Effects of nitrate emission from agricultural land use on groundwater quality in Northwest-Germany

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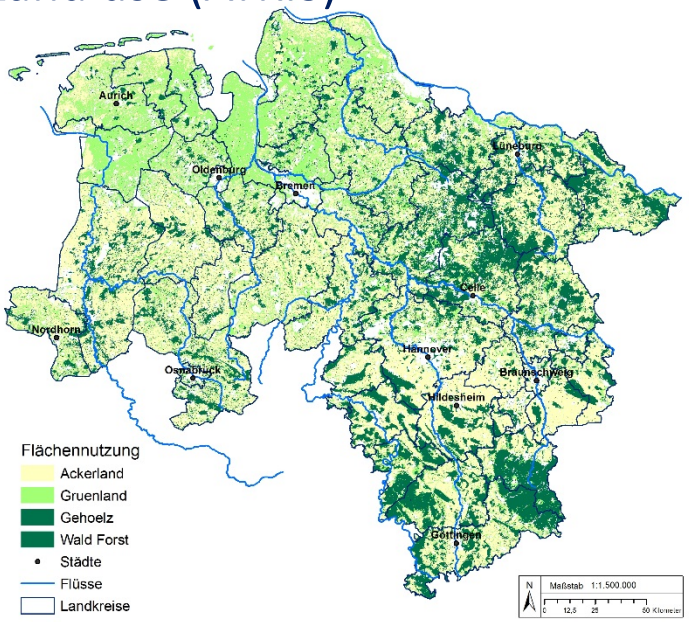
Niedersachsen

Why Northwest-Germany?

- I am from Lower Saxony, a state in Northwest-Germany,
- Area 47.000 km², about 10 % of Germany
- Problems in groundwater quality, especially nitrate due to
  - Regions with high pig and poultry density
  - High proportion of agricultural land (55 %)
  - Sandy soils (50 %), high leaching potential
  - groundwater bodies only partially covered with relatively impermeable rock (clay)

Land use (ATKIS)



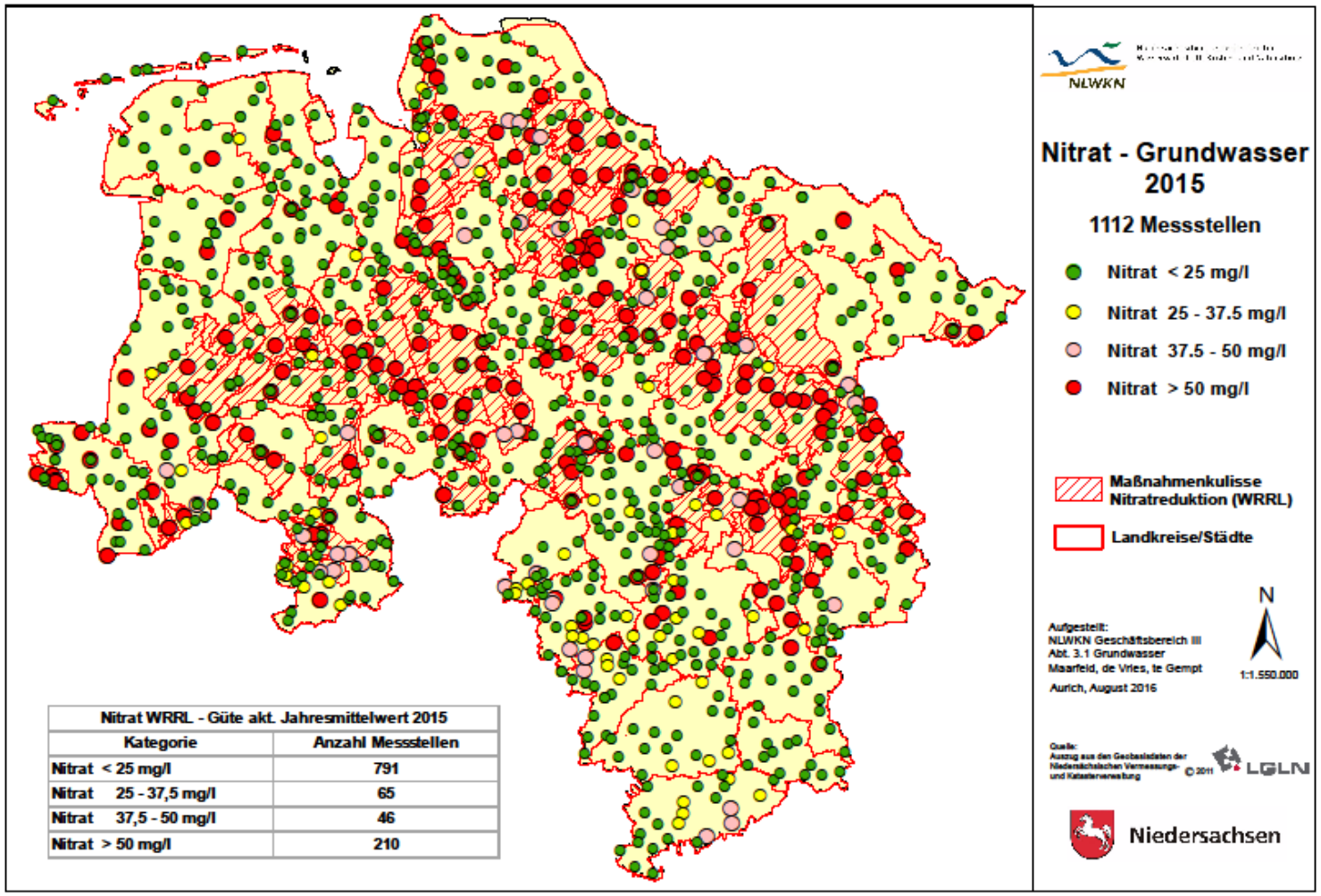
Outline

- How is the groundwater quality with respect to nitrate?
- Where does the nitrate come from?
- To which extent does the nitrate emission from agricultural land affect groundwater quality?
- Which measures are taken?
- Conclusions

How is the groundwater quality with respect to nitrate?

Groundwater Quality (Immission)

50 mg nitrate/l is exceeded in 210 of 1112 official groundwater wells

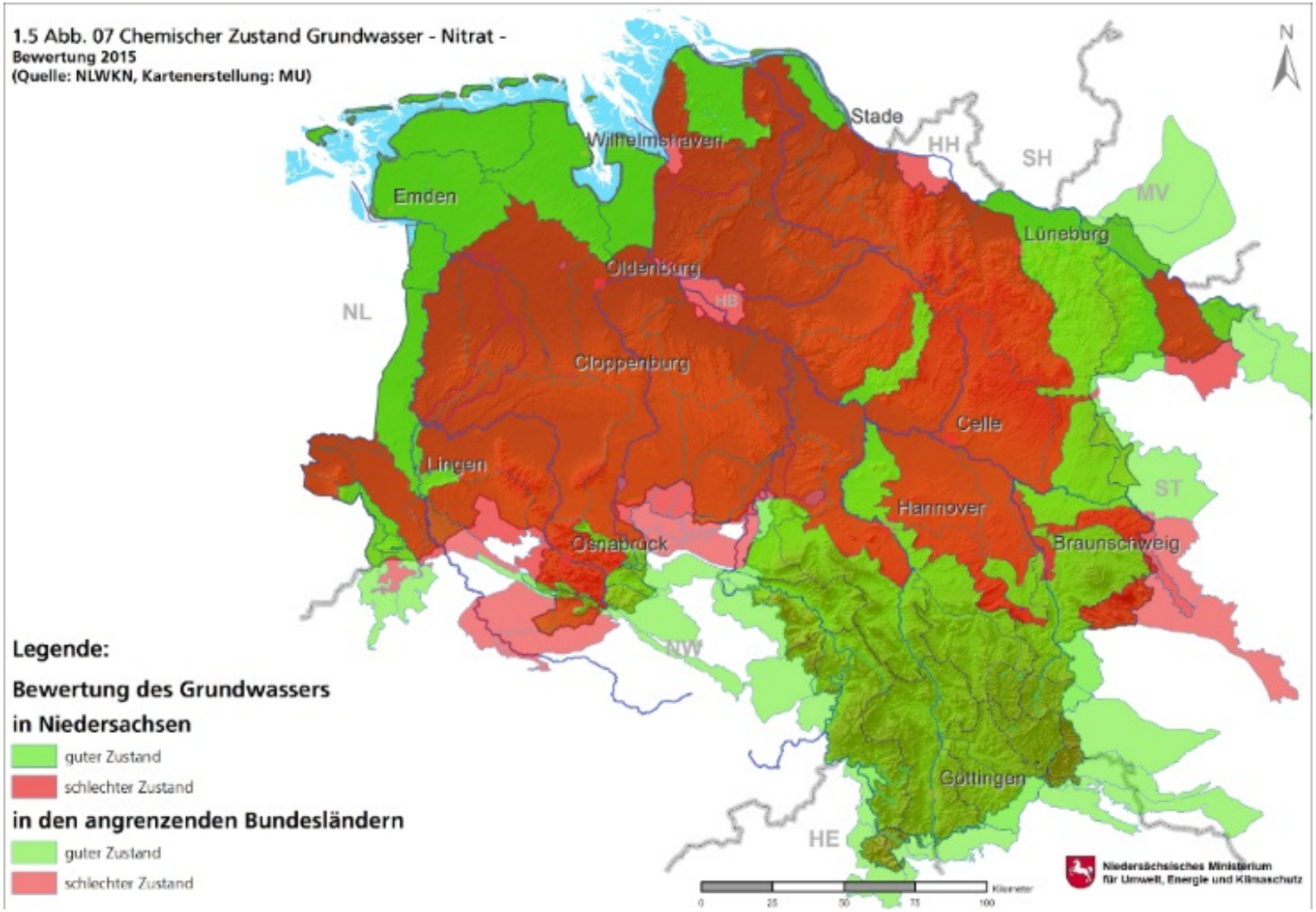


Nitrat WRRL - Güte akt. Jahresmittelwert 2015	
Kategorie	Anzahl Messstellen
Nitrat < 25 mg/l	791
Nitrat 25 - 37,5 mg/l	65
Nitrat 37,5 - 50 mg/l	46
Nitrat > 50 mg/l	210

NLWKN, 2016

Groundwater Quality

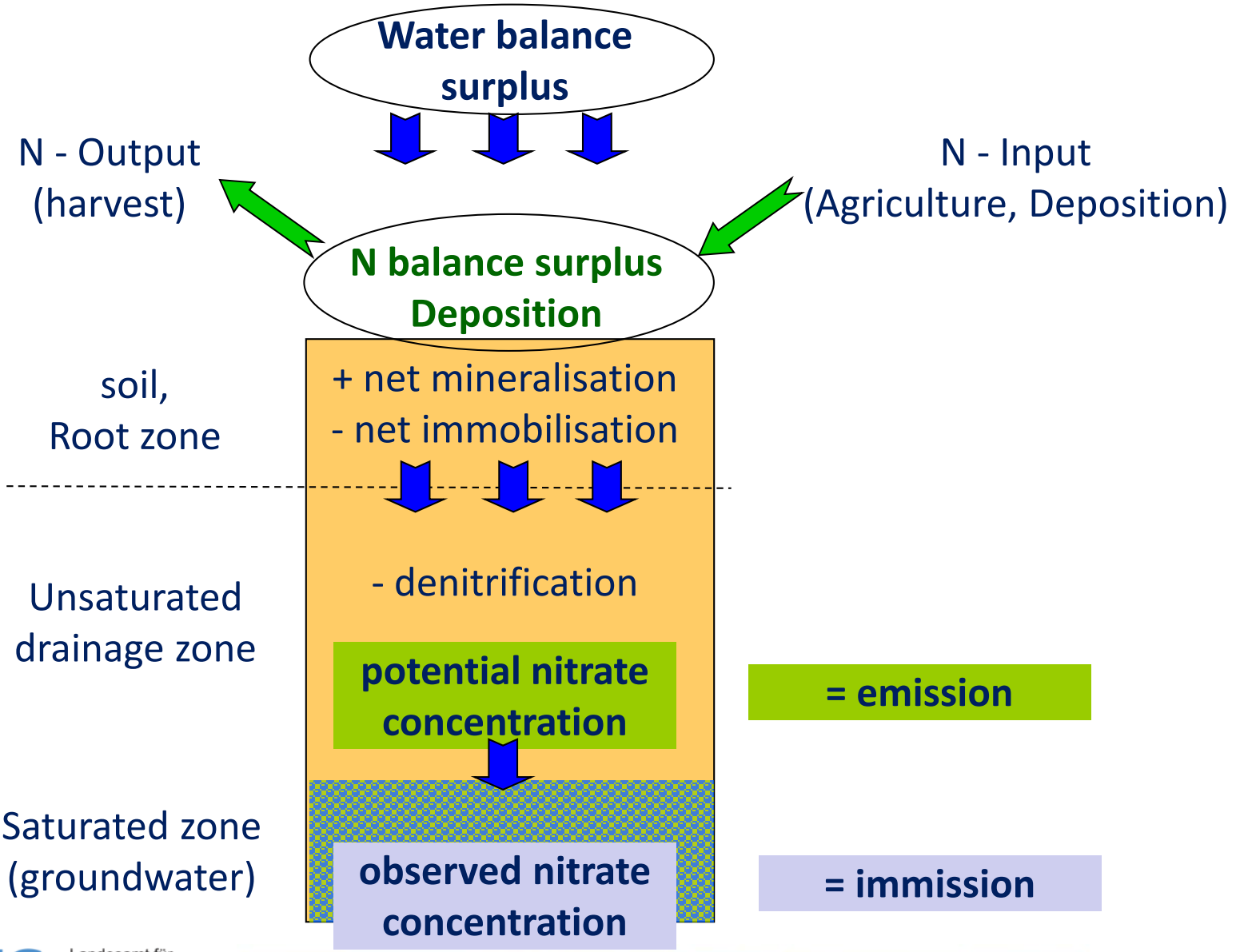
Groundwater bodies covering 60 % of the state of Lower Saxony are in a bad condition concerning nitrate (Evaluation 2015)



NLWKN, 2016

Where does the nitrate come from?

Emission-Immission-Approach



Advantages

- Emission covers the whole state area in contrast to immission (point data)
- All Input, output and transformation processes are taken into account
- Approach allows simulation of measures for efficiency considerations
- Due to time depending transport processes measures will first affect emission (close to soil surface) and later immission, depending on the depth of groundwater wells

Emission-Immission-Approach

1. Calculation of area based agricultural nitrogen balances using statistical data

2. Calculation of the amount of nitrogen potentially leached from soil into groundwater taking deposition and soil processes into account

3. modelling of nitrate leaching using of geografical data

Data and methodology sources

N-deposition (Builtjes et al., 2001), area based nitrogen balances (Osterburg & Schmidt, 2008), land use (ATKIS) denitrification in soils (Wienhaus et al., 2008), total runoff (GROWA06-2) (Wendland et al., 2003)

1. Calculation of area based agricultural nitrogen balance (surplus)

N balance = mineral fert. N + organic fert. N + legume N - removed N

Area based agricultural balance = N Input - N Output

Following Schmidt et al., 2007

No statewide data available on fertilisation practices or farm nutrient balances!!

Use of statistical data on different spacial scales

- Agricultural statistics (ca. 1000 municipalities): animals, crops ...
- Agricultural statistics (46 districts): yields
- Agricultural statistics (state): mineral fertilizer, sewage sludge, composts
- Empirically derived formula (e.g. mineral fertilizer use on a regional level)

Emission

2. Calculation of the amount of nitrogen potentially leached from soil into groundwater taking soil processes into account

Potentially leached Nitrogen
= N-deposition + N balance surplus + mineralised N* – immobilised N* – denitrified* N

*in the drainage zone of the soil

3. Calculation of the nitrate concentration in the leaching water

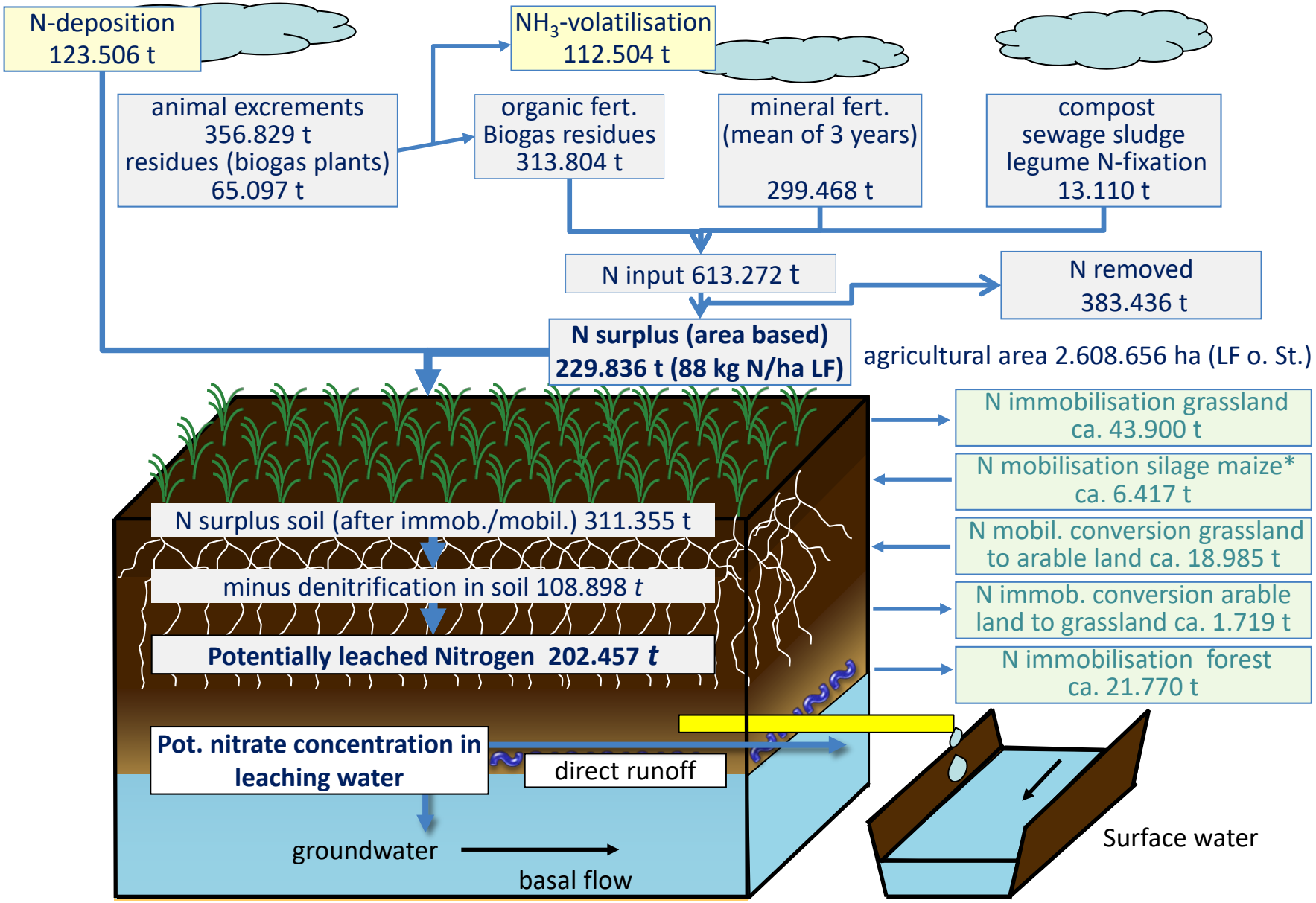
Potential nitrate concentration in leaching water
= potentially leached nitrogen * 4,43/ total runoff

Use of geografical data on different spacial scales (mostly 1:50.000)

- Atmospheric N deposition (wet and dry)
- Land use (arable land, grassland, forest, ...), also land use change
- Soil maps (denitrification, total runoff, field capacity)

To which extent does the nitrate emission from agricultural land use affect groundwater quality?

Annual nitrogen flow on state level (Lower Saxony, 2014)

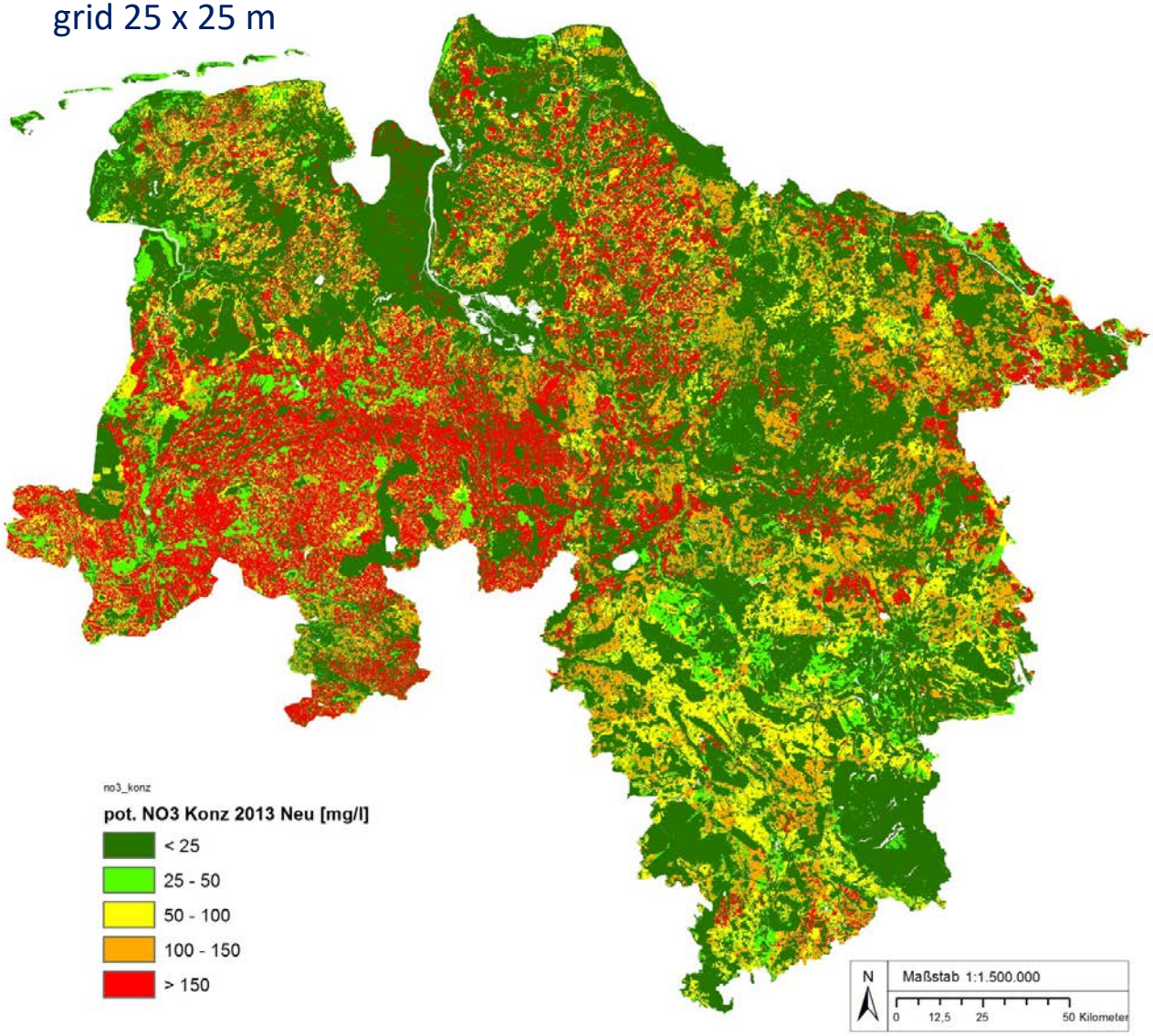


*additional mobilisation due to the extension of silage maize

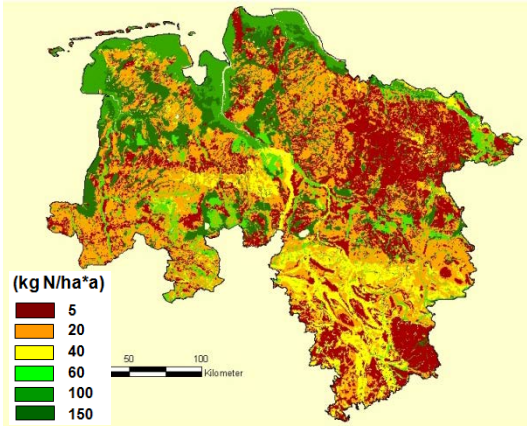
Potential nitrate concentration in leaching water

grid 25 x 25 m

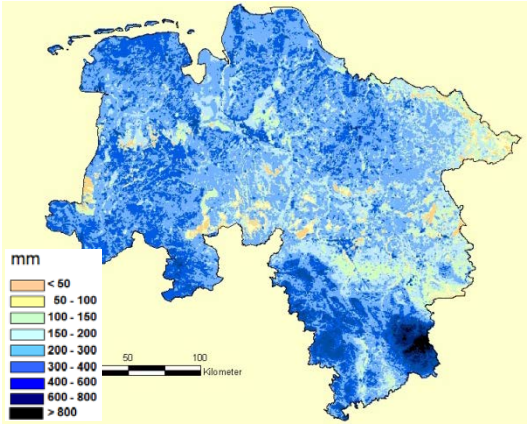
base: mean agricultural N balance surplus of 2007 and 2010



potential denitrification soil

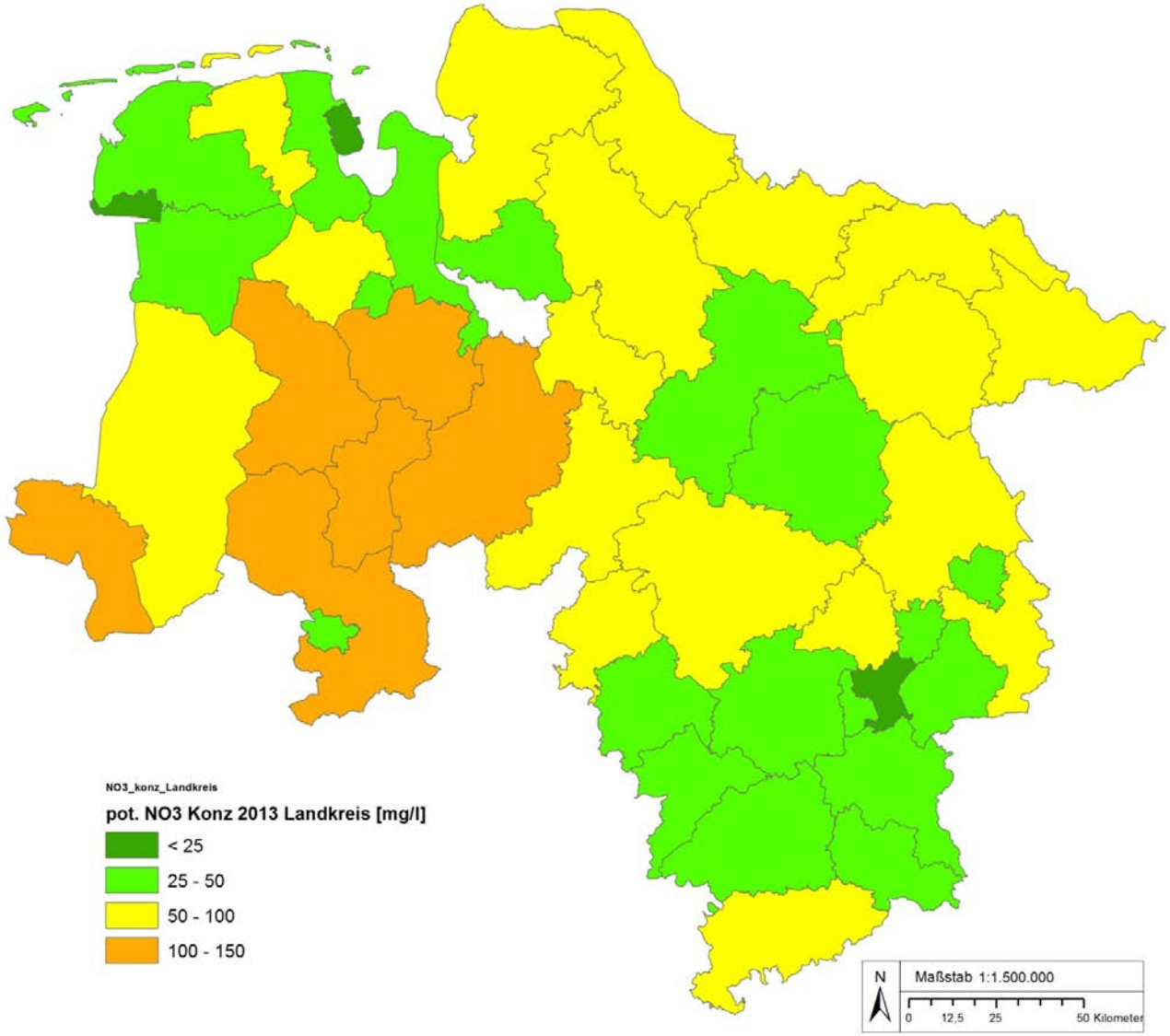


total runoff



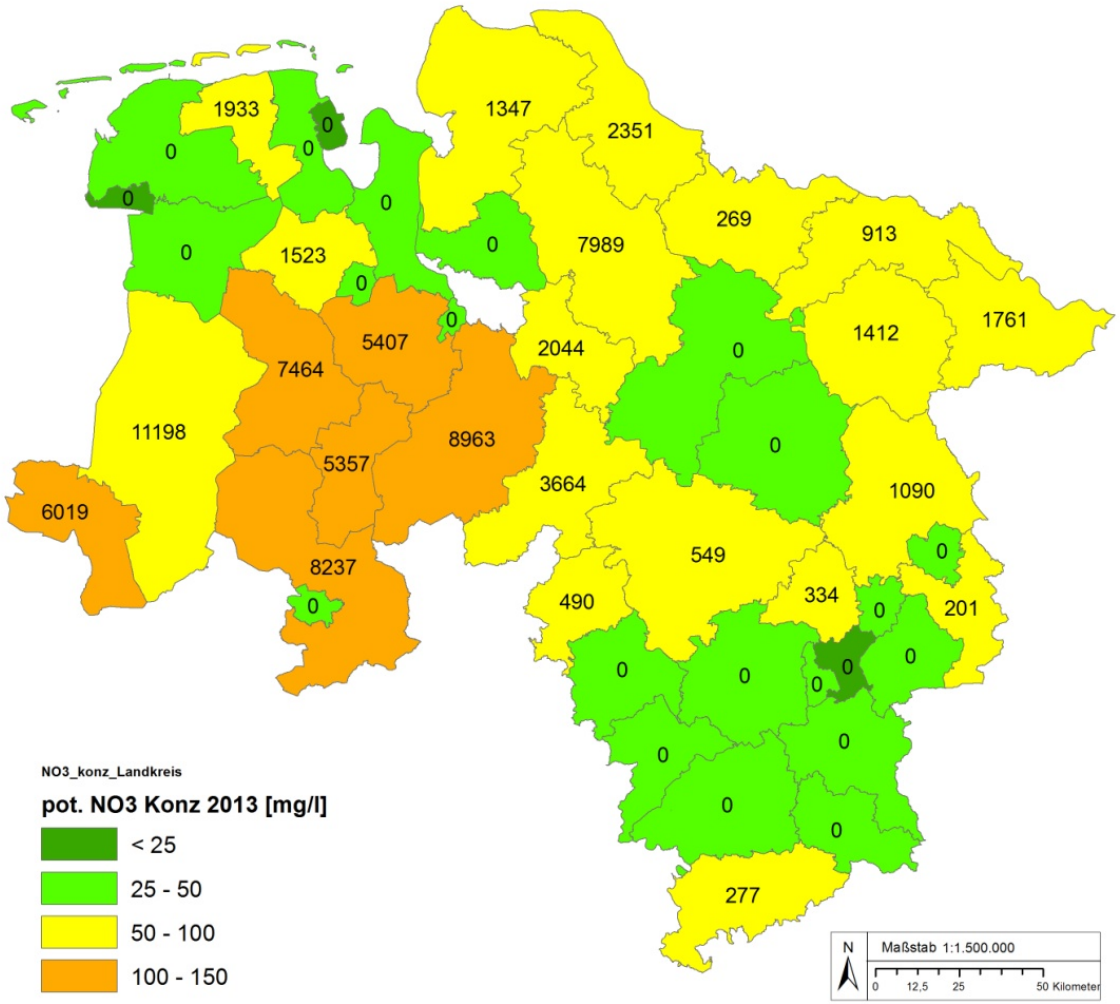
Potential nitrate concentration in leaching water

District level (mean values)



Required reduction of N emission[t] on district level

(to reach a mean concentration of 50 mg nitrate/l in leaching water)



Background:

mean district nitrate concentration (Report 2013)

Ca. 80.000 t
in 24 districts

Which measures are taken?

Measures

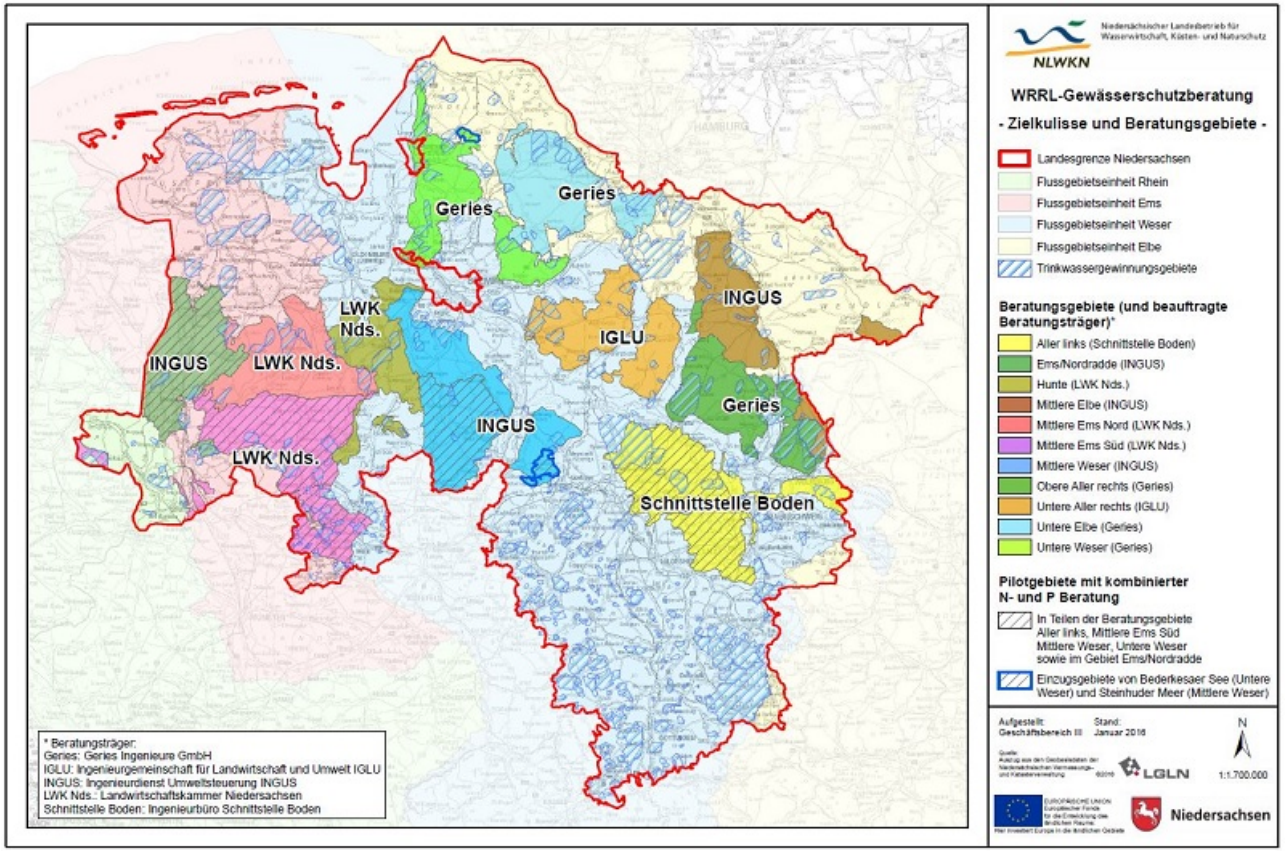
State level: Intensification of agricultural advisory services in hot spot areas

cooperative approach on a voluntary base

participation in agri-environmental programms

regionally combined with surface water protection measures

(e.g. cover crops, reduced fertilisation, flower or grass strips, conversion to organic farming)



Federal level: Amendment of the fertilization ordinance in 2017

- Regulation of the determination of fertilizer requirements
- Regulation of the use of organic fertilizers
- Regulation of maximum N and P balance surpluses on farm level (50 kg N, 10 or 0 kg P2O5/ha/year)
- Regulation of sanctions and control mechanisms

State Level: authorization to issue ordinances

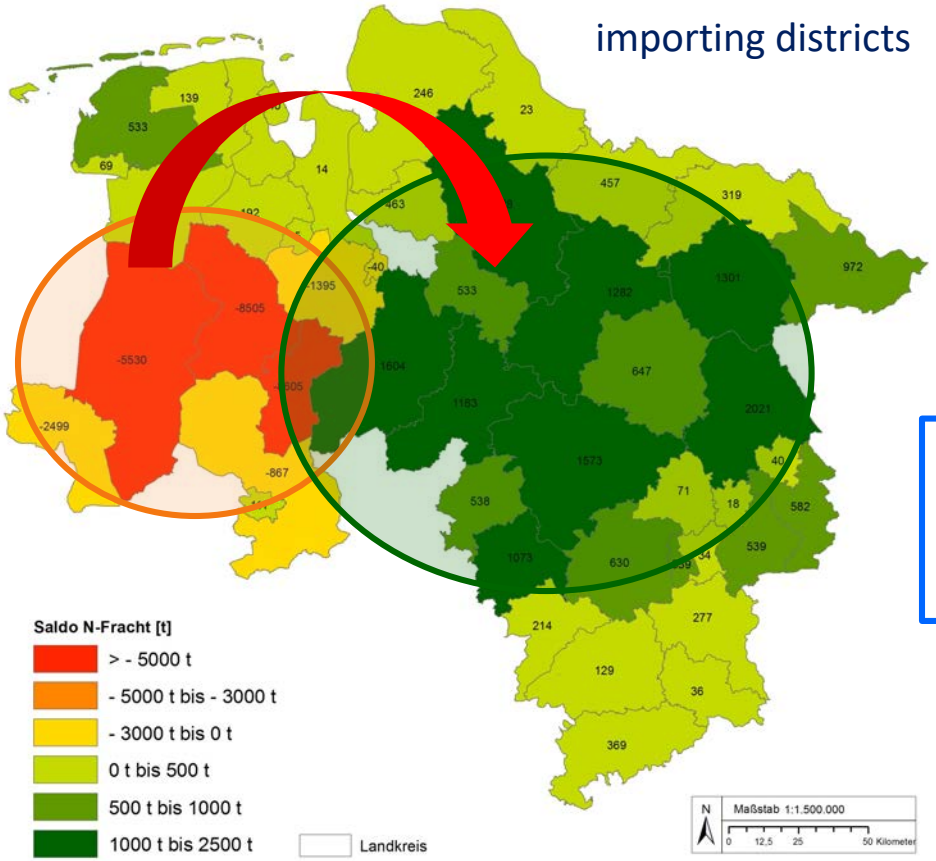
- concerning regions where the status of groundwater bodies is identified as bad
- catchment areas of surface water with significant nutrient inputs by agriculture, especially P
- reporting obligations of farm balances to control authorities

Technical measures

- export, shipment of organic fertilizers into regions with less surplus

importing districts

exporting districts



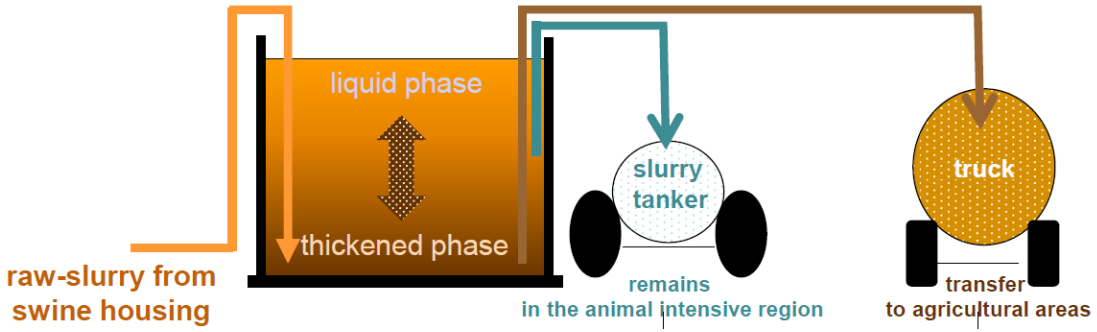
Export on district level in 2015/2016	
net export:	27.000 t N
net import within state	20.000 t N
net export outside state	7.000 t N

Chamber of Agriculture Lower Saxony, 2016

Technical measures

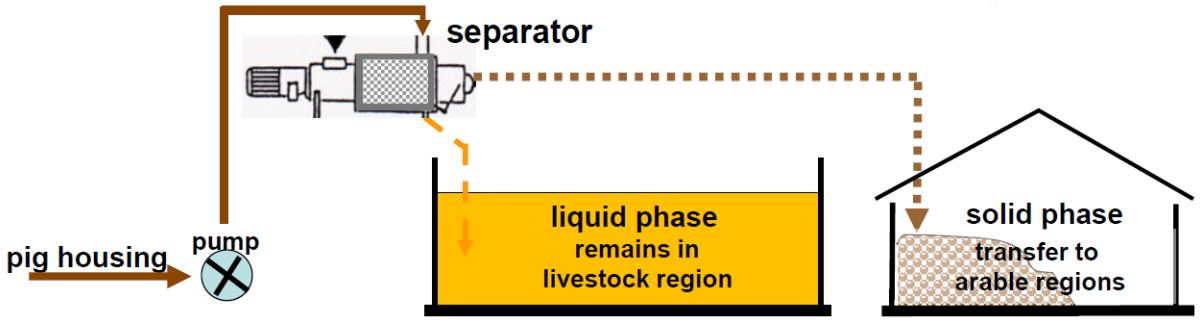
- treatment of organic fertilizers to reduce nutrient specific transport costs

slurry thickening



Kowalewsky (chamber of agriculture), 2015

slurry separation with screw press separators



- reduction of animal density

Conclusions

Conclusions

- A method was developed to estimate the effects of nitrate emission from agricultural land use on groundwater quality in Lower Saxony, a Northwest German state

- The mean annual area based nitrogen surplus was estimated
  88 kg N/ha agricultural land without deposition
  113 kg N/ha agricultural land including deposition

- A reduction of the nitrogen surplus by 80.000 t/year is necessary to reach a mean value of 50 mg nitrate/l in the leaching water in the mean of the district areas.

- Different, voluntary or legislative measures are taken on the state or federal level to reduce the nitrogen surplus

- The measures to mitigate the nitrogen surplus on the emission side will take time to reduce the nitrate concentrations in the groundwater (immission)

Thank you for your attention!