Challenges and solutions for climate care cattle farming from a system's perspective

ADSA conference, Kansas City, 19-23 June 2022

Peter W.G. Groot Koerkamp, professor Biosystems Engng

Abele Kuipers, Paul Galama, Sierk Spoelstra and others

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Wageningen University & Wageningen Research

13,153 BSc/MSc-students
2,303 PhD candidates
3,767 faculty and staff
Best Dutch university (17 years)

9 institutes – applied research
Turnover 373 M€
3471 staff
Organized in 5 science groups

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Education at the Farm Technology Group

Bert
Van 't Ooster

Design, greenhouse technology, research methods

Sam Blaauw

CAD, practicals, technical support

Rachel van Ooteghem

Modelling and control

Arni Janssen

Design, intro agro, conservation agriculture

BSc Agrotechnology

MSc Biosystems Engineering

Daniel Reyes Lastiri

Modelling, thesis coordinator

Tim Hoogstad

Modelling, engineering problem solving, physics

Eldert van Henten

professor

Peter Groot Koerkamp

professor & chair

Research at the Farm Technology Group

Self-learning in autonomous ag. systems

Congcong Sun

Nico Ogink

André Aarnink

Gert Kootstra

Environmental technologies

Simon van Mourik

Machine vision and robotics

Modelling and control

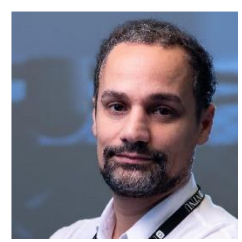
Biosystems Engineering Research

Haris Ahmed Khan

Rik van der Tol

Illumination and spectral imaging

Precision livestock farming



Eldert van Henten professor

Marjolein Derks

Design of agricultural production systems

Ricardo da Silva Torres prof. DS/AI

Peter Groot Koerkamp professor & chair

Dutch farms protesting against Nitrogen policies

Today, June 22

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The system's perspective

Laws & regulations

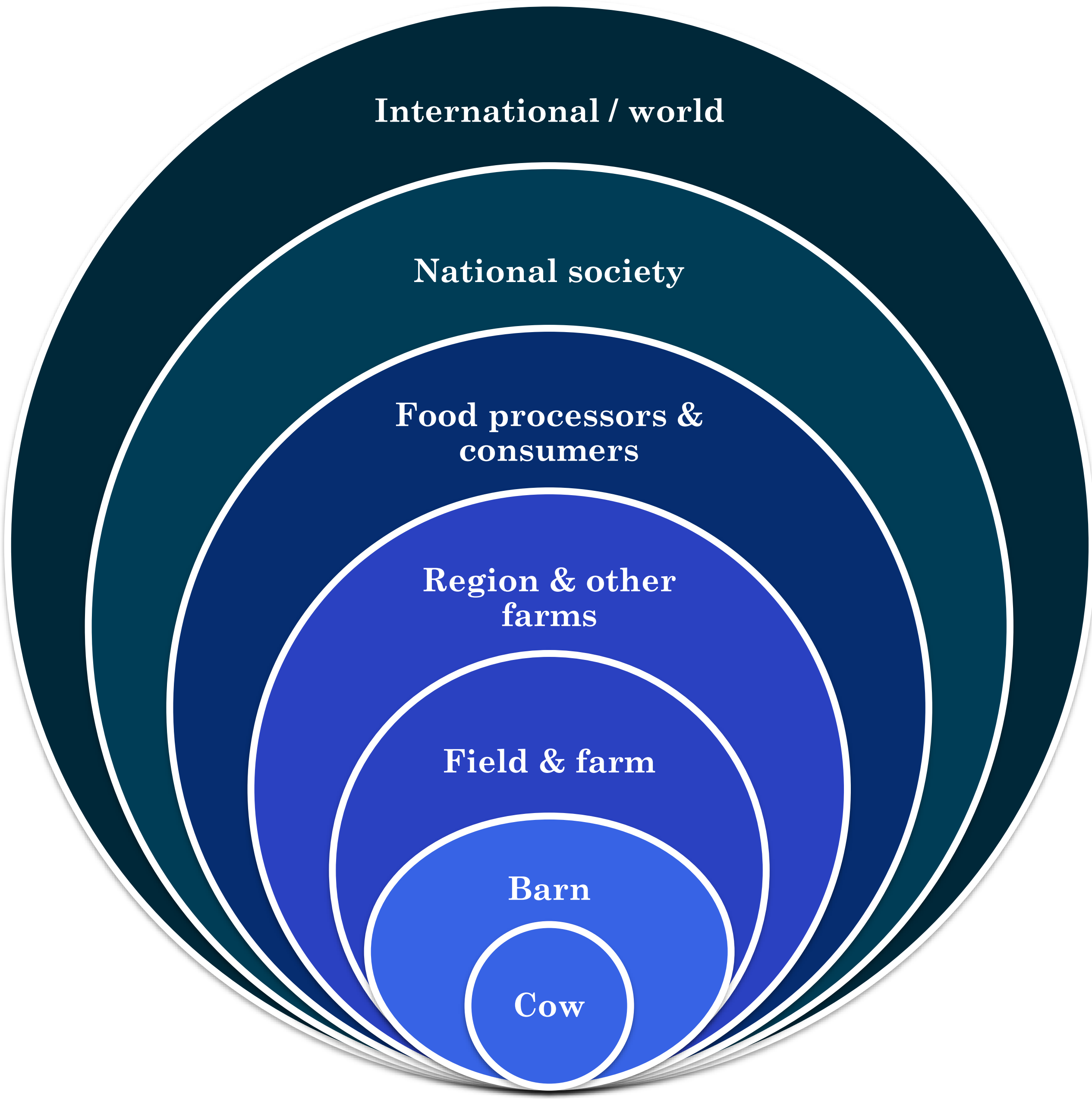
- Landscape / land use
- Animal welfare
- Pesticide use
- Ammonia emissions
- Greenhouse gas emissions
- Labour conditions

Market rules/societal concerns

- examples -

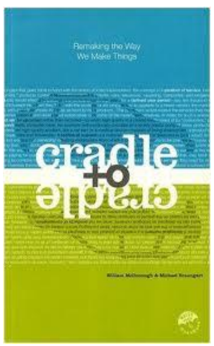
- Height of maize / corn
- Outdoor grazing
- 'Pesticide free' villages
- Nitrogen debate
- Planet-Proof milk
- Housing of guest workers

The system’s perspective is changing



Sustainable development

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
(People Planet Profit concept)



Taken from *Our common future*, UN report Brundtland committee 1987

How do we love all the children

of all species for all time?

Willam McDonough

UN Sustainable Development Goals

… to end poverty, protect the planet and ensure prosperity for all, in 2030! Enforced by January 1, 2016

Sustainable cattle farming

1. ‘Environmental’ challenges (focus the Netherlands)

2. Solutions to capture methane (& ammonia)

3. Integrated manure chain design & effects

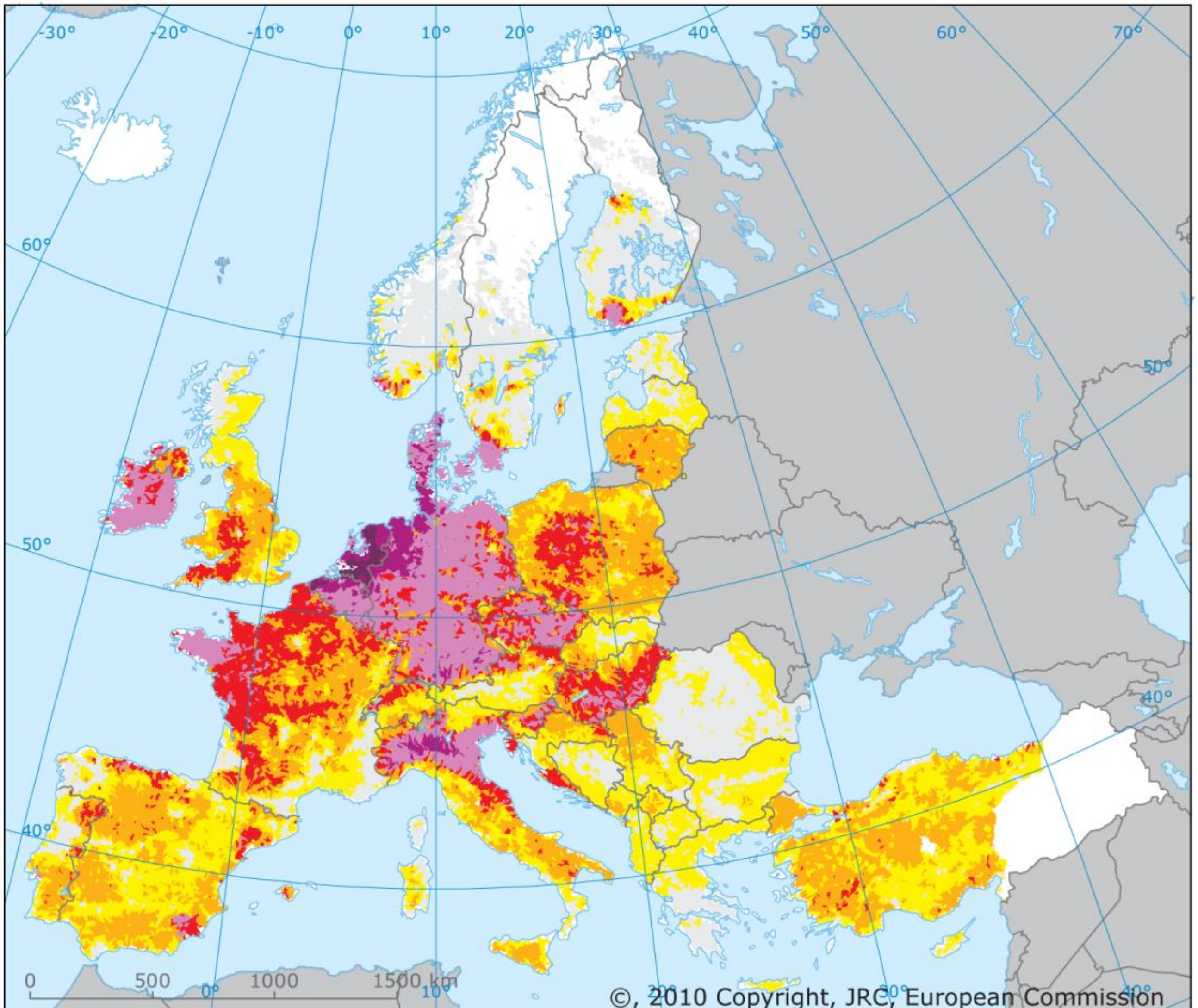
4. Concluding remarks

What can we learn from pigs?

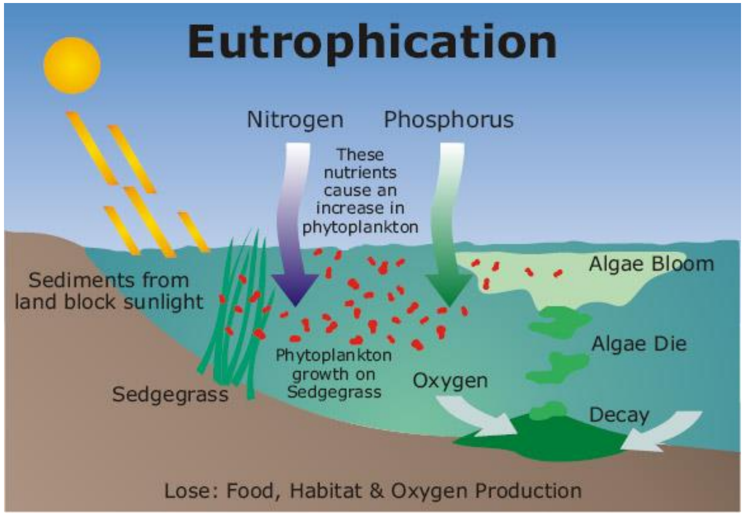
? =>

The nutrients challenge

surplus of N and P



The eutrophication challenge



Beaches in France & China

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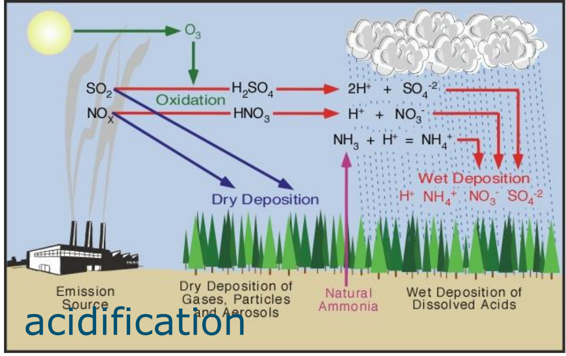
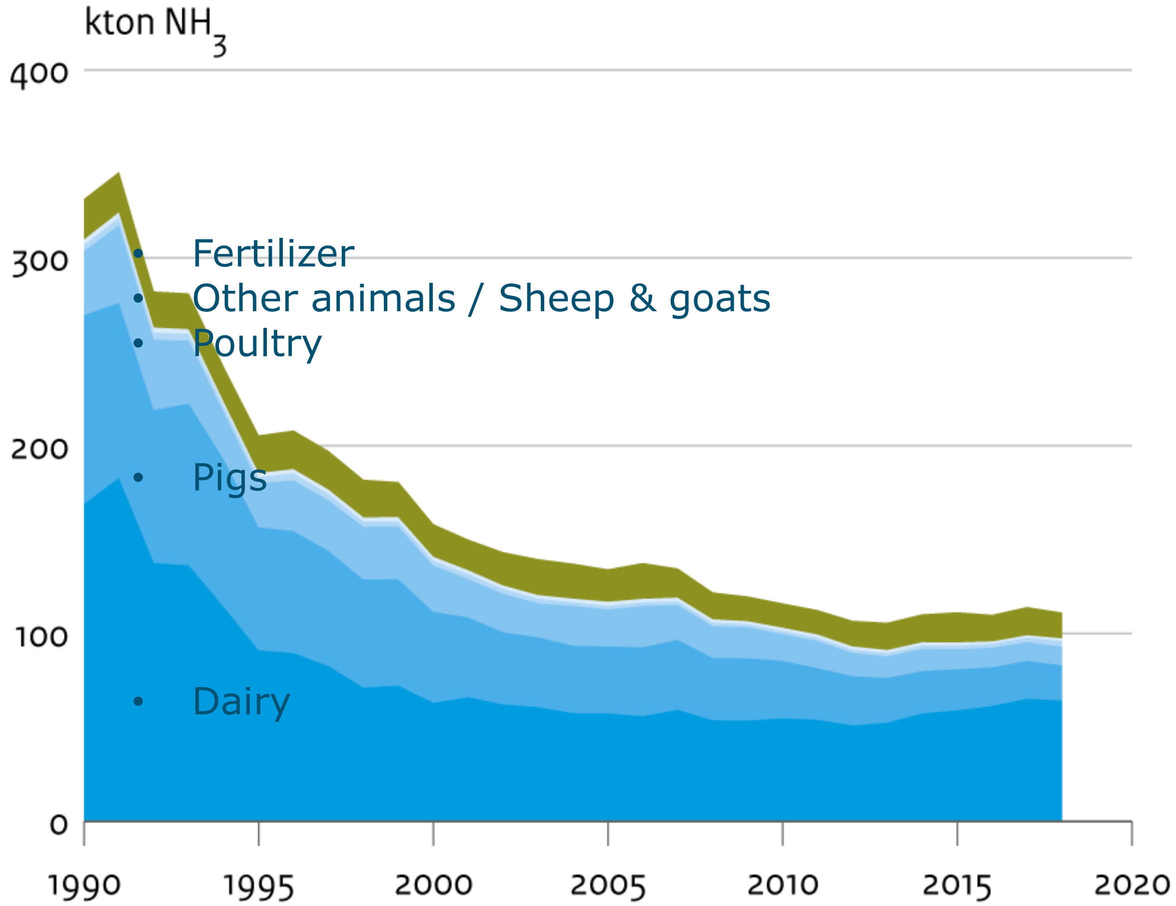
The ammonia challenge

dairy largest share, decrease stopped



acidification

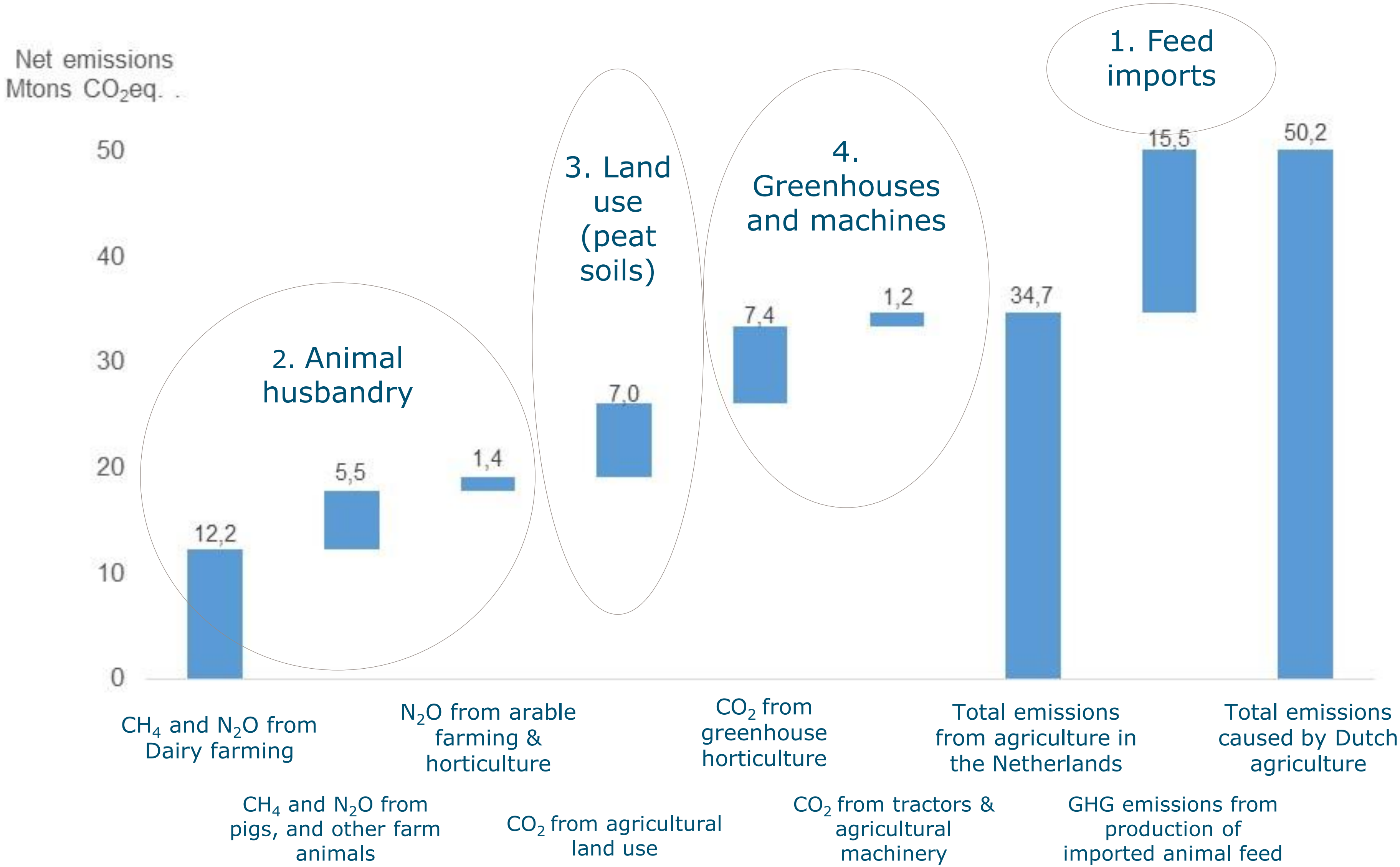
2018: Total 111 kton NH_3
equal to 63 kg NH_3 per hectare



Bron: RIVM/Emissieregistratie

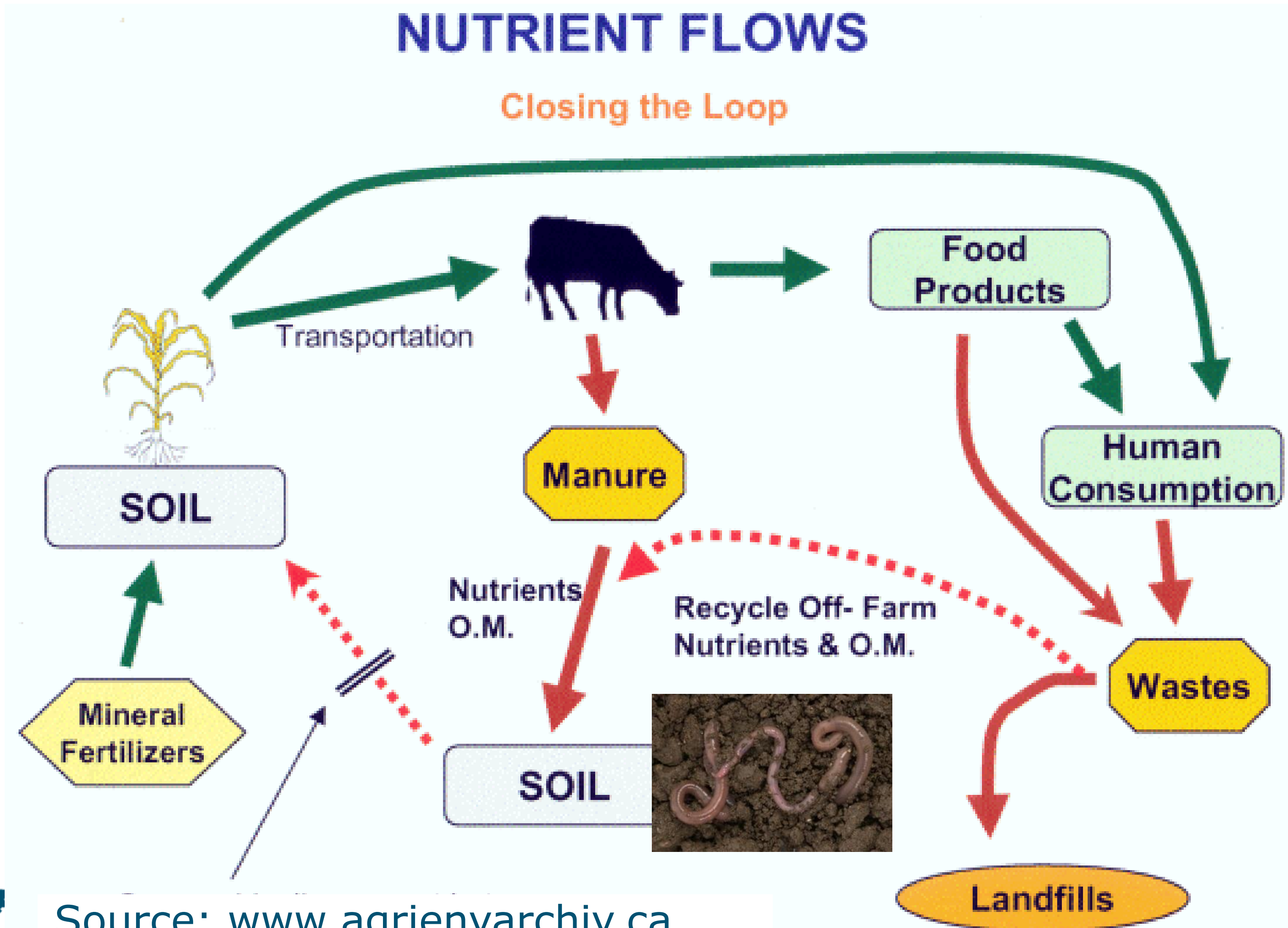
The greenhouse gas challenge

for climate neutral agriculture in NL



The soil quality challenge

NPK losses & accumulation, organic matter, compaction



Source: www.agrienvarchiv.ca

The climate change challenge

The socio-spatial challenge

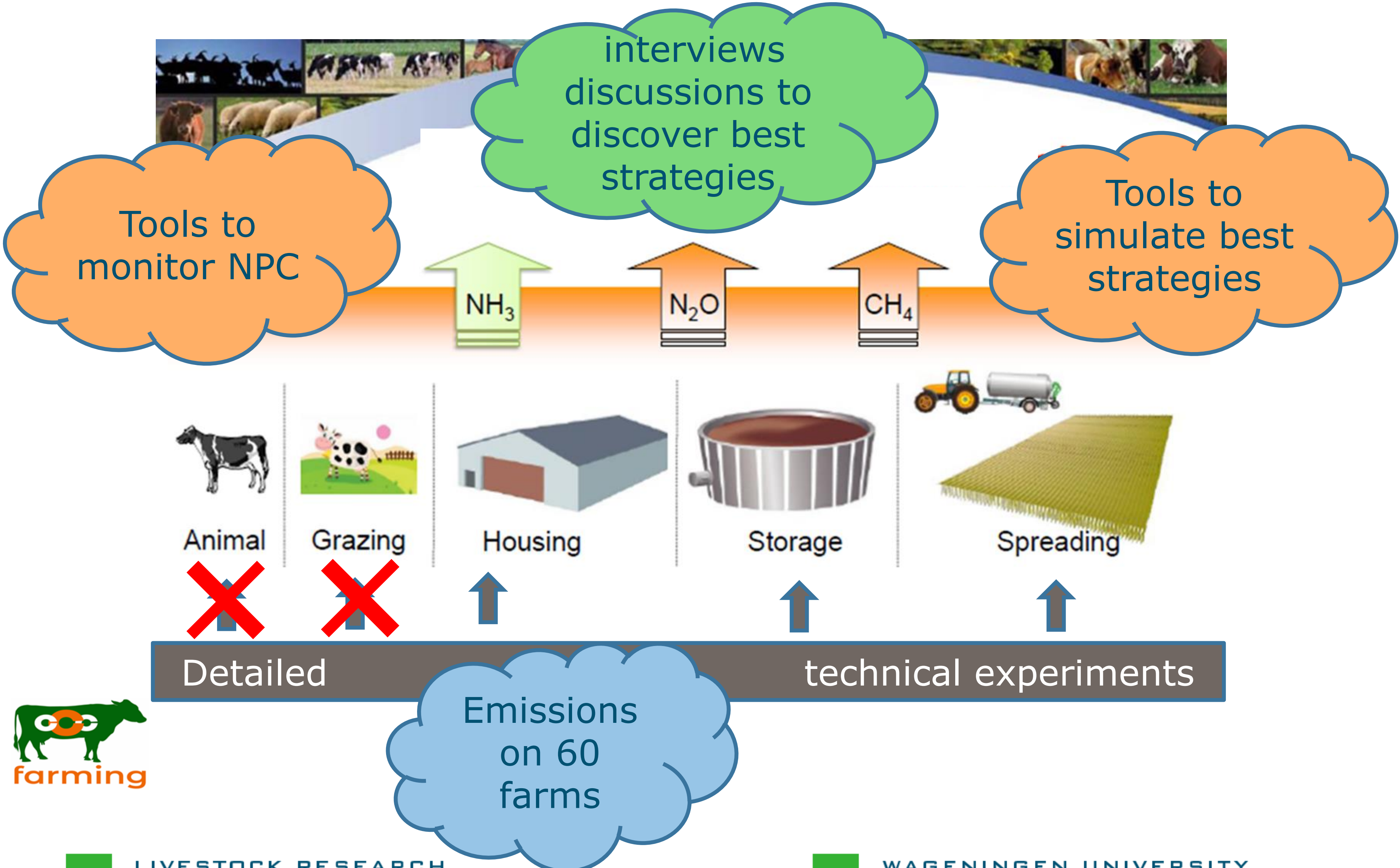
	Canada	USA	NL
Cattle (10^6) 	15	96	3.8
Pigs (10^6) 	15	61	11
Poultry (10^6) 	167	2 045	88
People (10^6)	33.5	307.2	16.7
Area (10^6 km^2)	9.98	9.63	0.04
People density (km^{-2})	3.4	31.9	418
Poultry density (km^{-2})	16.7	212.4	2200

- Metropolitan agriculture – farming in the backyard of 18 M people
- Dutch export: >70% of produce to NW Europe (but not manure!)

In summary, challenges for dairy farming

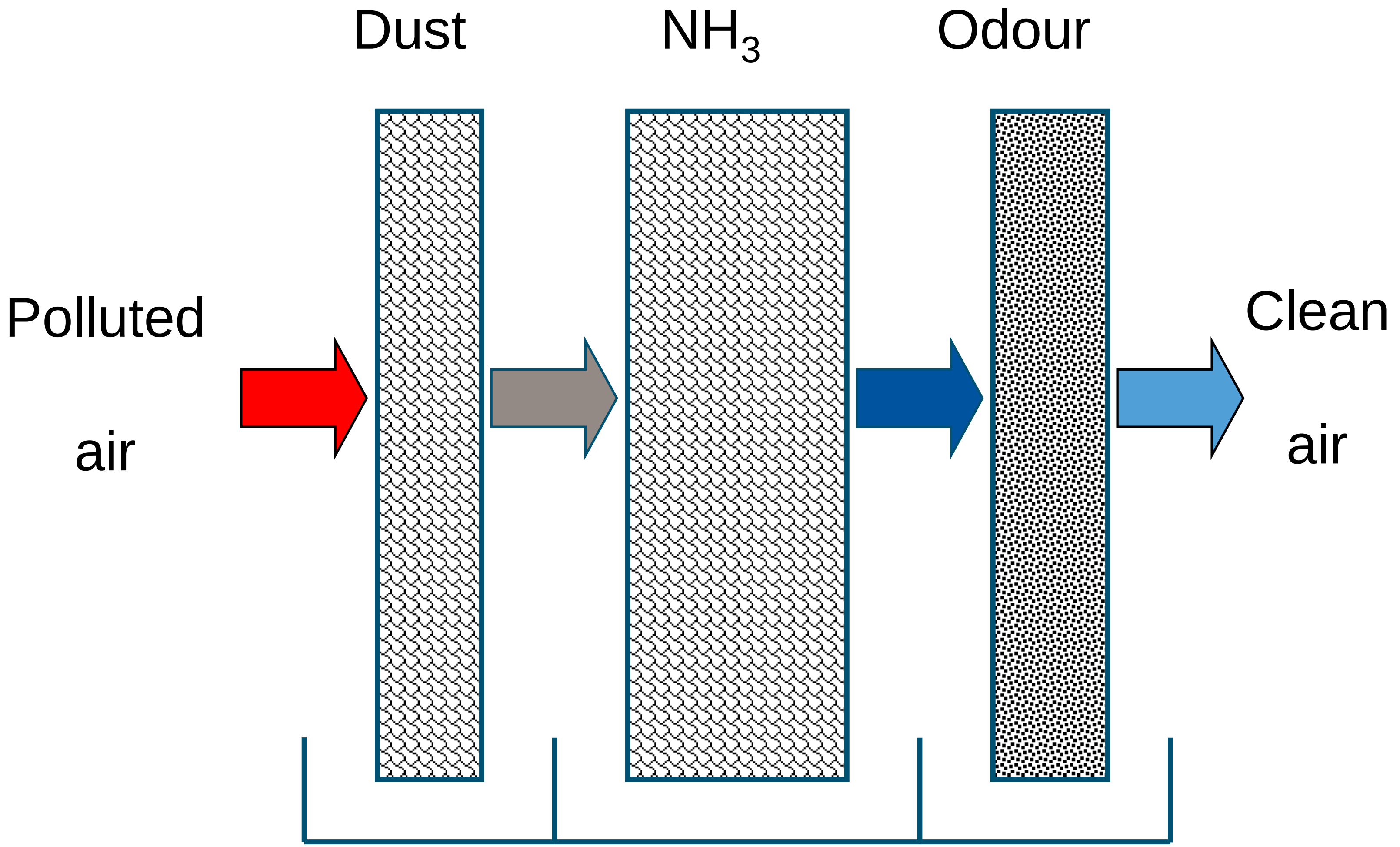
- Imported feed ingredients / concentrates X
- Enteric methane production from dairy cows ☜
- Range of losses / emissions from excreta ☜
- Use of peat land with low water tables X
- Soil quality / fertility / water balance (x)

The Climate Care Cattle farming project



2 Options / Solutions to capture methane

Air scrubbing (SotA 2022)



Dairy farm with ammonia scrubber (acid)

Air outlet

Backside of the barn

Reduced inlets

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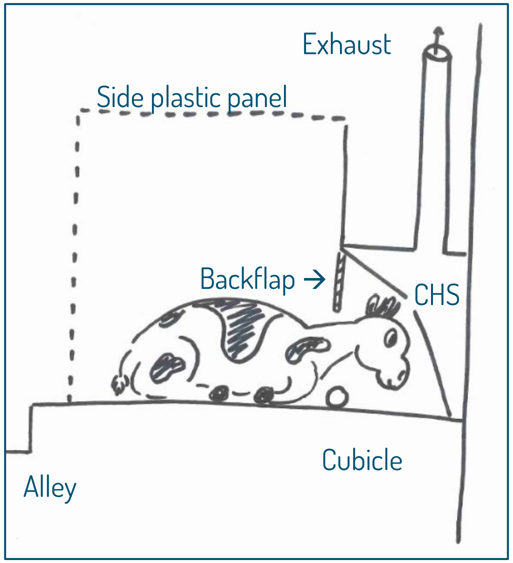
Extraction of concentrated air at sources:

slurry/urine pit | cubicle | feeding fence



Lely Sphere

Cubicle Hood Sampler

=> CH_4 collector

Adapted hood

’Process’ air with ammonia and methane

Biobed with wood chips

Burning air from slurry storage

Challenge: increase capture/conversion rate per m^3

3 Integrated manure chain design

Waste management is
… all handling of waste
from excretion and collection,
storage in & outside the animal house,
any type of processing or treatment,
up to transport and application
in crop production

Sustainable waste management

- Maximize nutrient recycling in the whole chain
- With no (minimal) undesired environmental impact

Applied technologies & solutions NL 2022

Transport of slurry/solids

Filtration – Reversed Osmosis

Slurry separation

Drying & pelletizing

Storage

Digestion of slurry

Nitrification / denitrification

Incineration poultry manure

Trade-offs & pollution-swapping with current techniques & approaches

- Energy use, N-loss, N_2O emission, high € costs

… and most importantly:

- Effect / impact: reductions and improvements are limited
- Also, for combinations of techniques!

- Short term environmental goals not met
- Long term environmental goals infeasible

Complexity of processes

- Microbial degradation, conversion, (de)nitrification
- Chemical reactions and equilibria
- Physical processes, e.g. volatilization

Many influencing factors (animal house, waste, soil):

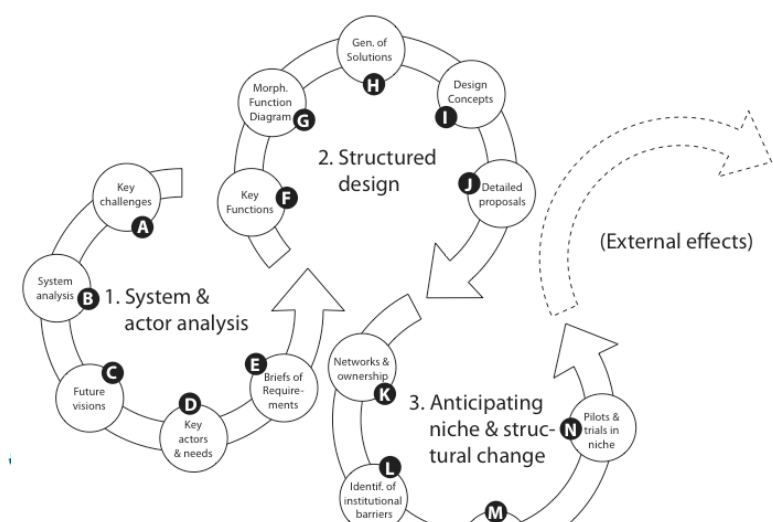
- temperature
- pH
- oxygen concentration
- carbon availability
- air velocity
- water activity / water content
- …

Sustainable waste management

- Maximize nutrient recycling in the whole chain
- With no (minimal) undesired environmental impact

Design a waste management system
(from excretion up to application)
that fulfils needs of plant and soil,
and with minimal environmental side-effects

J.W. de Vries et al, 2015. Integrated manure management to reduce environmental impact:
I. Structured design of strategies.
Agricultural Systems 149: 29-37



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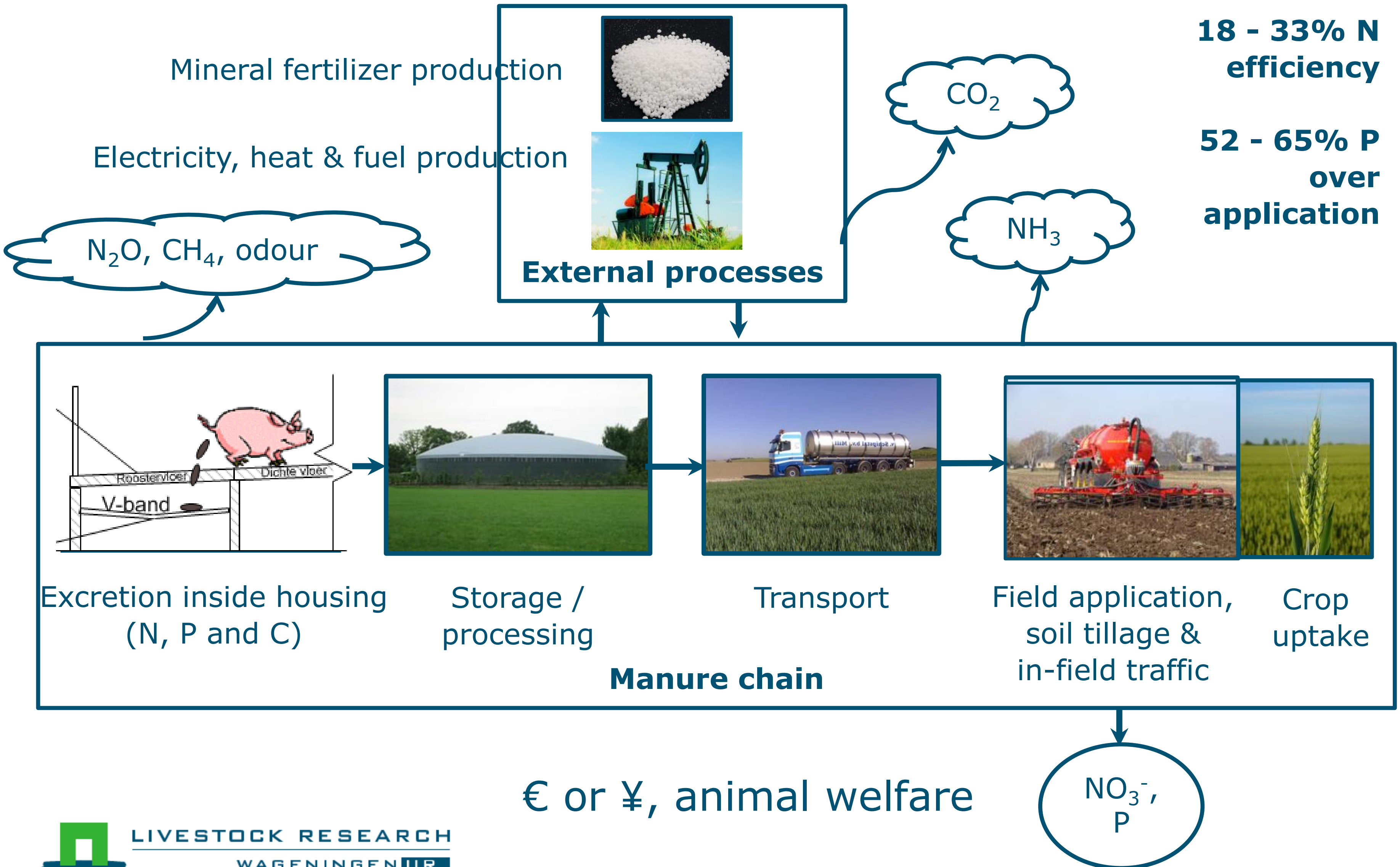
Manure management & environment



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Selected technical solutions with main effects in brackets

- Segregation of pig and dairy cattle urine and feces inside the housing system (CH_4 & NH_3 emission)

Belt system for pigs (first in 1998) separates urine and faeces and allows straw!

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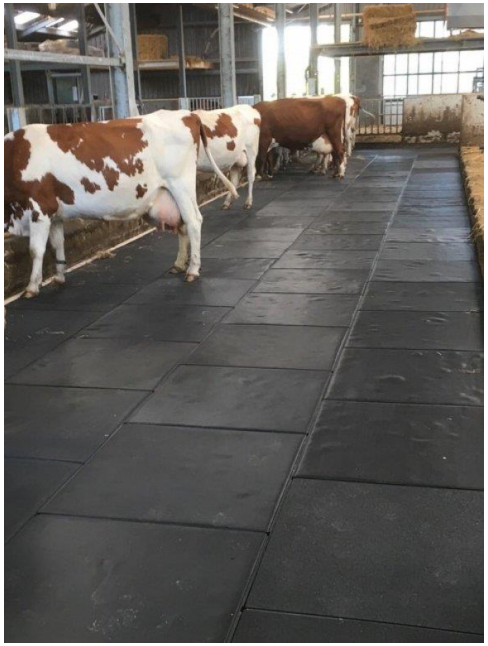
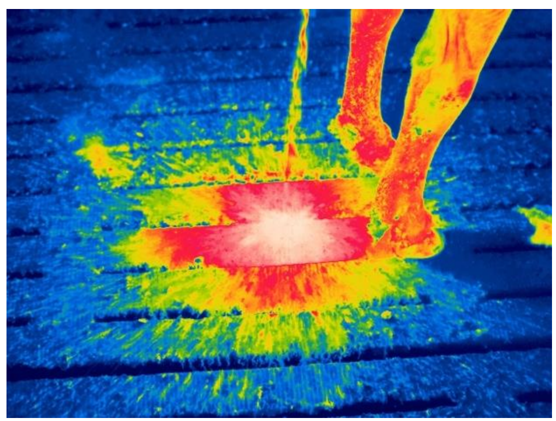
Segregation systems for dairy cows



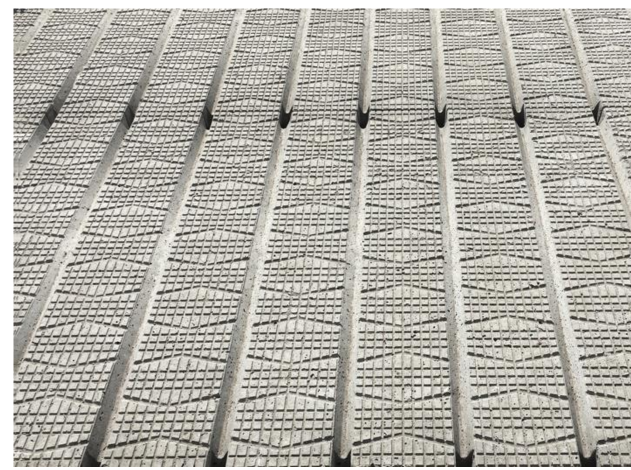
Zeraflex permeable floor

Cow garden with permeable floor

Lely Sphere feces collector



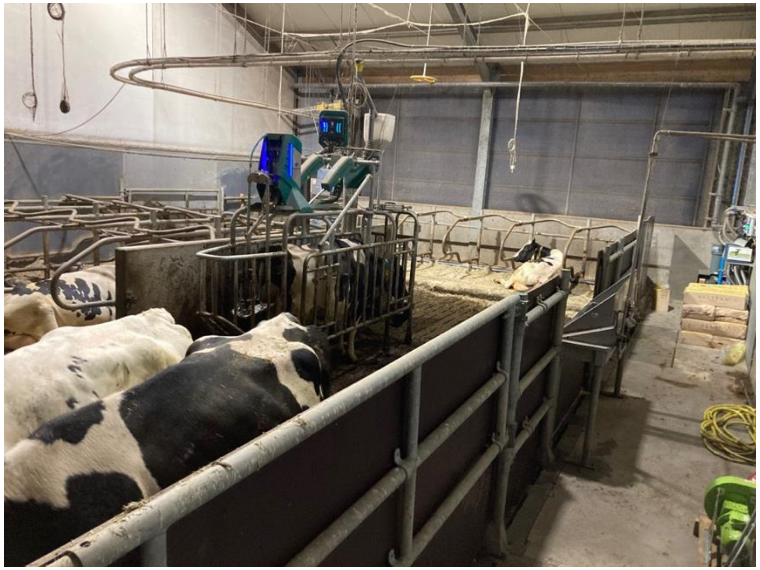
IR-graph of urine puddle



Swaans G6 floor with drain holes

CowToilet for direct urine collection

https://Hanskamp.nl/en/cowtoilet



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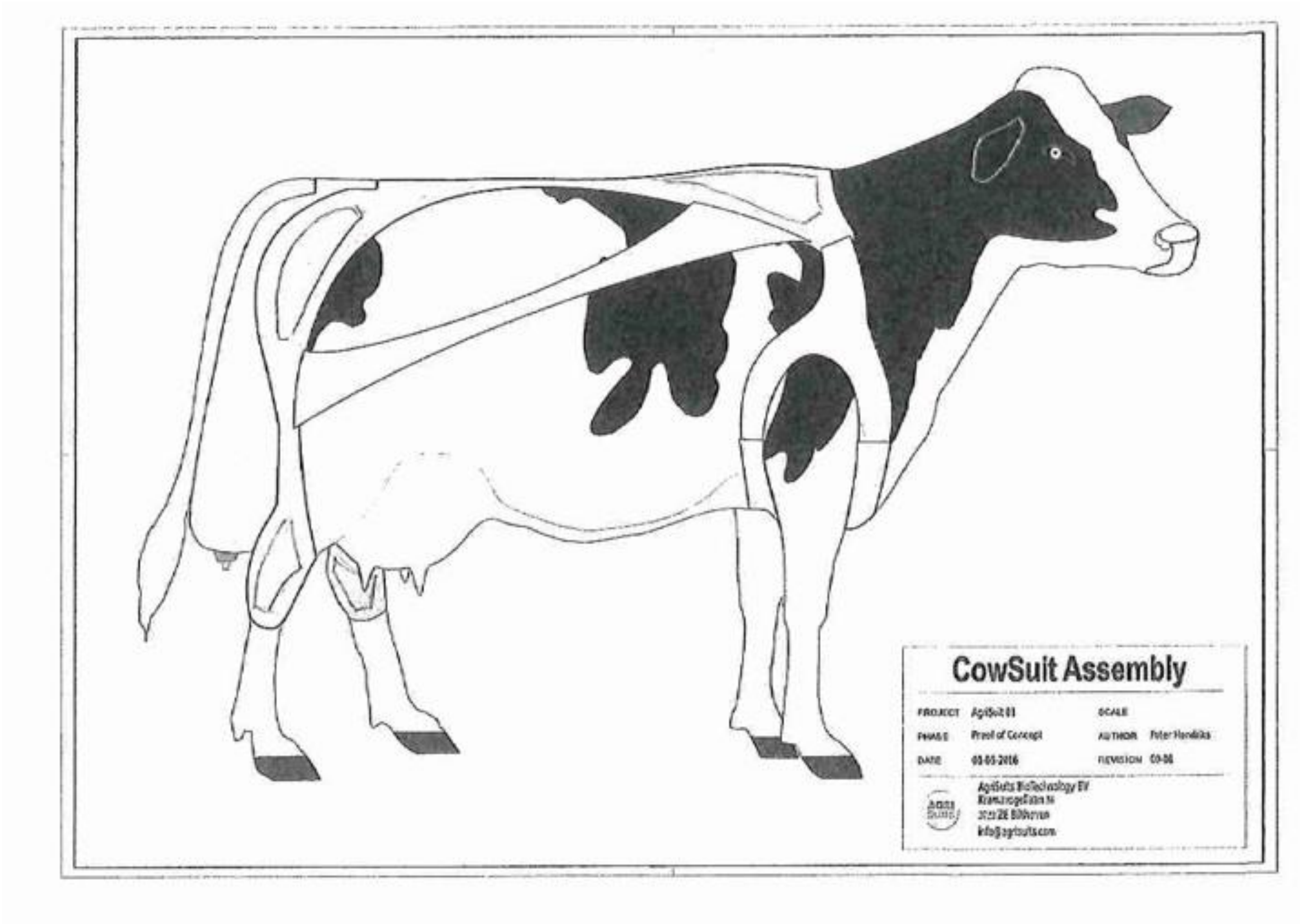
The CowSuit
with catch bag for faeces & urine



www.agrisuits.com

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Selected technical solutions with main effects in brackets

- Segregation of pig and dairy cattle urine and feces inside the housing system (CH_4 & NH_3 emission)
- Bio-energy production from feces (gas/electricity/heat)
- Addition of zeolite to solid dairy cattle manure (NH_3)
- Sealed separated storages (volatilization of N and C)
- New field application techniques (NH_3)
- Minimum tillage and CTF (N_2O, fossil energy, N loss)

CTF Controlled Traffic Farming

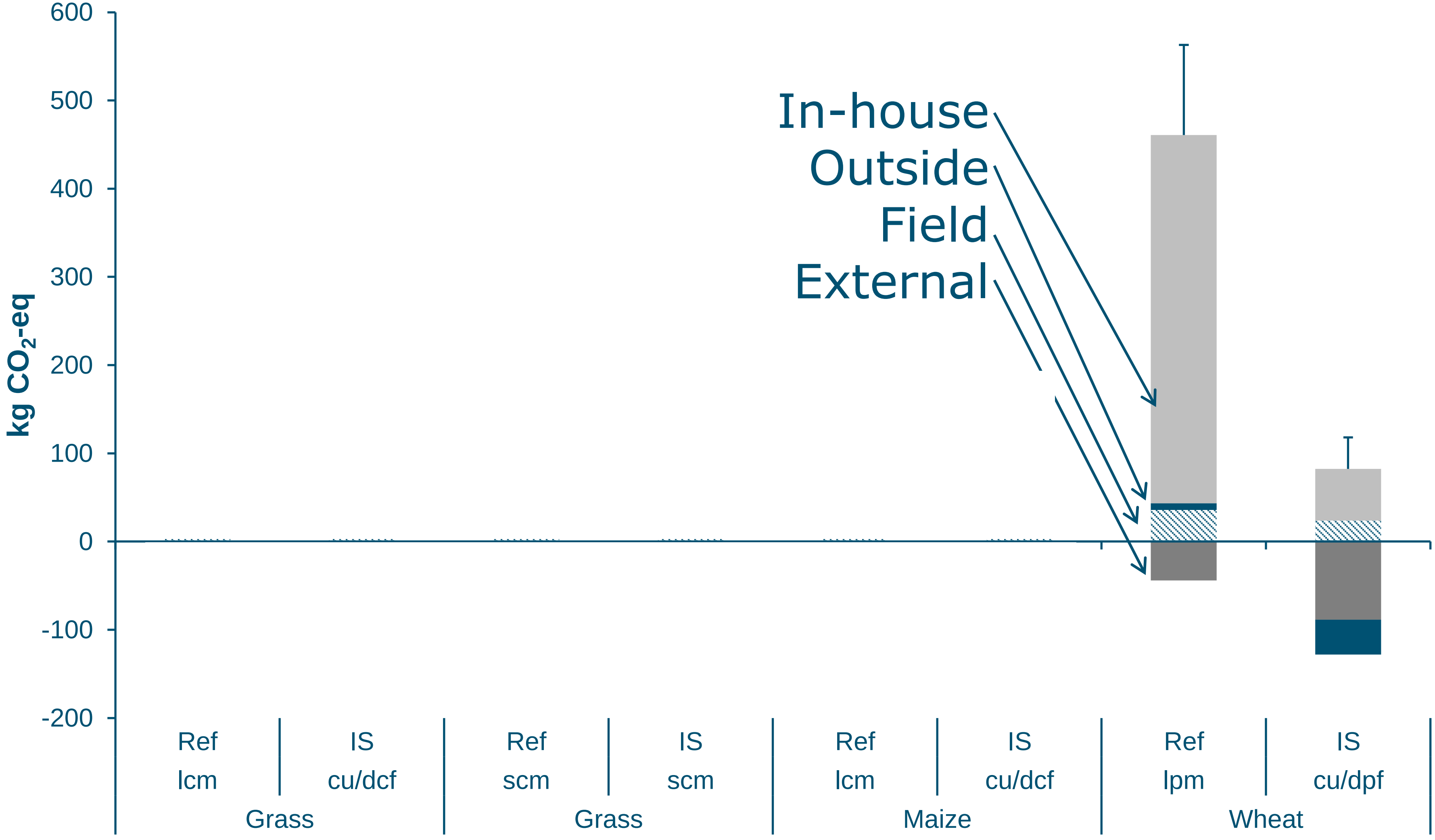
Life Cycle Assessment to assess effects

4 representative crop-manure combinations in NW-Europe:

- Gras – liquid cattle manure
- Gras - solid cattle manure
- Maize – liquid cattle manure
- Wheat – liquid pig manure

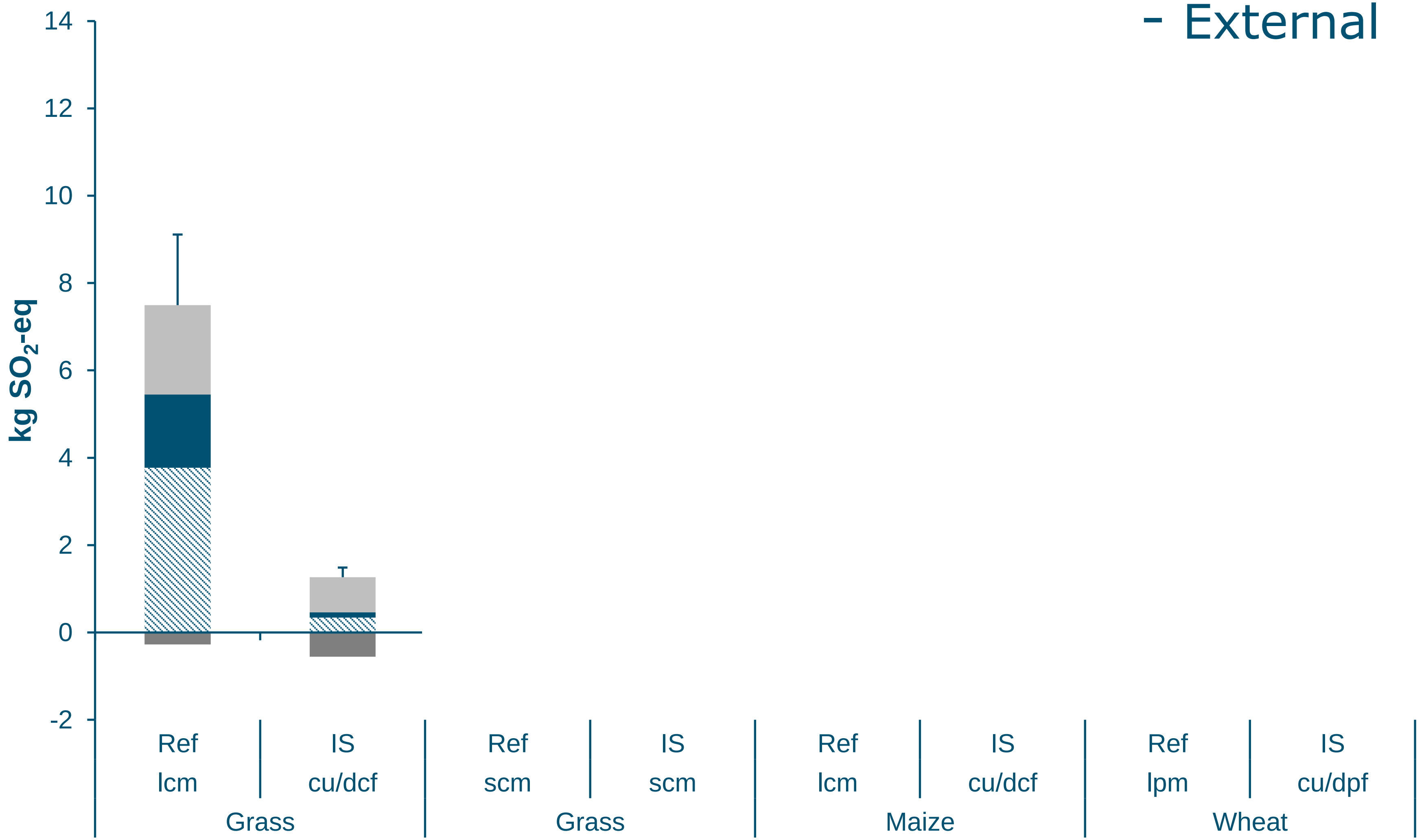
- Reference: house with slats & storage, no storage covers, broadcast spreading, plowing, random traffic
- Effects: Climate Change, Terrestrial Acidification, NUE

Climate change (CO_2, N_2O and CH_4)

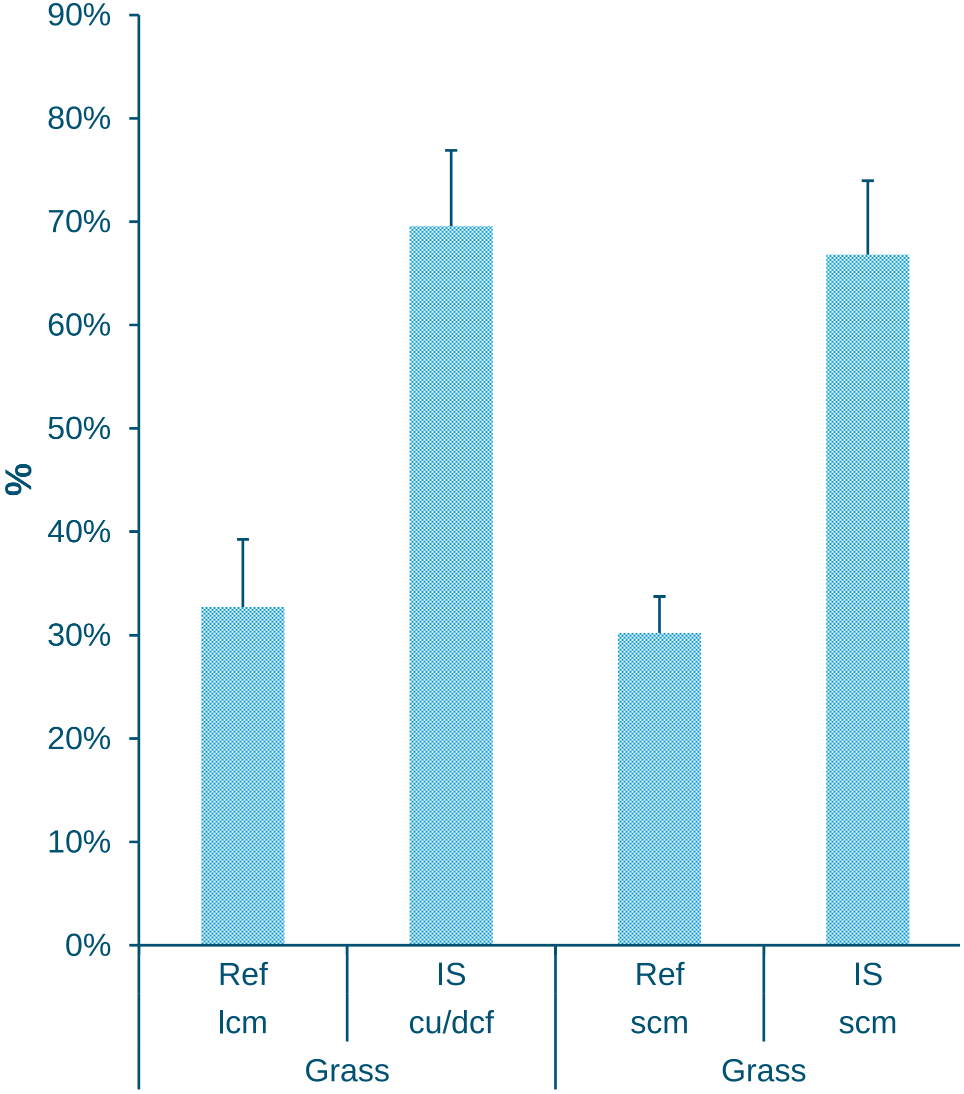


Terrestrial acidification (NH_3)

- In-house
- Outside
- Field
- External



Nitrogen Use Efficiency (crop:excreted)



Discussion & conclusion

- Integrated manure chain, ‘simple’ techniques!
- All environmental impacts reduced >50%, most >70%

- Validate model results of emissions: lab & field & practice

  ongoing with PhD Jihane el Mahdi in EU FertiCycle program

- Economic consequences & practical implementation

Take home message:
Segregation of faces & urine is key to success!

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Thank you for your attention

To explore the potential of nature to improve the quality of life

peter.grootkoerkamp@wur.nl

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Further reading

- De Vries, J.W., W.B. Hoogmoed, K.M. Groenestein, J.J. Schröder, W. Sukkel, I.J. De Boer, P.W.G. Groot Koerkamp, 2014.
  Integrated manure management to reduce environmental impact: I. Structured design of strategies.
  Accepted for publication in Agricultural Systems
- De Vries, J.W., W.B. Hoogmoed, K.M. Groenestein, J.J. Schröder, W. Sukkel, I.J. De Boer, P.W.G. Groot Koerkamp, 2014.
  Integrated manure management to reduce environmental impact: II. Environmental impact assessment of strategies.
  Accepted for publication in Agricultural Systems

Organize a new model!

The 'stick':
Enforcement
- EU legislation
- Nat. legislation
- Trade agreement

The 'carrot'
Positive incentives:
- €
- Yield/production
- License to produce

Environmental effects of losses & accumulation

Effect	– Cause
■ Eutrophication	- loss of N &P
■ Acidification	- emissions of NH_3 - deposition
■ Biodiversity loss = loss of species (various scales)	
	- intensity of production
	- use of agro-chemicals
	- transfer nature to crop land
■ Global warming	- emissions of CO_2, CH_4, N_2O,
■ Reduced water quality: ground & surface water	
	- loss of N & P, agro-chemicals
■ Reduced air quality: for worker, animal & neighbourhood	
	- particulate matter
	- gases & odour

Environmental effects: other issues

Effect	– Cause
Depletion of natural (limited) sources:	
	- phosphate as fertilizer
	- water for irrigation
	- fossil carbohydrates for energy
Reduced soil quality	- low organic matter content - soil compaction

Session program EAAP Exchange Symposium

EAAP Speaker: Peter Groot Koerkamp, WUR, the Netherlands peter.grootkoerkamp@wur.nl	Challenges for climate care cattle farming from a system's perspective
Jasmine A. Dillon, Colorado State Jasmine.Dillon@colostate.edu	Modeling the environmental impact of enhanced production efficiency.
Kyle Taysom, Dairyland Laboratories, Inc. ktaysom@dairylandlabs.com	Practical feed analysis tools for a more efficient nutrition program.
EAAP Speaker: Sven Koenig, Justus Liebig University, Germany sven.koenig@agrar.uni-giessen.de	Potential of reducing cow methane emission from breeding perspective
Discussion	

Session: Joint ADSA Production, Management, and the Environment Committee/EAAP Exchange Symposium: Harnessing Cow Efficiency and Technical Innovation for a Climate Caring Dairy Sector
Location: Bartle 2215C Date/Time: Wednesday, June 22, 2:05PM CDT, Duration: 0:30

After much deliberation, it has been decided that the travel reimbursement policy for ADSA-member invited speakers will need to remain in place. However, for this year, member invited speakers will receive a complimentary hotel room for two nights and discounted registration (discount code will be sent in the coming weeks). The addition of covering hotel rooms was made to help offset expenses for all member invited speakers as we try to return to travel. We will not be able to pay for airfare and meals.

Brittany Morstatter, ADSA Scientific Program Support
Albert De Vries, Professor, Department of Animal Sciences, University of Florida

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Abstract text #86306 #1418

Challenges and solutions for climate care dairy farming from a system's perspective

The Dutch Agri&Food sector has developed very successfully after WWII. This success is largely attributed to the focus on maximizing production at minimal costs. This led to homogenous low stress environments, the use of large quantities of external inputs (N-fertilizers and fossil energy), chemical control of pests and diseases (biocides), intensive soil intervention (ploughing and tillage) and plant and animal varieties adapted to those specific conditions. This development was facilitated by excellent infra-structure and policies, mechanisation (e.g. milking robots) and upscaling of farm sizes.

The Dutch dairy sector currently highly contributes to national environmental impacts such as acidification of nature areas (mainly by NH_3), eutrophication of water bodies (losses of N and P), global warming (emissions of CH_4), reduced water and soil quality (e.g. by pesticides) and biodiversity loss.

Improvements and reductions have been achieved, to various extents, by single-issue policies and solutions (e.g. 65% NH_3 reduction by slurry injection). Further strong improvements on all environmental aspects are needed, without causing negative side-effects. This is a huge challenge for typical highly populated regions as the Netherlands with intensive livestock production and a very critical society. An integrated approach to the long-term challenges (2050) is developed and specific technologies and practices are designed, developed and tested.

In this contribution we focus on innovative cattle housing & technology and integrated manure and air handling systems, which adapt the environment to the animal. We will present an integrated approach and how a range of technical solutions (at different Technical Readiness Levels), such as flooring systems that segregate urine and faeces, manure treatment like acidification and digestion, autonomous robots collecting faeces, a cow toilet collecting 30% of excreted urine, ventilation and air treatment systems for ammonia and methane fit in this approach. Environmental impacts as well as the coherence with farm economics, societal acceptance (grazing) and animal welfare will be indicated.

Trade-offs & pollution-swapping (1/3)

- Belt drying, tunnel drying, pelletizing
  - Energy use
  - Costs
  - NH_3 loss
- Storage of solids and farm yard manure (stackable)
  - High N-loss
  - N_2O emission
- Incineration of poultry manure
  - Re-use of P?
  - Loss of OM
- Veal calf treatment
  - High energy use
  - N_2O emission

Trade-offs & pollution-swapping (2/3)

- Digestion of slurry
  - Use of by-products
  - Costs
- Composting
  - High N-loss
- Chemical air scrubbers
- Biological air scrubbers
  - Energy use
  - Indoor climate
  - N_2O emission
- Floor systems
  - Effectiveness questioned
  - Costs
  - Impact animal welfare