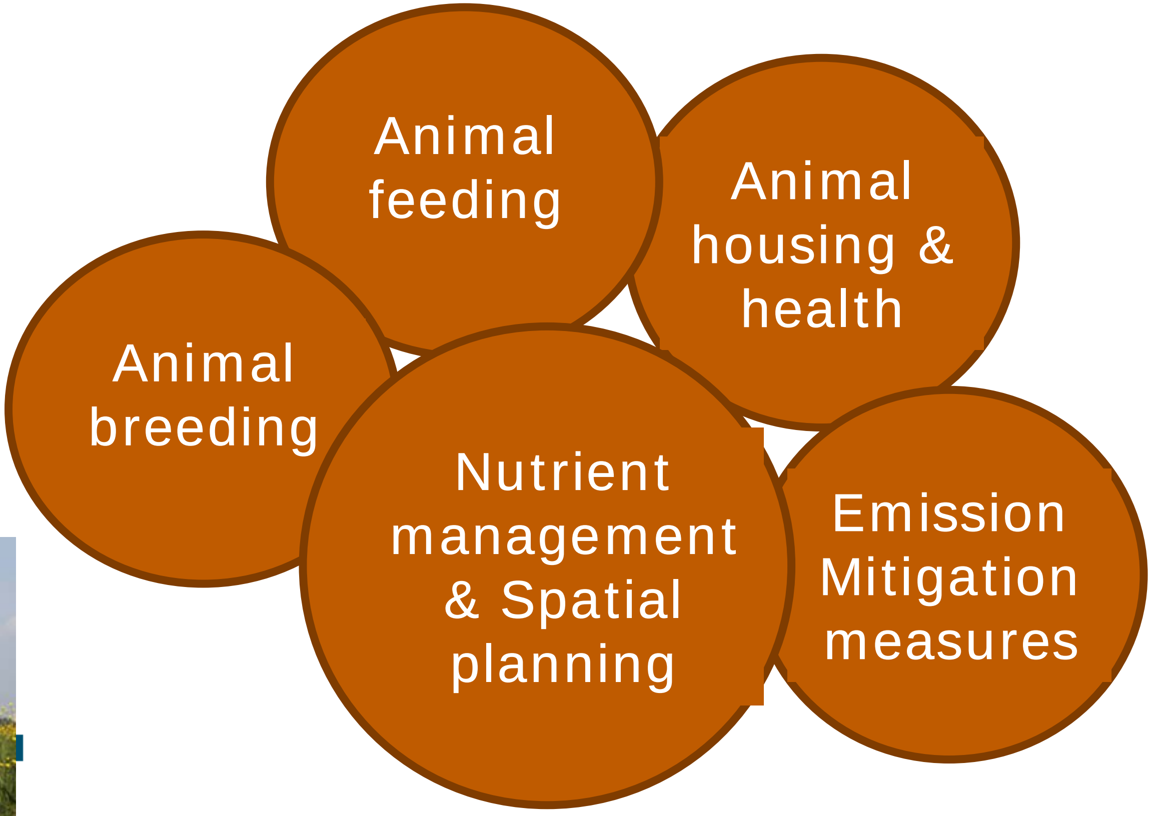
- Nutrients are in the news
- Impacts of N and P losses are large;
- Resource depletion demands for recycling
- 10 key action proposed
- A common methodology needed for estimating N and P excretion in urine and faeces

- Interested in this methodology?
  - Email: oene.oenema@wur.nl

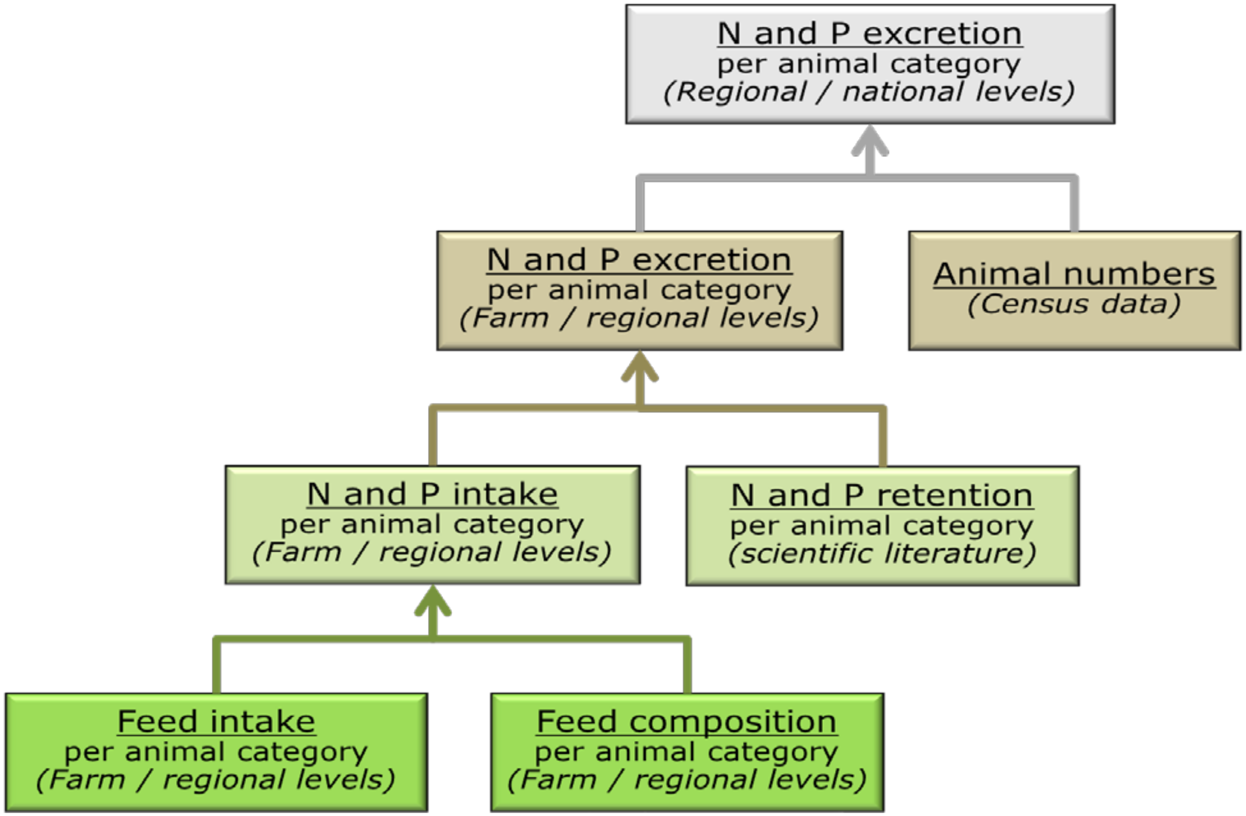


Nutrient use efficiency in animal production

Through an integrated “***5 action strategy***”, nutrient use efficiency can be increased by 10 to more than 100%.



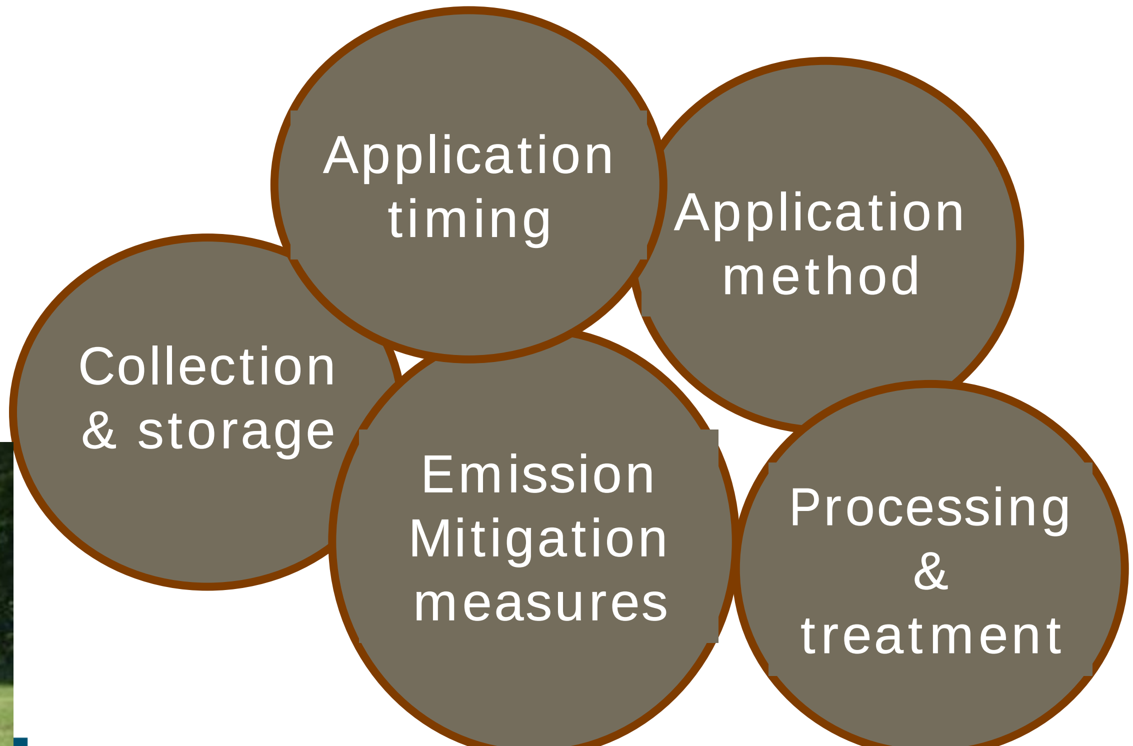
Ideal flow of data and information



WAGENINGEN UR
For quality of life

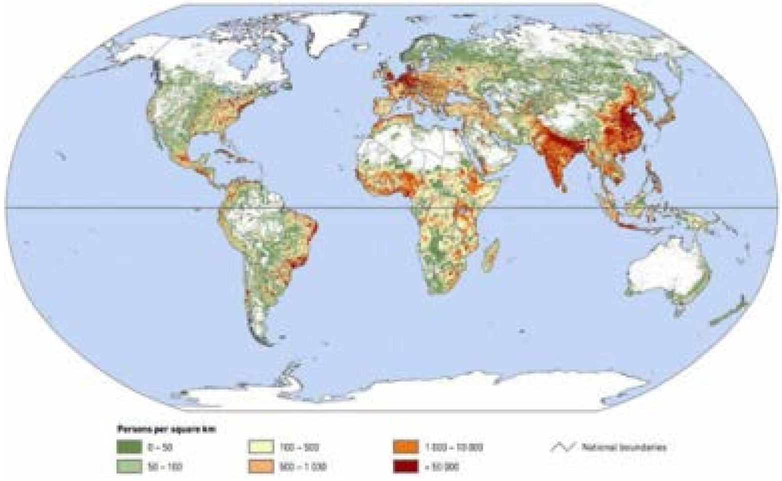
Increasing the value of manure and wastes

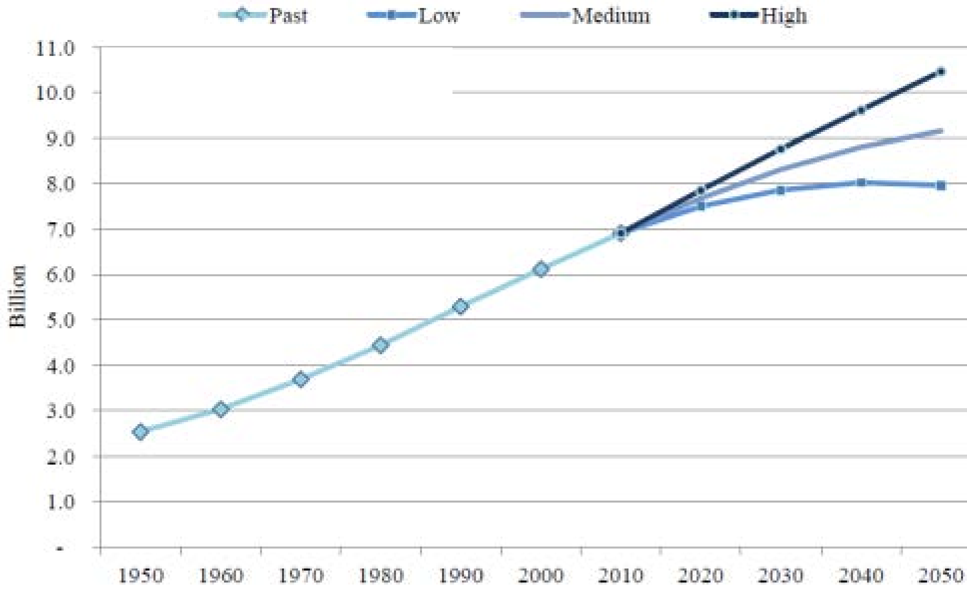
Through a "***5 action strategy***", ammonia emissions can be decreased by >50% and the nitrogen fertiliser value can be increased to >60%



Rapid changes occur in food production

- Increasing population; more food needed
- Urbanisation & wealth: more animal-derived food
- Globalisation: agglomeration & transport
- Technological developments: changing systems
- Governmental policies (agriculture, industry, environ.)





Mean N contents of pig diets (g/kg)

Category	IRL	Italy	Germany	NL	UK
Starter diet piglets	35.2	29.1	29.6	27.0	35.2
Grower diet piglets	32.0		28.0	27.9	32.0
Starter diet finishing pigs	32.0		28.8 – 29.6	27.1	32.0
Grower diet finishing pigs	29.6	24.5	26.4 – 28.0	26.2	29.6
Finisher diet	27.2		22.4 – 23.2	23.6	27.2
Rearing sow diet	25.6	?	23.2 – 28.0	24.5	25.6
Standard sow diet	?		27.2	23.8	?
Lactating sow diet	27.2	24.0	28.0	24.5	27.2
Gestating sow diet	20.0		23.2	20.4	20.0

Sebek et al, 2012

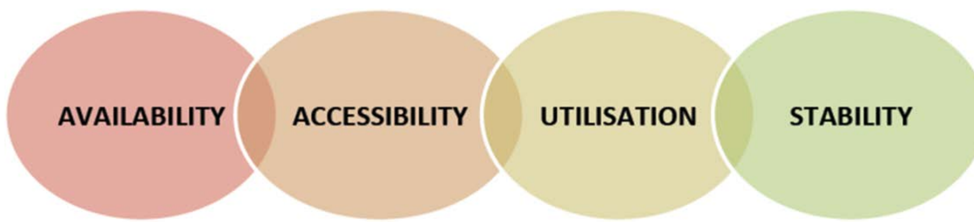
Mean N contents of pigs (g/kg liveweight)

Category	Weight, kg	Ireland	Italy	Germany	NL	UK
Dead piglet	1.3	?	?	25.6	18.7	?
Culled piglet	2.8	?	?	25.6	23.1	?
Culled piglet	9.0	?	?	25.6	24.3	?
Weaned piglet	7.0	30.4	?	25.6	?	30.4
Weaned piglet	11.0	25.0	?	25.6	24.4	25.0
Culled piglet	12.0	?	?	25.6	24.5	?
Growing pig	26	25.0	24.0	25.6	24.8	25.0
Finishing pig	114	25.0	24.0	25.6	25.0	25.0
Rearing sow	125	22.0	?	25.6	24.9	22.0
Rearing sow	140	22.0	?	25.6	24.9	22.0
Rearing boar	135	27.4	?	25.6	24.9	27.4
Boar	325	27.4	?	25.6	25.0	27.4
Breeding sow	220	25.6	?	25.6	25.0	25.6
Sow at slaughter	220	25.6	?	25.6	25.0	25.6

Sebek et al, 2012

Uneven distribution:

- More than 2 billion people in the world suffer from (micro) nutrient deficiency, especially in developing countries. Most critical are protein-nitrogen, phosphorus, calcium, zinc, iron, iodine
- An increasing number of people is obese



Livedate project; 2012-2014

Inventory of methodologies & numbers

In-depth analyses of methodologies

Analysis of coherences & differences

Best practices & common methodology

Regional differentiation

EUROSTAT studies

"Methodological studies in the field of Agro-Environmental Indicators"

Lot 1. Nitrogen and phosphorus excretion factors for livestock ('LiveDate')

Objective: "*to bring clarity into the issue of excretion factors so that a recommendation on a single, common methodology to calculate N and P excretion coefficients can be identified*"

WAGENINGEN UR
For quality of life