Food Safety and soil quality
Conceptual framework and examples

Bert-Jan Groenenberg Paul Römkens
Alterra – Wageningen UR

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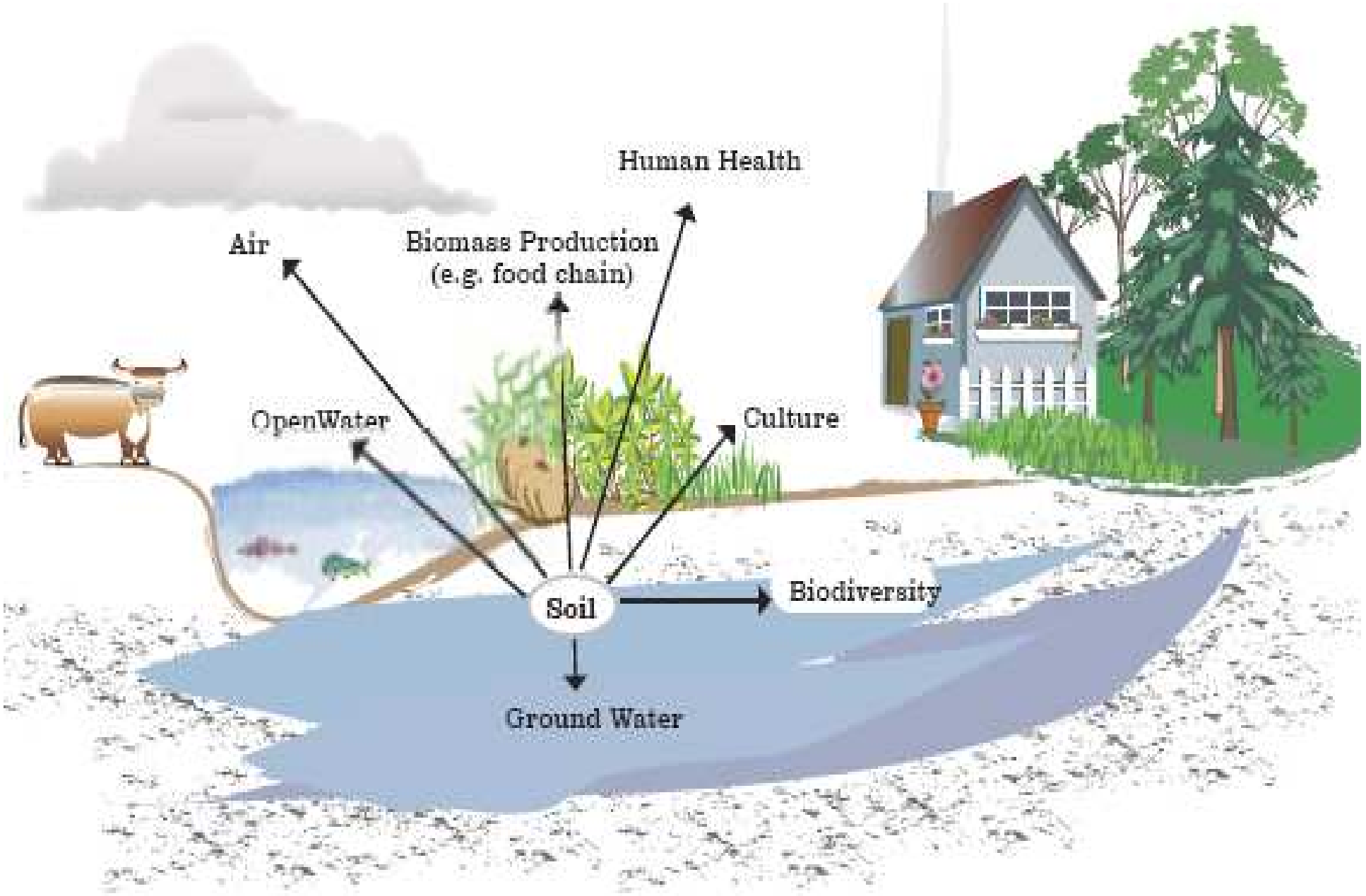
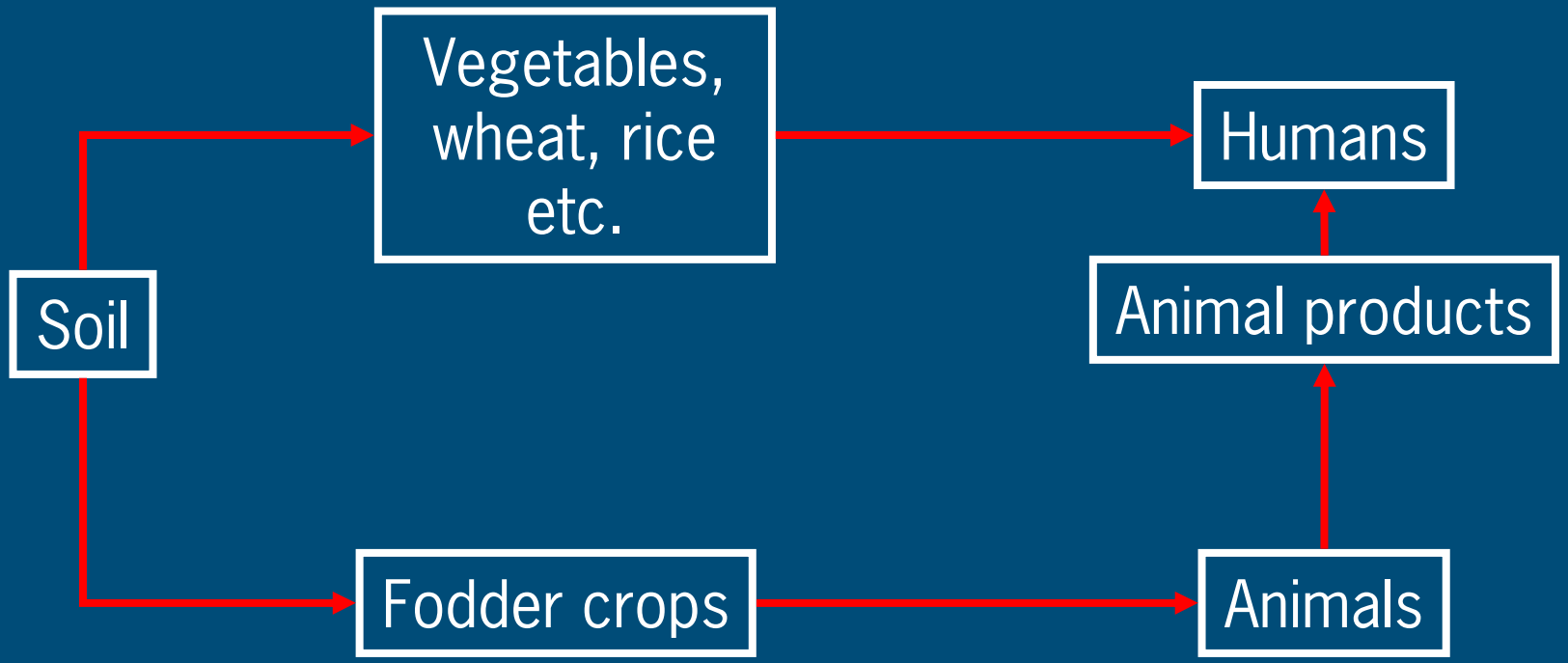
Outline

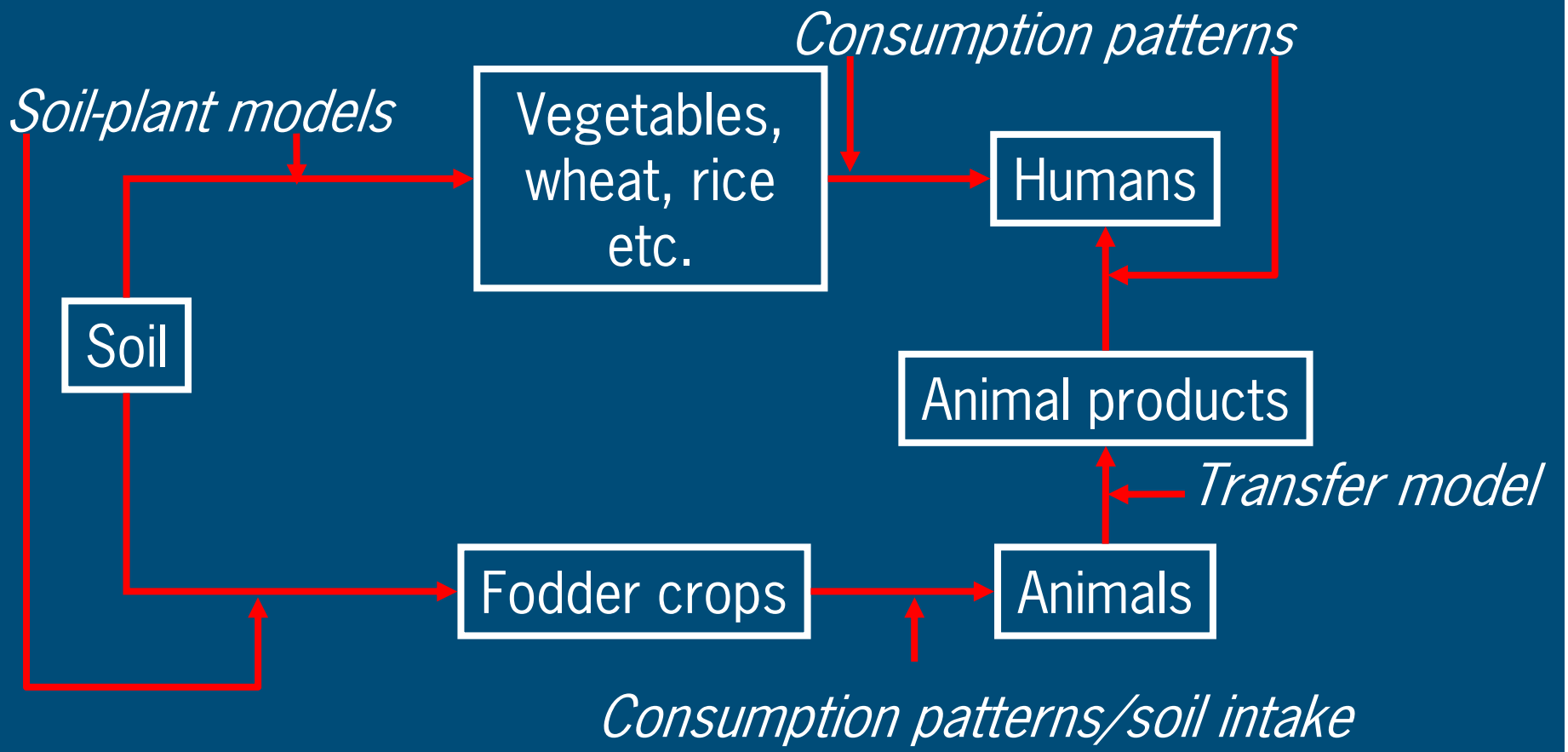
- Conceptual framework and soil standards for agriculture in Dutch legislation
- Case study Kempen area (Netherlands and Belgium)
- Scenario studies for the Netherlands


Human Health
Air
Biomass Production
(e.g. food chain)
OpenWater
Culture
Soil
Biodiversity
Ground Water

Food safety and soil quality: the concept

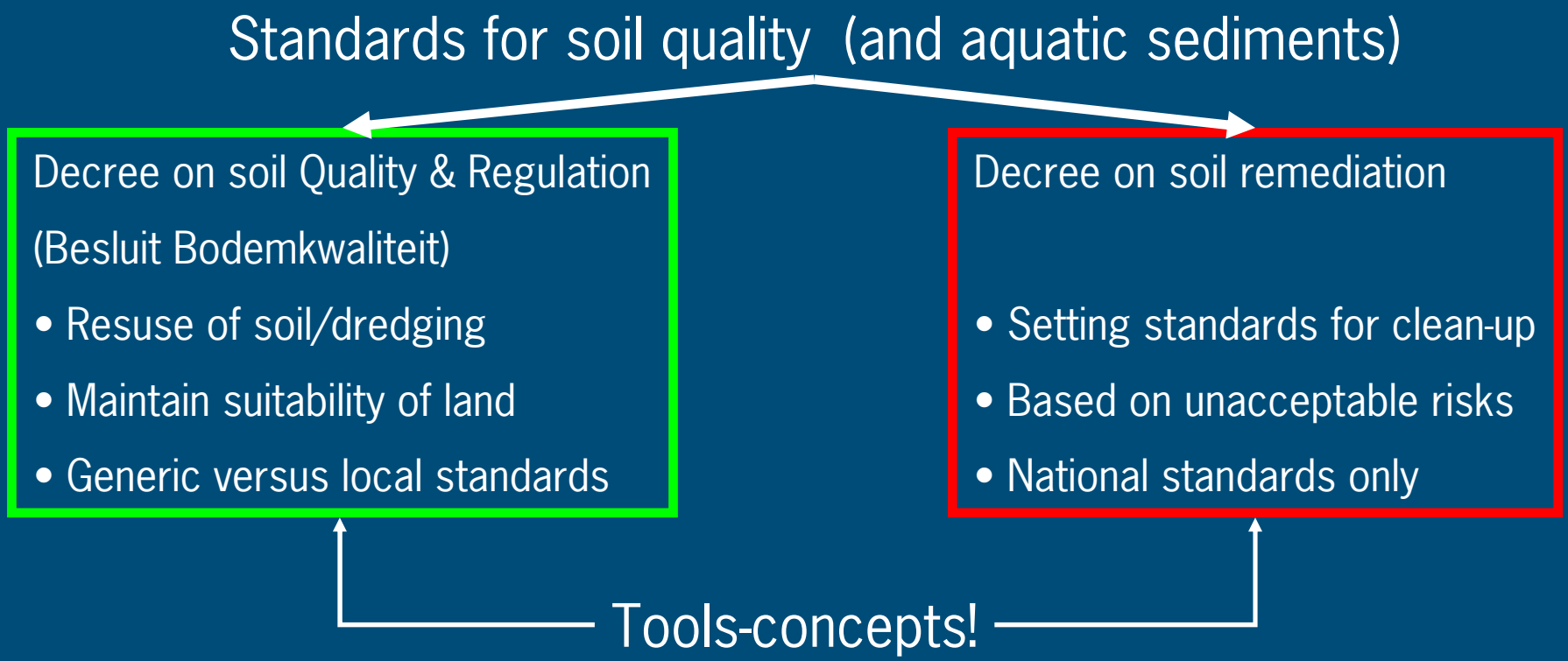


Food safety and soil quality: tools



Soil pollicy in NL: management versus cleanup

- One framework but two legal instruments

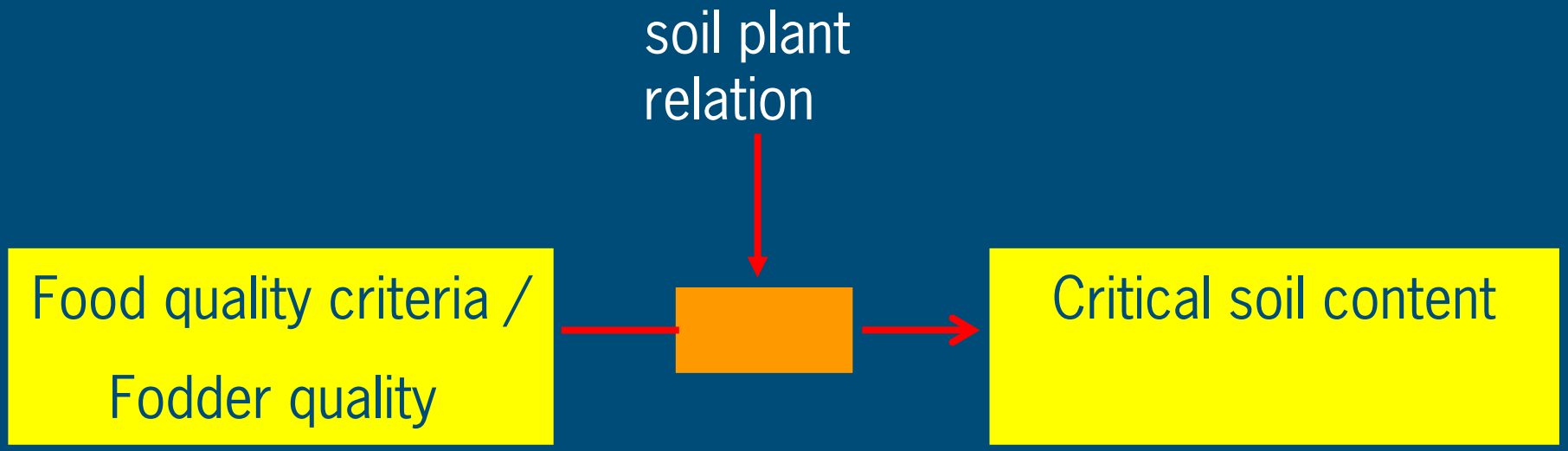


Soil standards for Agriculture

- Back calculation from relevant criteria to protect human and animal health (e.g. critical levels in food) to critical levels in soil taking into account:
  - Bio-availability
  - Differentiation between crops / land use (grass land / arable land)
  - Chain analysis (soil inputs) -> soil ->plant ->animal ->human

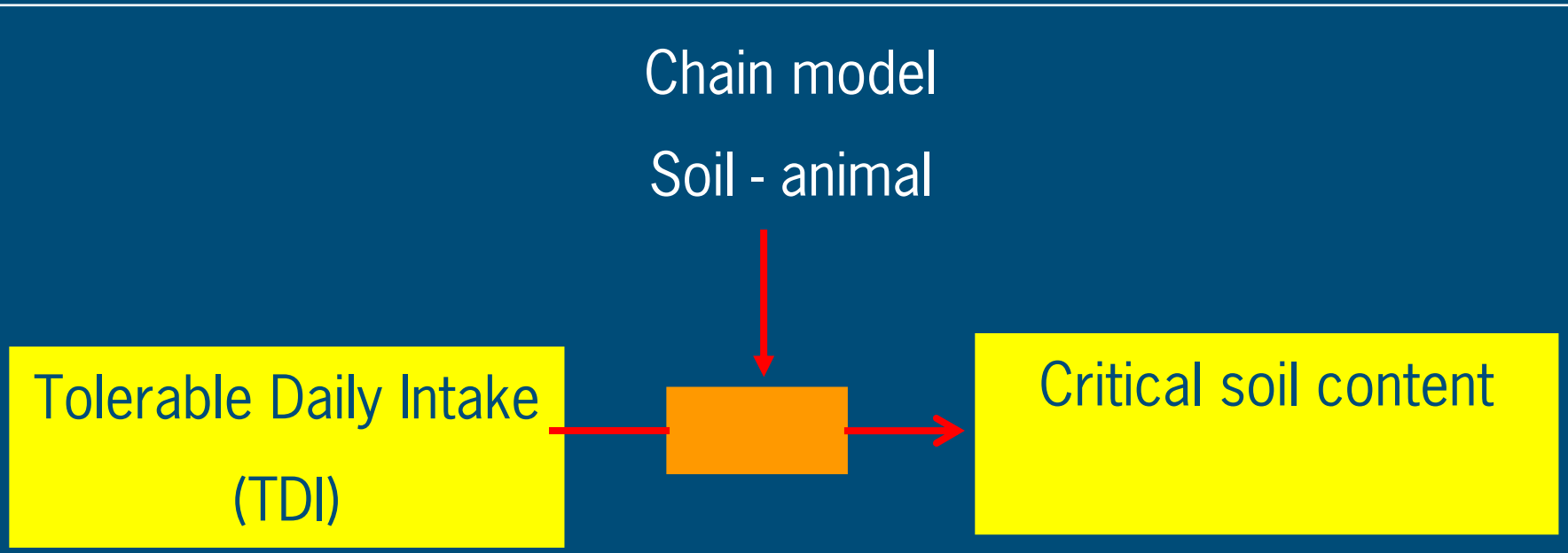
Standards for Agriculture: what to protect?

- Relevant criteria for protection
  - Fodder quality (for Cd = 1 ppm at 12% moisture)
  - Health criteria cattle (critical levels in kidney and liver)
  - Food quality criteria animal products
  - Food quality criteria for arable crops (vegetables, rice etc.) and animal products (meat, milk etc.)
  - TDI for human beings (0.5 for Cd and 3.6 for Pb)



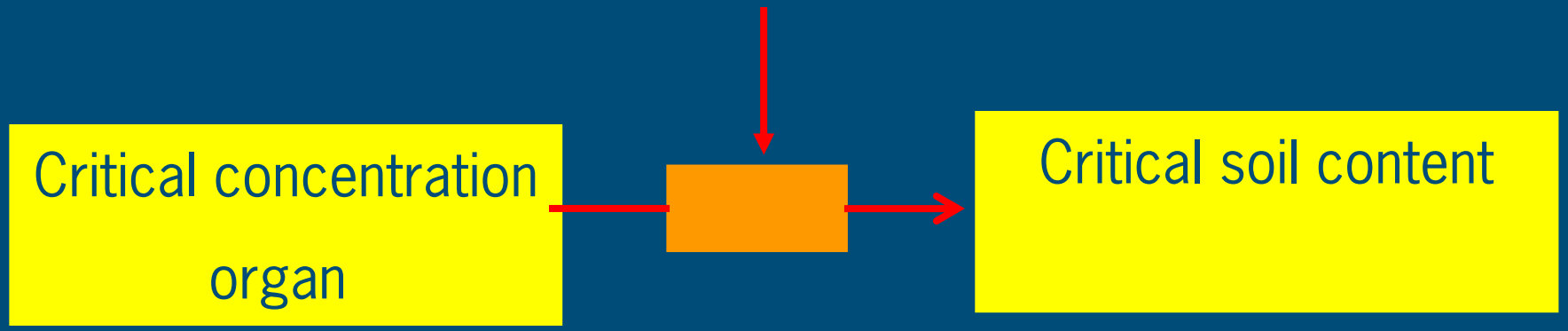
log(Cd-plant)=

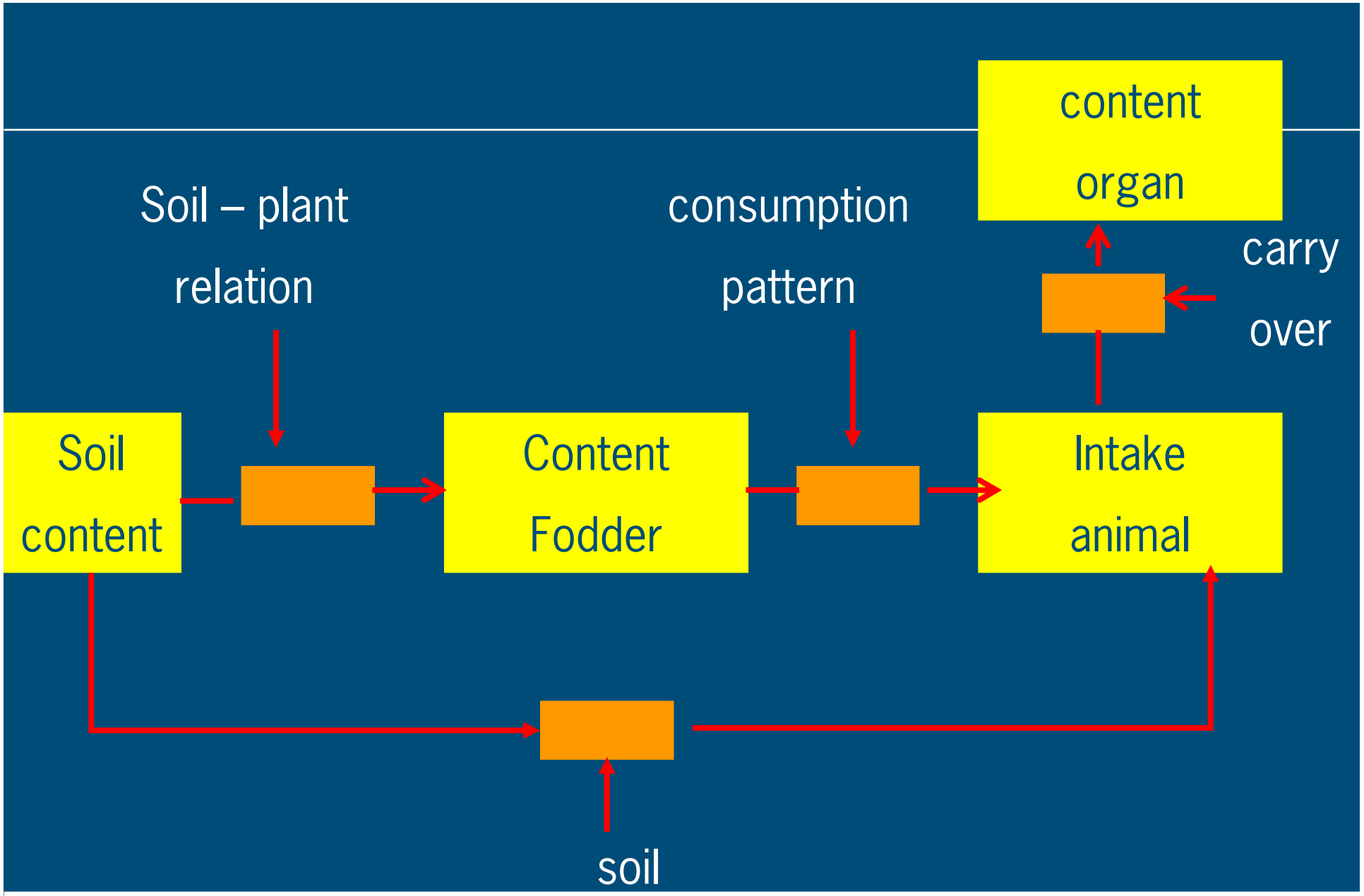
int + a*pH + b*10log[SOM] + c*10log[Cd-soil]


Chain model
Soil - animal
Tolerable Daily Intake
(TDI)
Critical soil content

Chain model

Soil - animal




content
organ
Soil – plant
relation
consumption
pattern
carry
over
Soil
content
Content
Fodder
Intake
animal
soil
ingestion

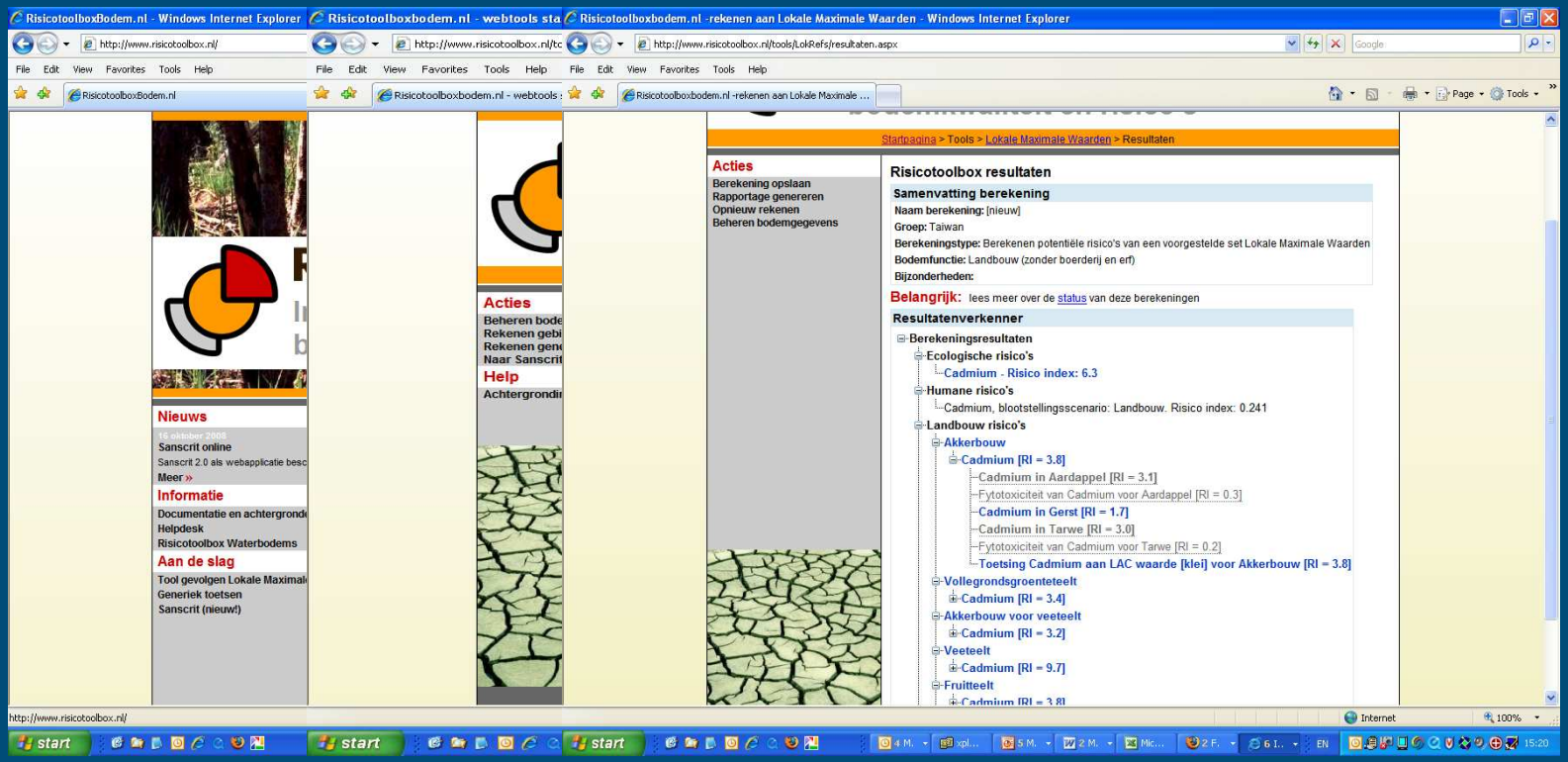
Local Standards for Agriculture: examples

		Land Use					
		Arable Crops			**Fodder production**		
	Soil type:	sand	clay	peat	sand	clay	peat
Arsenic	As	30	50	50	30	50	50
Cadmium	Cd	1	1	2	1	3	2
Chromium	Cr	100	180	140	100	180	140
Copper	Cu	50	160	200	50	80	80
Mercury	Hg	2	2	2	2	2	2
Lead	Pb	100	200	200	100	200	200
Nickel	Ni	15	50	60	15	50	60
Zinc	Zn	150	350	350	150	660	720

- Values must be higher or equal to Background values
- Values cannot exceed Intervention value
- Values in red changed
- Model calculated values sometime less strict than fixed values

Internet tools

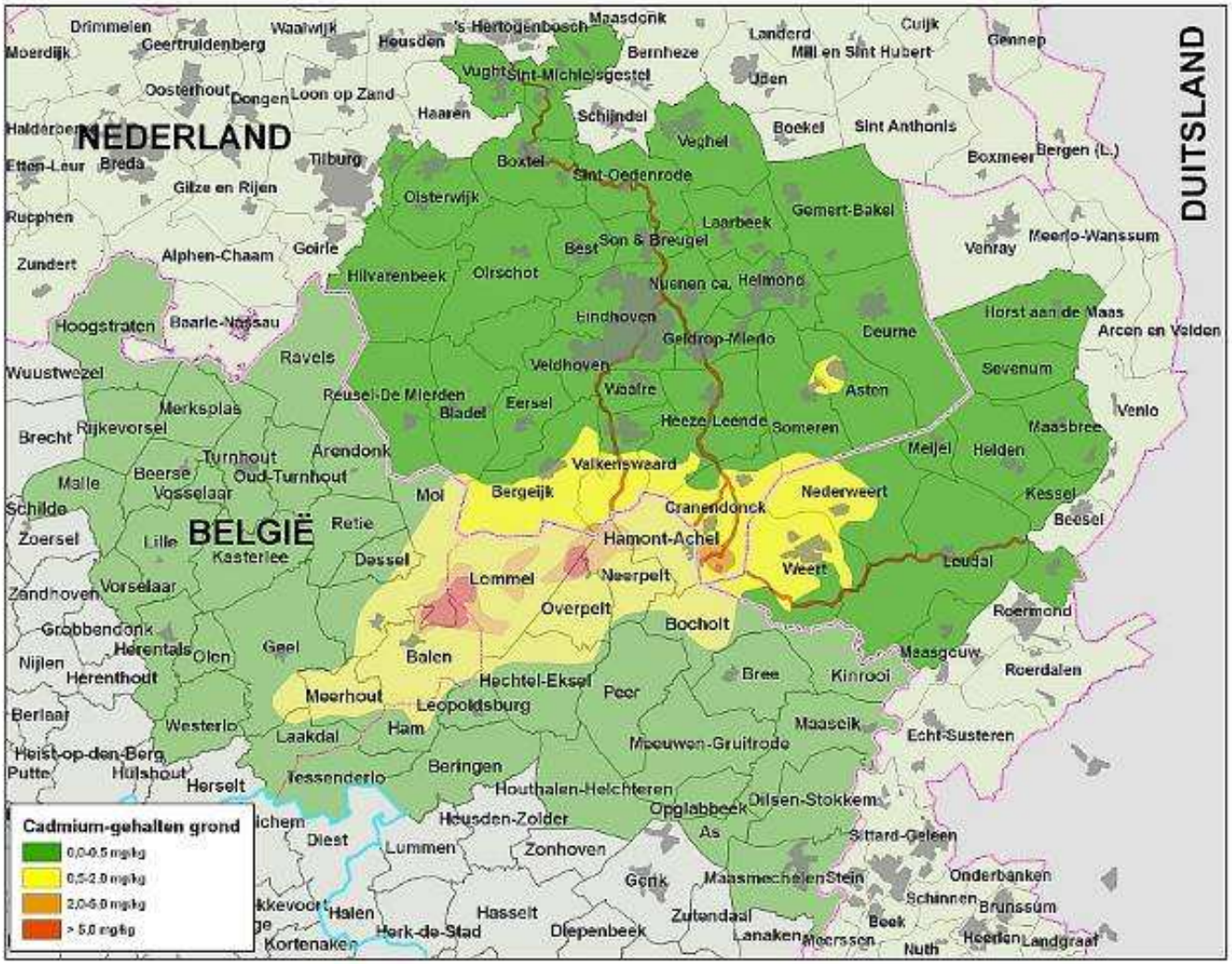
As of 2007, Internet based tools are available to calculate national/local maximal values



Examle 2: Kempen area

- Kempen Area (NL/B):
  - Input of Cadmium (and Zinc) to soil through thermal ore processing until mid-1970's
  - Affected area pm 350 km^2
  - Soils: sandy, acid, low organic matter
  - High mobility and (bio)availability of cadmium in soil
  - Leaching to ground/surface water: impact on ecosystem
  - Intake by grazing animals: animal health/quality animal products
  - Uptake by crops: quality of arable crops
  - Exposure of human beings: health effects?

The Kempen Area: cross border problem



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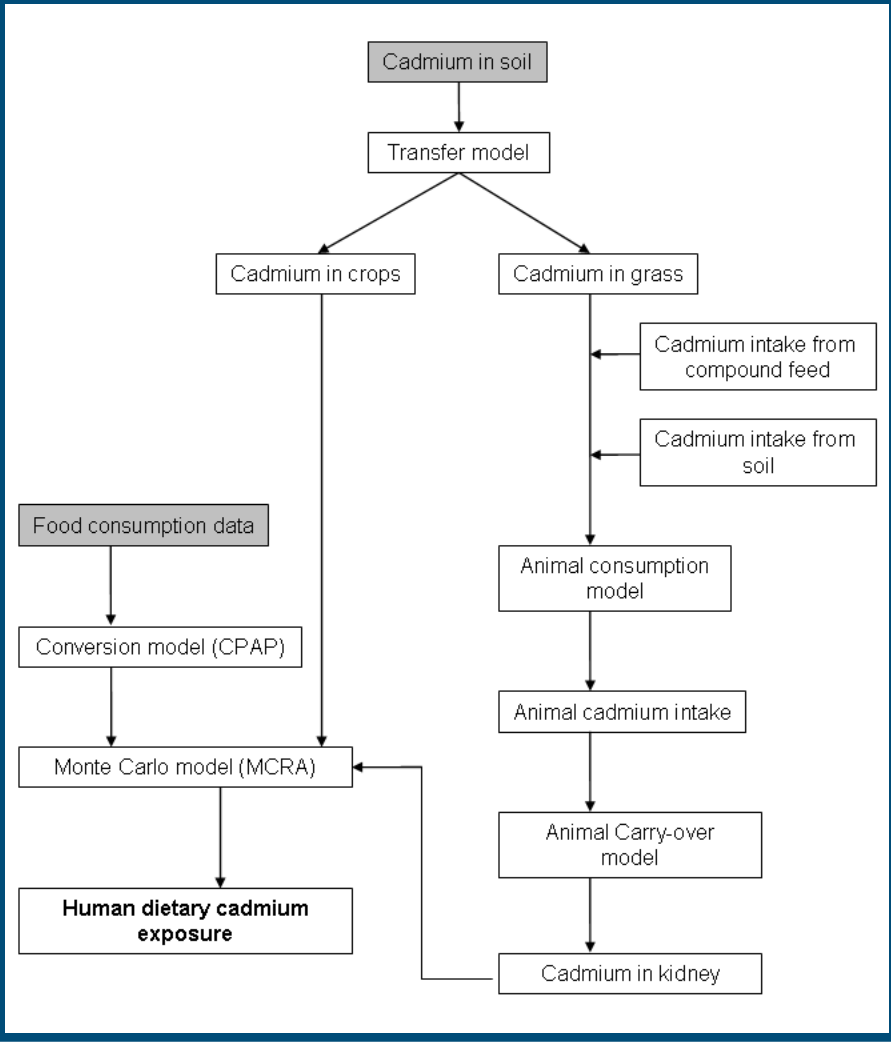
The question

- What impact has cadmium in soil on exposure of cattle and humans?

The Approach: chain model (from soil to salad)



1. Soil to Crop model (field data) by ALTERRA
2. Animal Consumption Patterns by ASG
3. Animal Carry-over Model by RIVM
4. Food consumption and dietary exposure model by RIKILT

Basic Needs

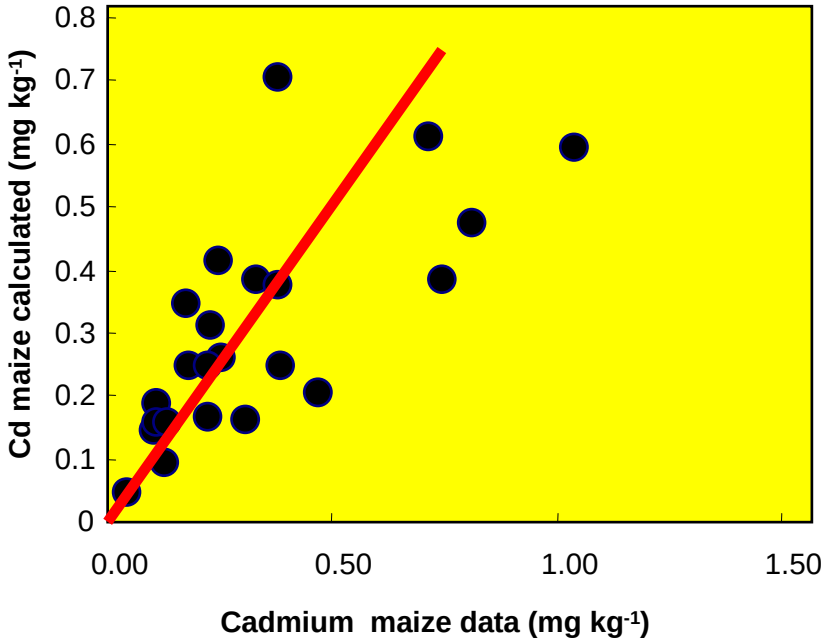
- Soil map: organic matter, pH, clay content
- Soil cadmium map
- Data on soil and crop quality: soil – plant model (field data!): fodder and arable products
- Data on consumption of cows of different age
- Data on levels of Cd in different animal products
- Data on average (and range in) consumption patterns of people

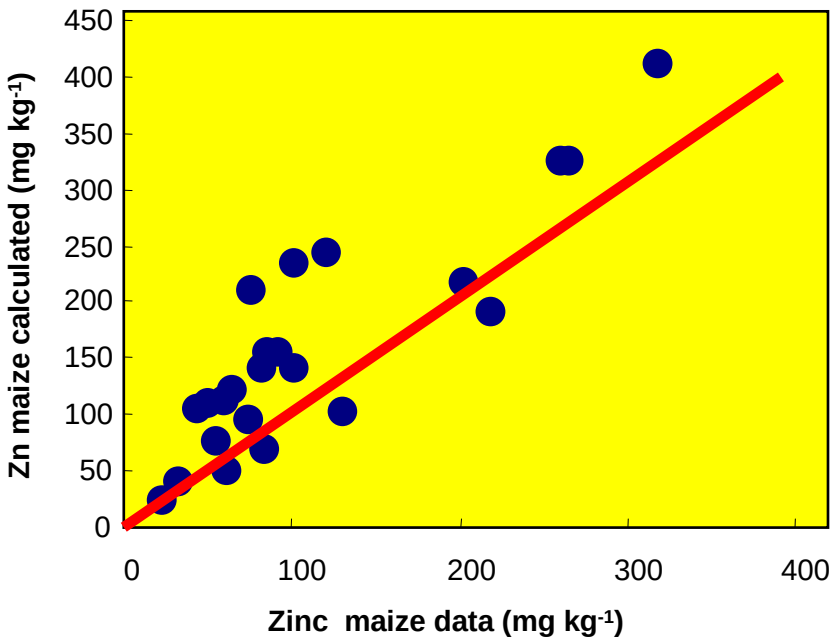
Soil – Plant Model

- Soil : plant
  - non-linear Freundlich-type model including effect of pH, organic matter and Cd-soil (Brus et al., 2005)
- $^{10}\log(\text{Cd-plant}) = \text{INT} + a*\text{pH} + b*{}^{10}\log[\text{Org Mat}] + c*{}^{10}\log[\text{Cd-soil}]$
- Calibration based on field data

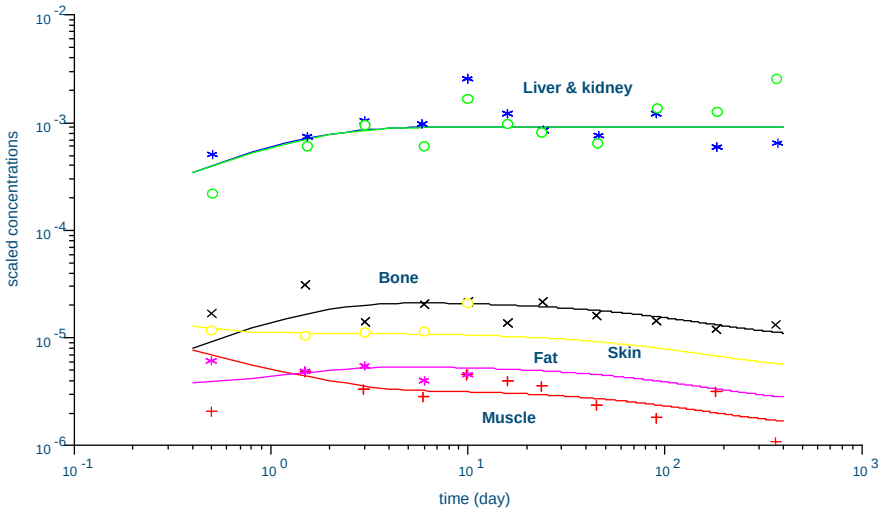
Soil – Plant Model

Measured vs predicted levels of Cd and Zn in fodder





Accumulation of Cadmium in kidneys



Model derivation:
Beresford *et al.* (1999, 2001)

Model validation:
Crout et al., (2004)

Conclusions:

1. No excretion (Cd) in kidney
2. Derivation of linear BTR
3. Short term study….

Food Consumption and Exposure

- Based on 12500 measured food consumption patterns
- Intake based on MCRA (Monte Carlo Risk Assessment program version 6 (de Boer et al., 2007).
- Variability distribution of short-term intakes
- The exposure was modeled for the total population (1-97 years, 36.3 years, 62.8 kg, n=6250) and for children (1-6 years, 3.6 years, 17.1 kg, n=530).

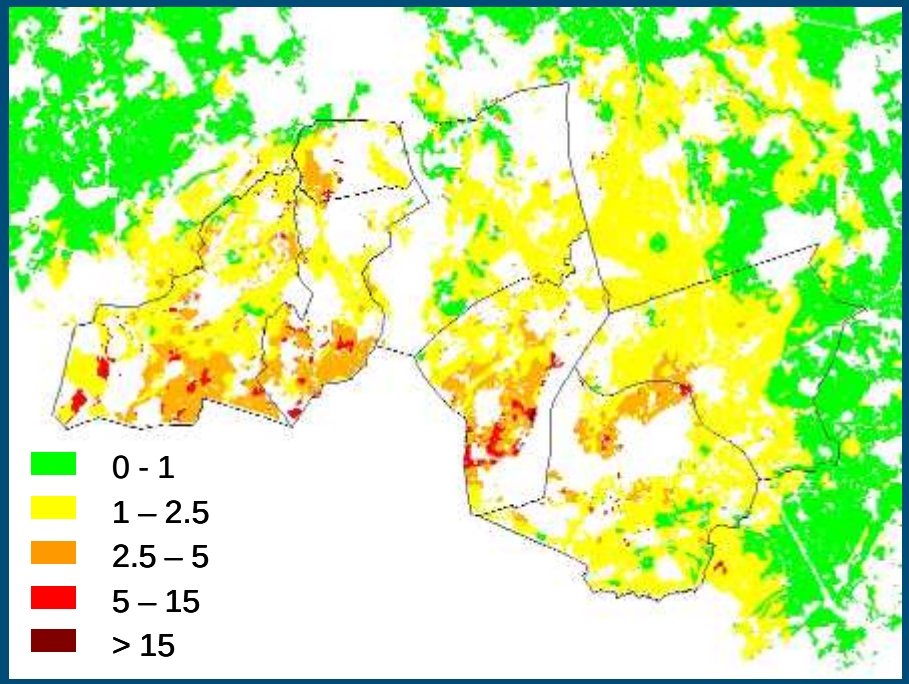
Human Exposure: scenarios

A. NL scenario (average consumption from non-polluted areas
B. Kempen scenarios (100% consumption from Kempen)

Scenario	Cadmium level soil (mg kg^{-1})	pH	Description
1	0.5	4.5	Clean – low pH
2	0.5	5.5	Clean – high pH
3	1.0	4.5	Average – low pH
4	1.0	5.5	Average – high pH
5	2.5	4.5	Contaminated – low pH
6	2.5	5.5	Contaminated – low pH

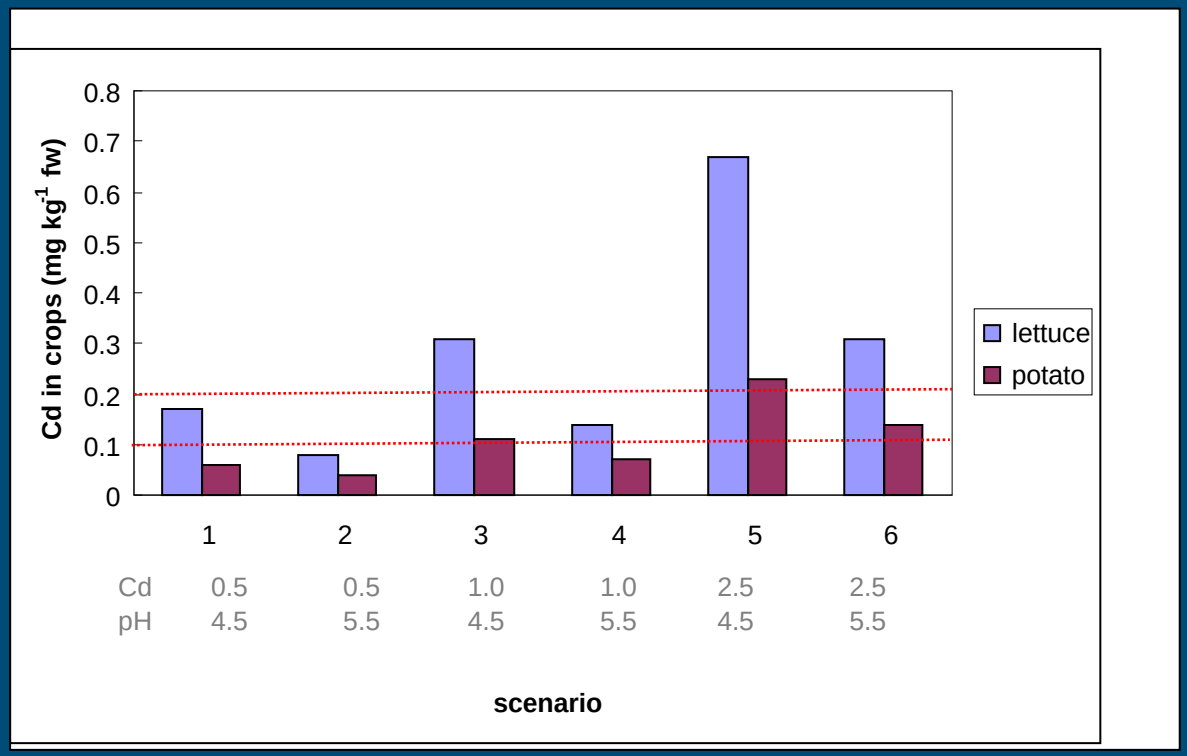
Quality of organ meat in the Kempen area

Predicted Cadmium levels in kidneys of cows (6 yr)



Conclusion: Cd in organ meat exceeds acceptable level as set by EU regulations

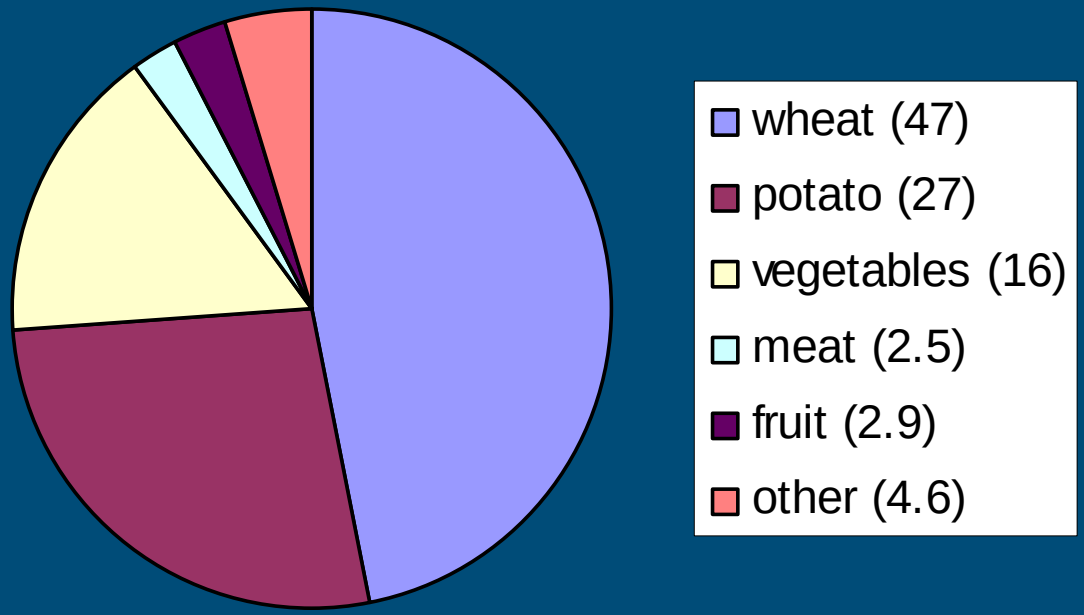
Quality of Arable products in scenarios



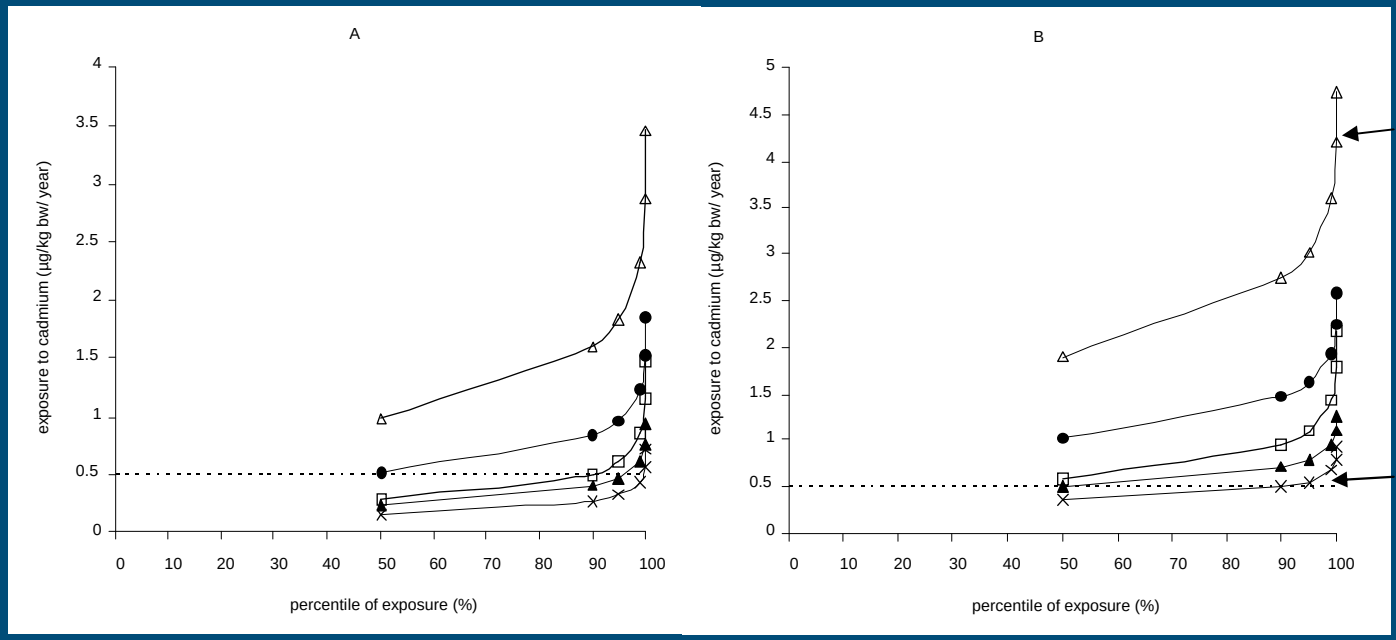
Quality of products like beans, cucumber is OK in all scenarios

Human Exposure: Results

- Contribution to exposure:



Exposure: variability and distribution



Worst case scen.

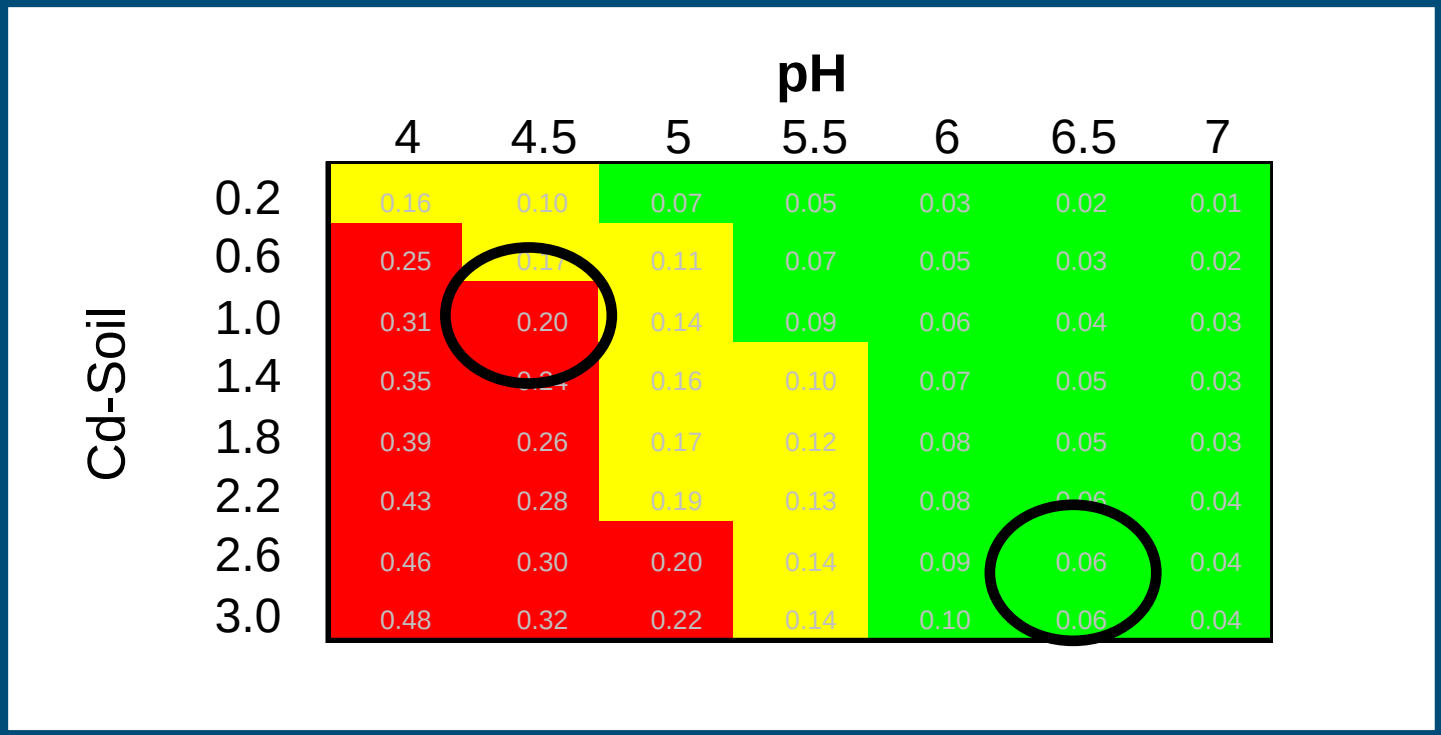
Nat. monitoring data

1 – 97 yrs

< 6 yrs yrs

Source: Franz et al. (2008)

Practical Solutions: Look-up Tables



Example 1: Cd-soil 1.0, pH 4.5 **Quality insufficient**

Example 2: Cd-soil 3.0, pH 6.5 **Quality Sufficient**

Conclusions (I)

- Chain model gives insight in impact of soil quality on exposure in food chain;
- Small additional exposure in Kempen area;
- Risk area (soils > 2 ppm and pH < 5) is small

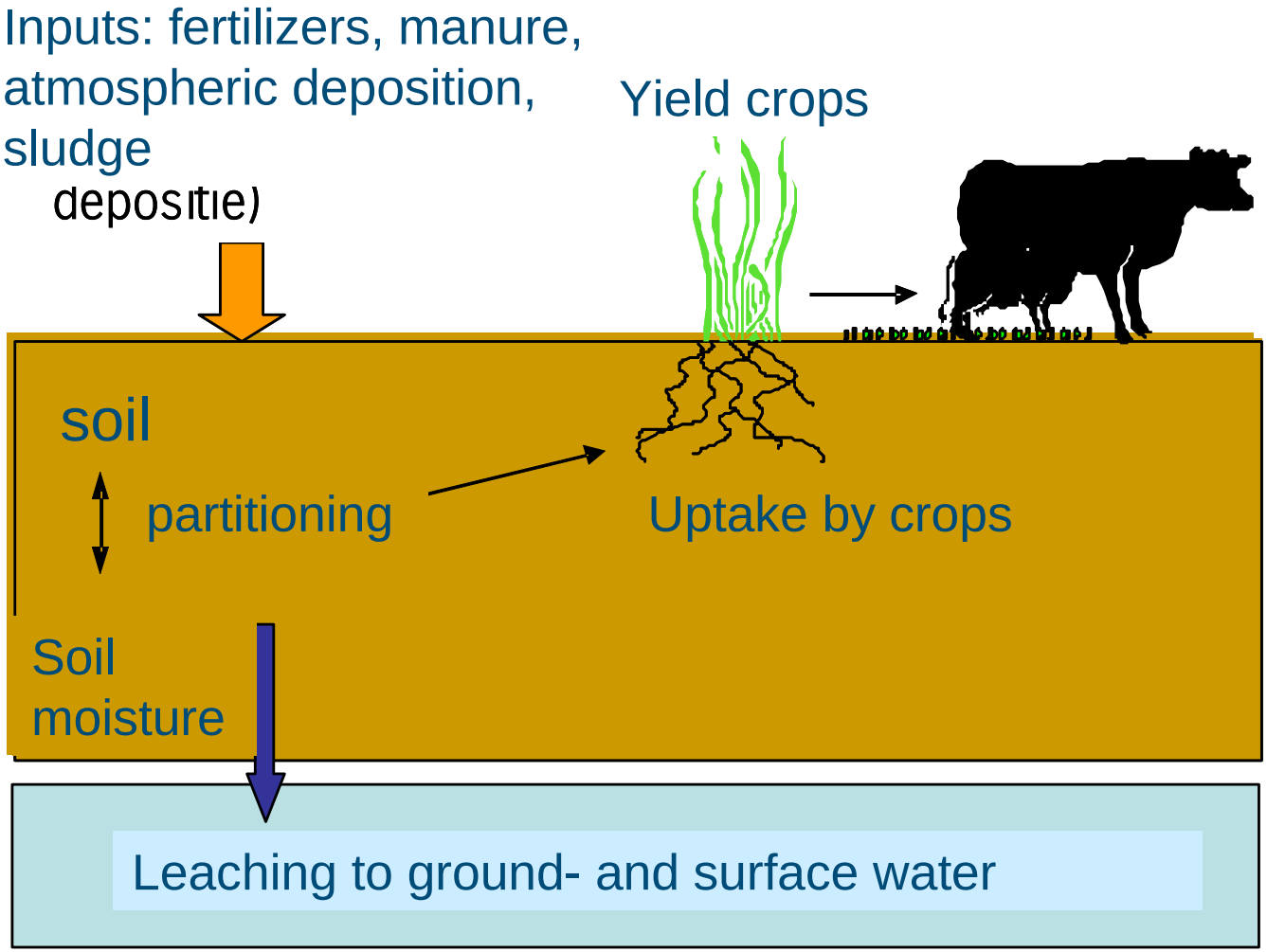
Conclusions (II)

- Measures to reduce risks relatively easy (increase soil pH);
- Advice not to grow lettuce, endive and celery in peoples gardens;
- Model approach can be easily adapted to local/regional conditions;
- Applicable on field level and regional/(inter)national level;
- Uncertainty in some model parts can be considerable (transfer into animal organs).

Examle 3: scenario studies metal balances

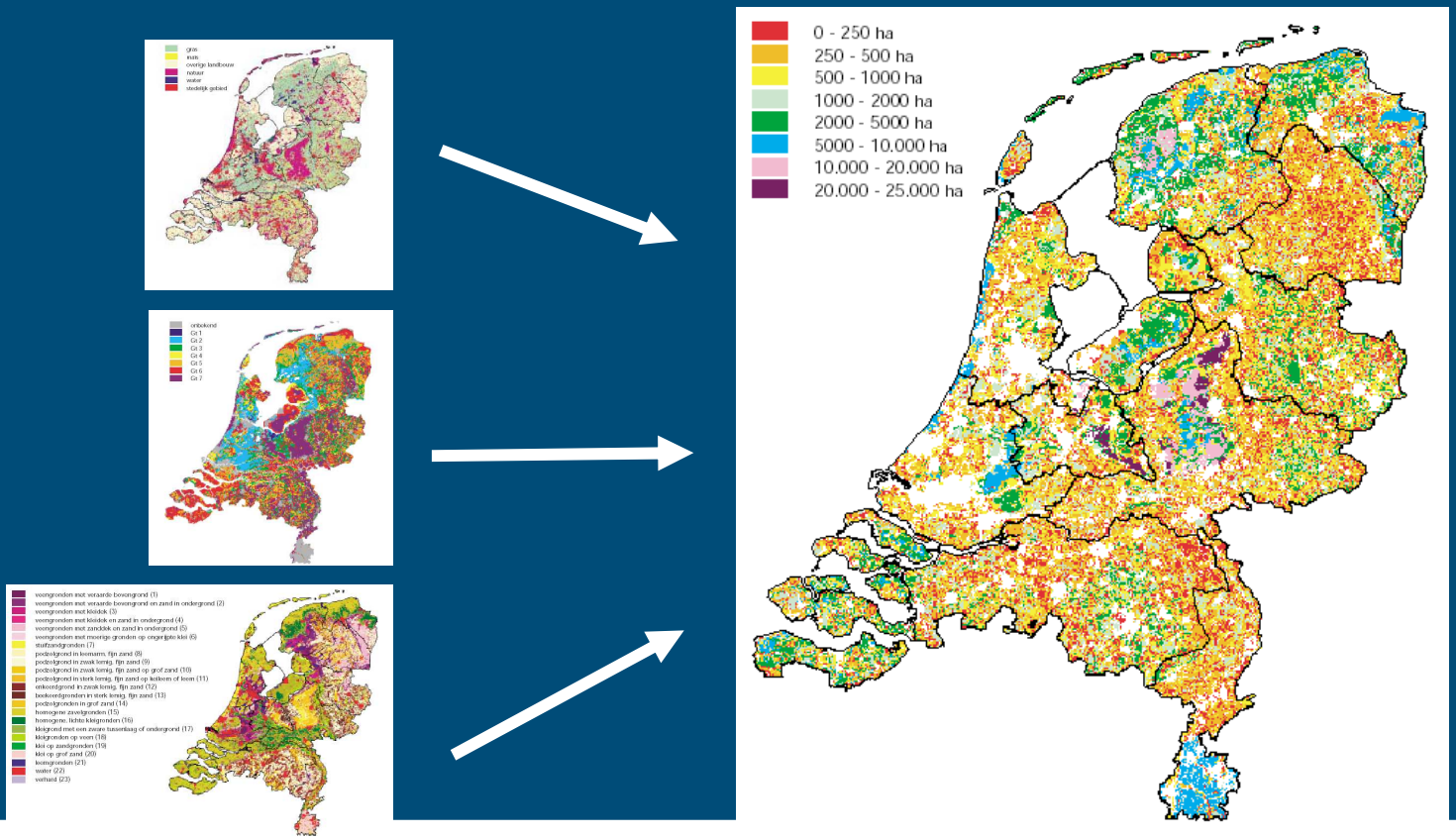
"in the
long term input of heavy metals resulting from applications of manure and fertilisers must be balanced by the output, which is the amount leaving the system via crops and leaching to groundwater. The balance must be set in such a way that the ecological health of soil is maintained, **concentrations of substances in crop or animal products do meet standards for food safety** and **the flux to groundwater does not lead to pollution of ground- and surface water**"

Source: REPORTS OF THE TECHNICAL WORKING GROUPS STABLISHED UNDER THE THEMATIC STRATEGYFOR SOIL PROTECTION VOLUME – IV CONTAMINATION AND LAND MANAGEMENT

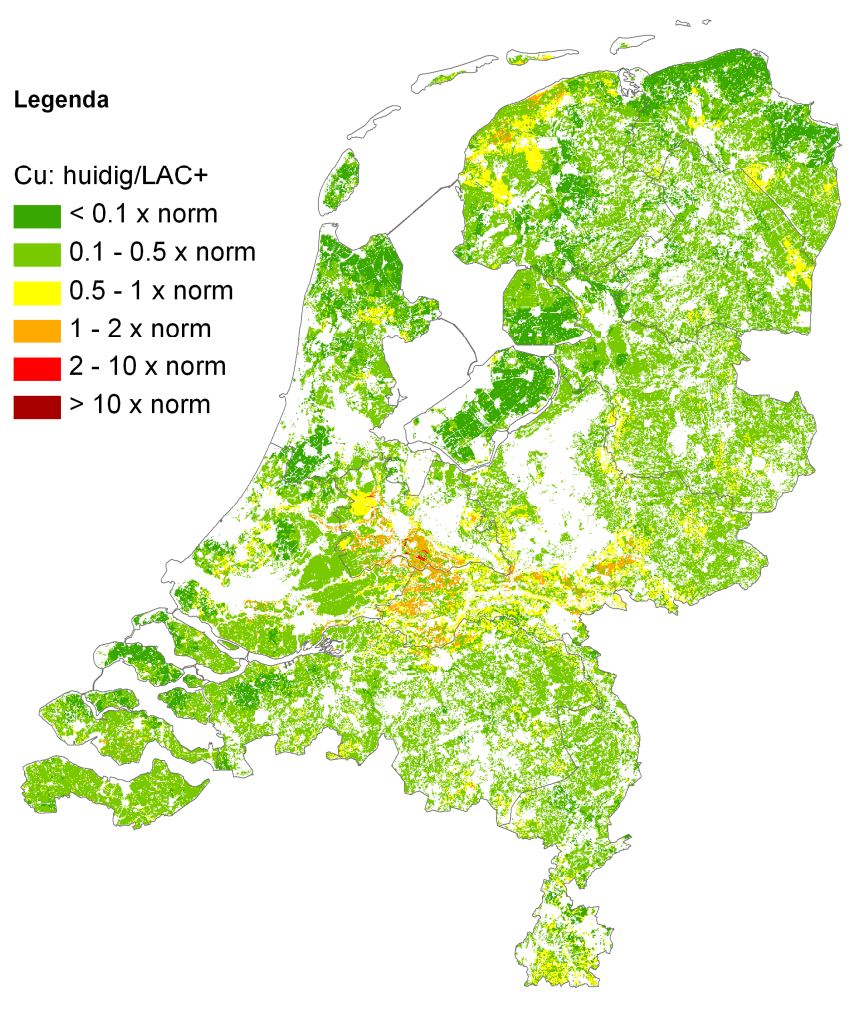

Inputs: fertilizers, manure, atmospheric deposition, sludge
deposition)
Yield crops
soil
partitioning
Uptake by crops
Soil moisture
Leaching to ground- and surface water
Water

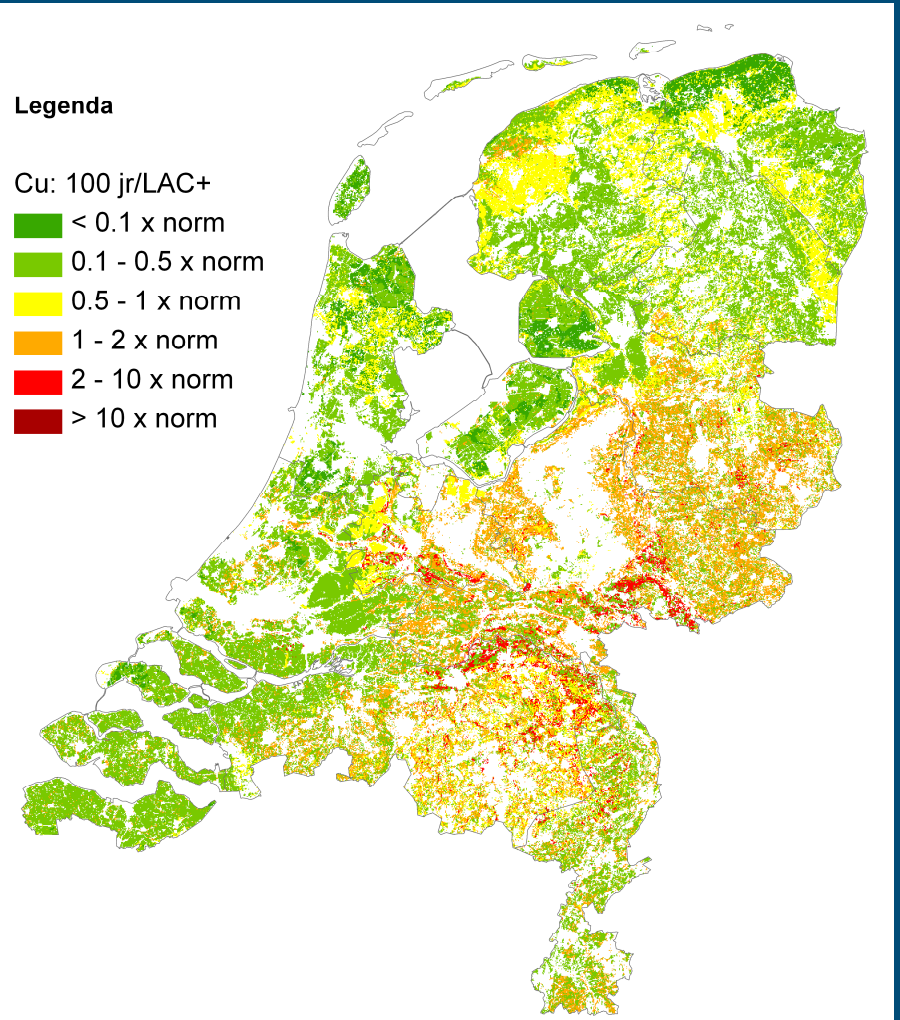
Regional scale

Netherlands in 6405 unique units: combinations of soil type, hydrology and land use



scenario studies





- Framework can be used from local to national scale
- Concept is general applicable (not country specific)
- EU: harmonisation of concepts rather than harmonisation of standards

Acknowledgements

- Ministry of Agriculture, Nature Conservation and Food Quality (NL)
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Merci pour votre attention

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