Pesticide Risk Reduction Programme – Ethiopia

Groundwater: model, vulnerability and scenario selection procedure

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joint collaborative programme on pesticide registration and post-registration

MoA

ALTERRA

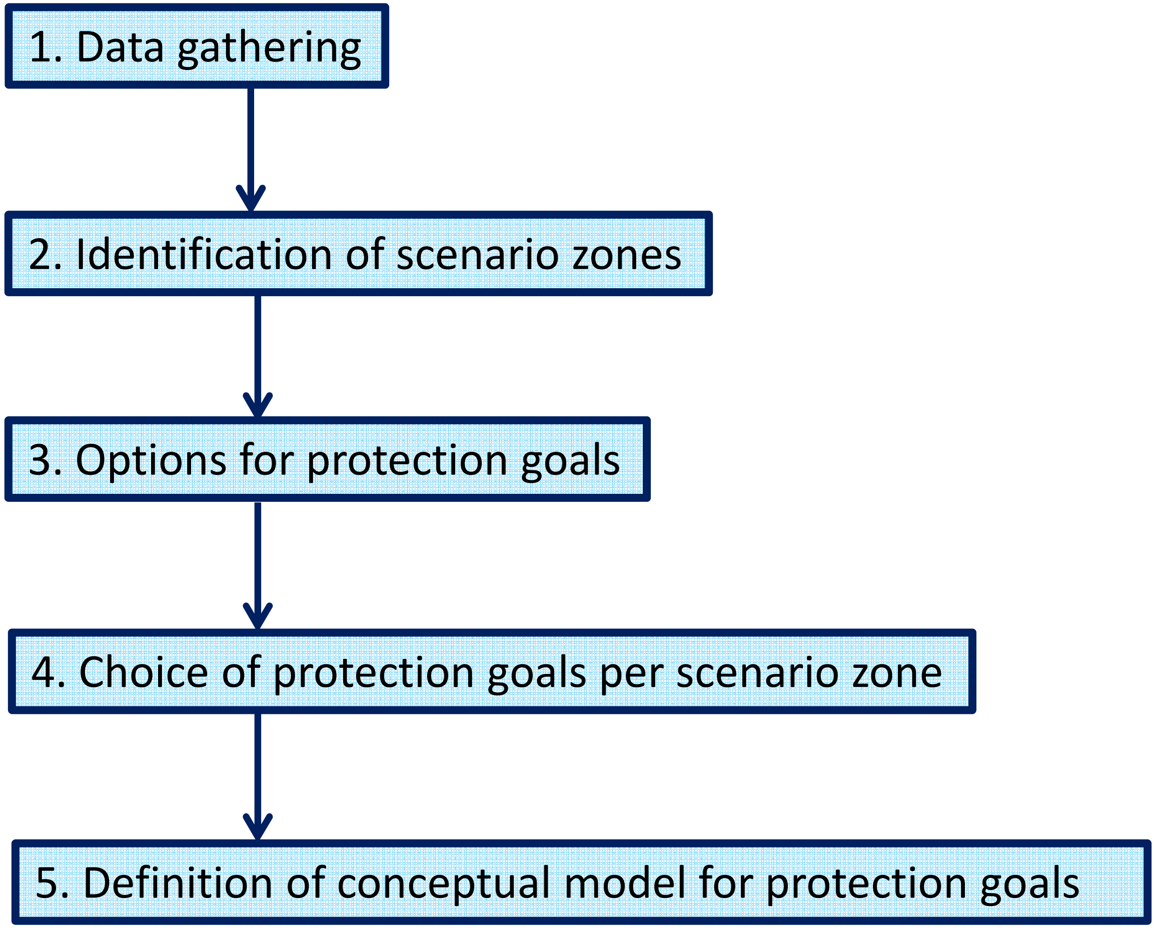
Towards a sustainable use of pesticides in Africa

Definition of gw protection goals

Outline

- Model selection and explanation
- Vulnerability
- Scenario selection procedure

Definition of groundwater protection goal



Operationalising the groundwater protection goal

6. Choice of models

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7. Definition of vulnerability drivers and development of scenario selection procedure

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8. Application of scenario selection procedure

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9. Parameterization of scenarios in the models

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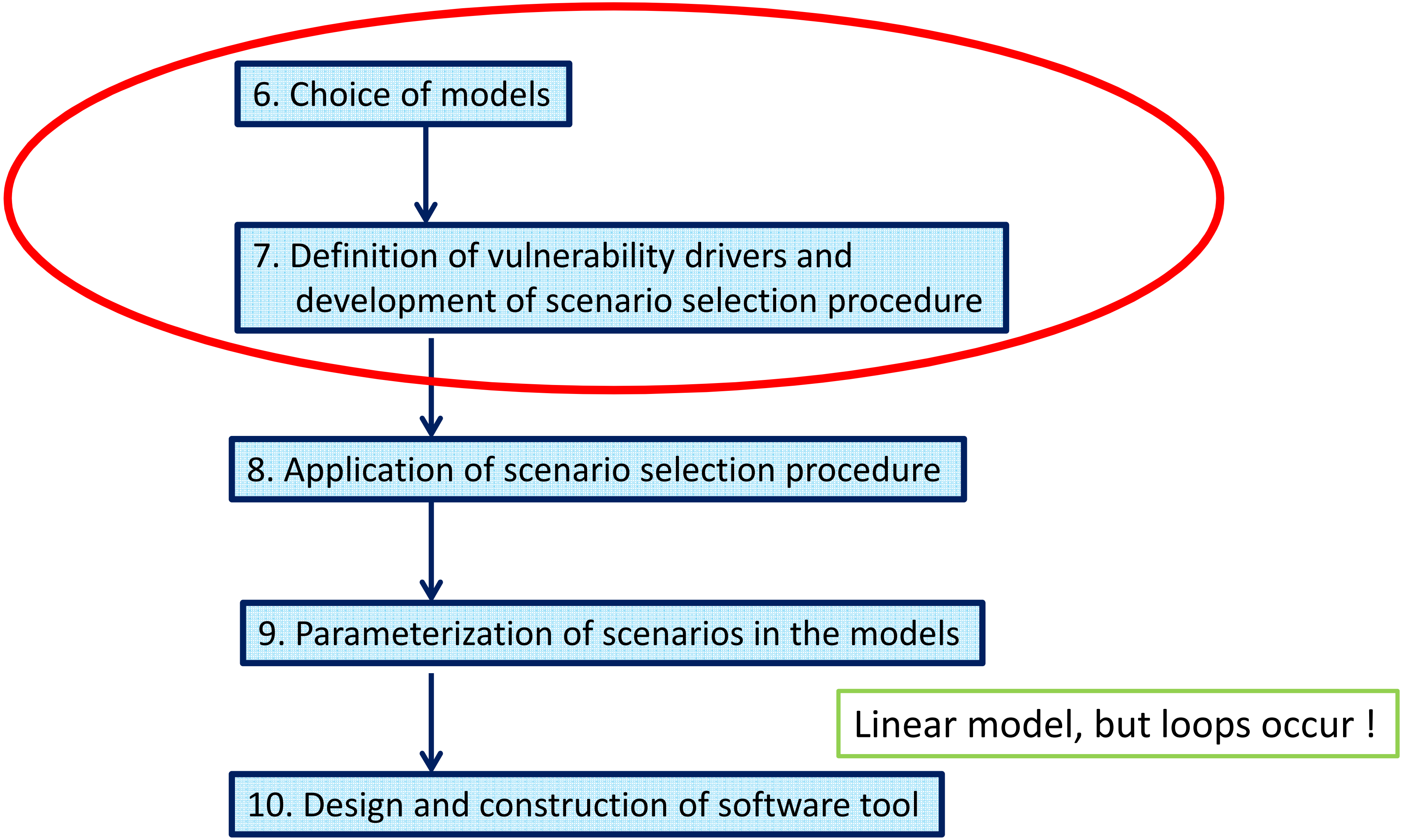
10. Design and construction of software tool

Linear model, but loops occur !

Operationalising the groundwater protection goal



Groundwater protection goal

6. Choice of models

The EuroPEARL meta-model

$Ln\ (C_L) = \alpha_0 + \alpha_1 * X_1 + \alpha_2 * X_2$

C_L : the concentration (µg/L) in leaching water at 1 m depth, given a net soil deposition of 1 kg/ha

α_0 , α_1 , α_2 : regression parameters that depend on
- temperature and annual rainfall
- not compound specific, but specific to a region

X_1, X_2 depend on
- soil properties (organic matter and water content)
- compound properties (K_{om}, DT50 degradation)

TIKTAK ET AL.: MAPPING GROUND WATER VULNERABILITY TO PESTICIDES

J. ENVIRON. QUAL., VOL. 35, JULY–AUGUST 2006

Groundwater protection goal

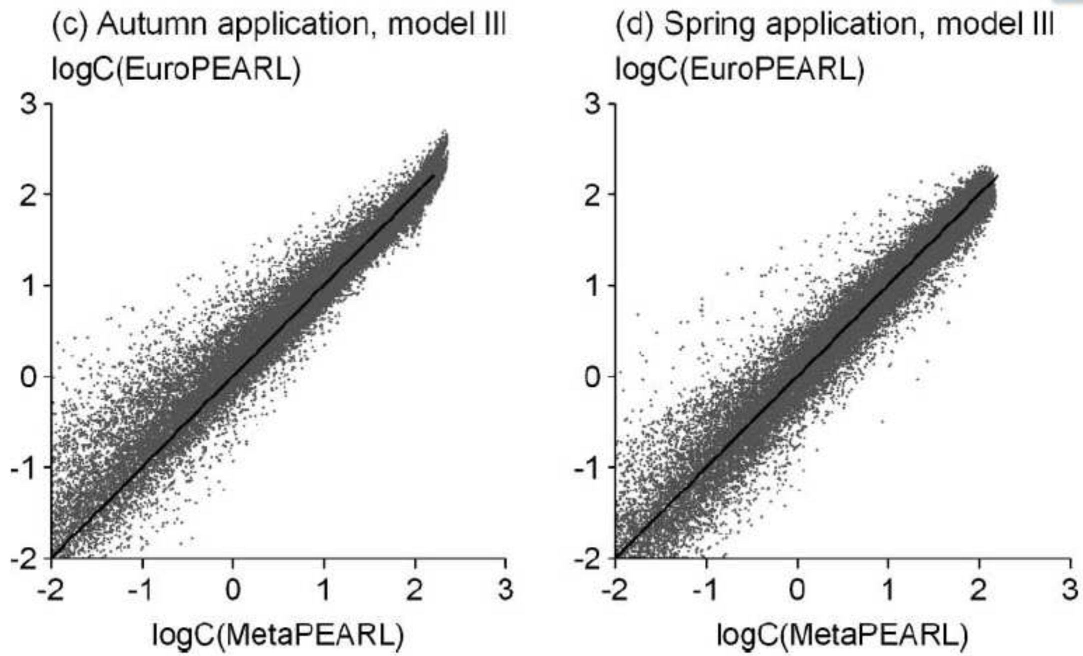
6. Choice of models

The EuroPEARL meta-model

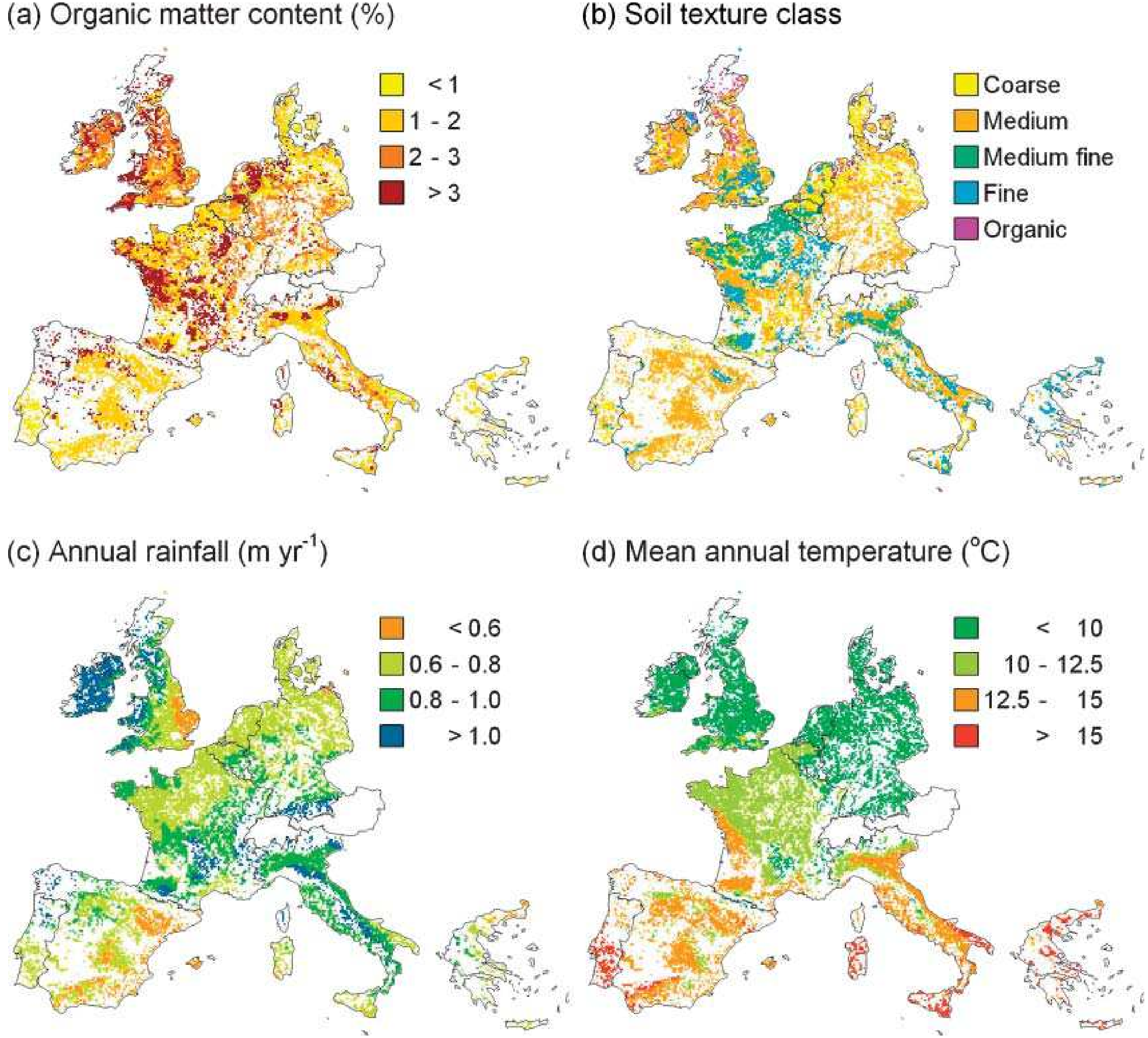
$$Ln\ (C_L) = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1} * X_1 + \boldsymbol{\alpha_2} * X_2$$

- parameters $\boldsymbol{\alpha_0}$, $\boldsymbol{\alpha_1}$, $\boldsymbol{\alpha_2}$ determined by regression of output of EuroPEARL (spatially distributed model) and the metamodel output
- $\boldsymbol{\alpha_0}$, $\boldsymbol{\alpha_1}$, $\boldsymbol{\alpha_2}$ for four major climate zones:
  - Temperate, dry
  - Temperate, wet
  - Warm, dry
  - Warm, wet

> 800 mm/yr and > 12.5 C
Out of four is this one most representative for Ethiopia



- Basic maps for EuroPEARL, so validity area of the metamodel



Groundwater protection goal

The EuroPEARL meta-model

6. Choice of models

$$Ln\,(C_L) = \alpha_0 + \alpha_1 * \boldsymbol{X_1} + \alpha_2 * \boldsymbol{X_2}$$

(Tiktak et al., 2006)

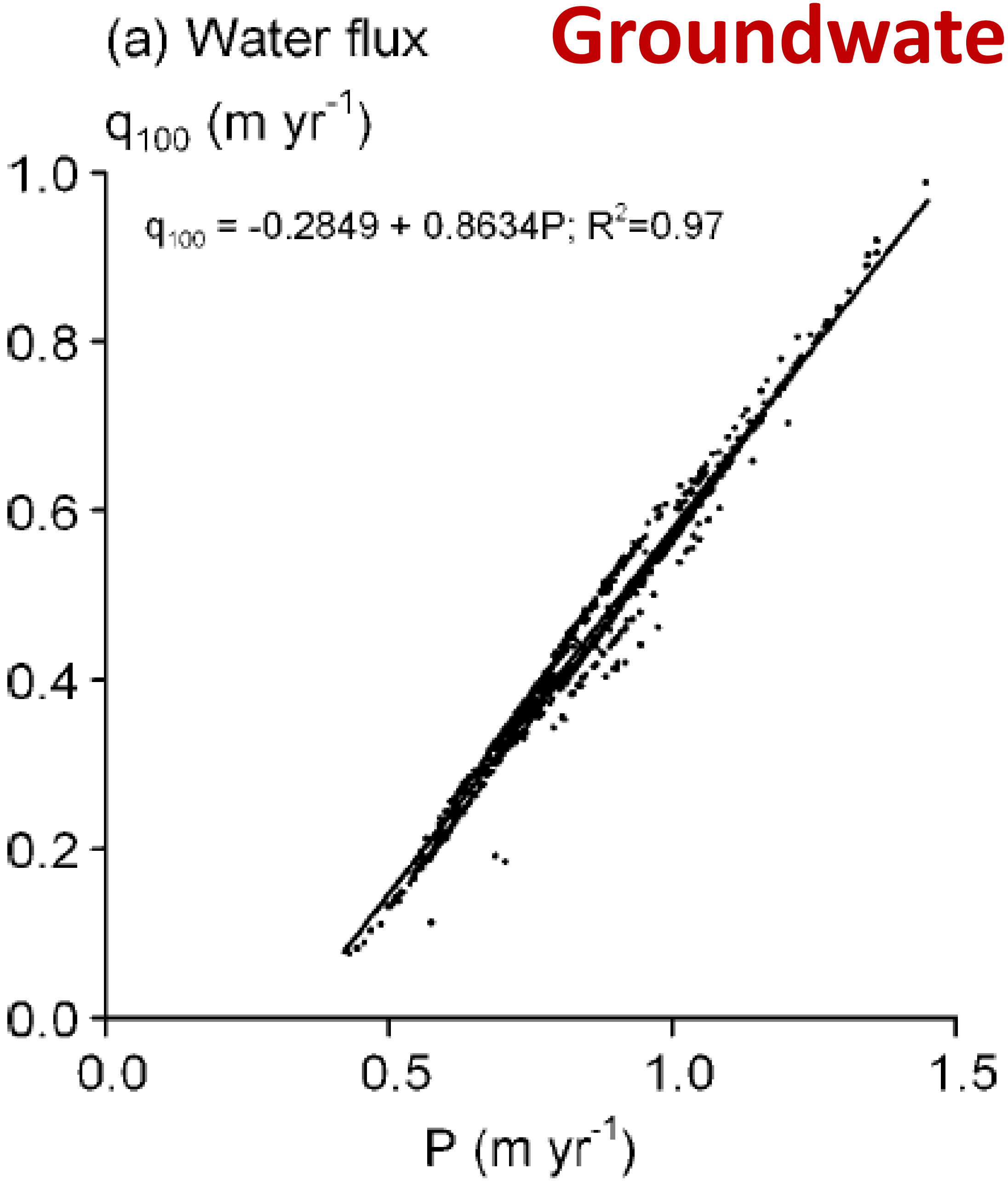
$X_1 := k_s\, \Theta\, D_{gw} / q$

k_s = degradation rate coefficient in soil (1/d), where $k_s = \ln(2)/DegT50_{soil}$
Θ = volume fraction of water (default value = 0.25 m^3/m^3)
D_{gw} = depth groundwater (default = 1m)
q = volume flux of water (m/d)

$X_2 := k_s\, \rho_b\, f_{om}\, \Theta\, D_{gw} / q$

ρ_b = dry bulk density soil (kg/dm^3)
f_{om} = organic matter content (kg/kg)

Groundwater protection goal



6. Choice of models

Water balance:

q = P + I – ET- R

Metamodel:

q = (-0.2849/365) + (0.8634 P/365) →

based upon regression q from EuroPEARL model and P (domain: 500-1500 mm/yr)

Groundwater protection goal

6. Choice of models

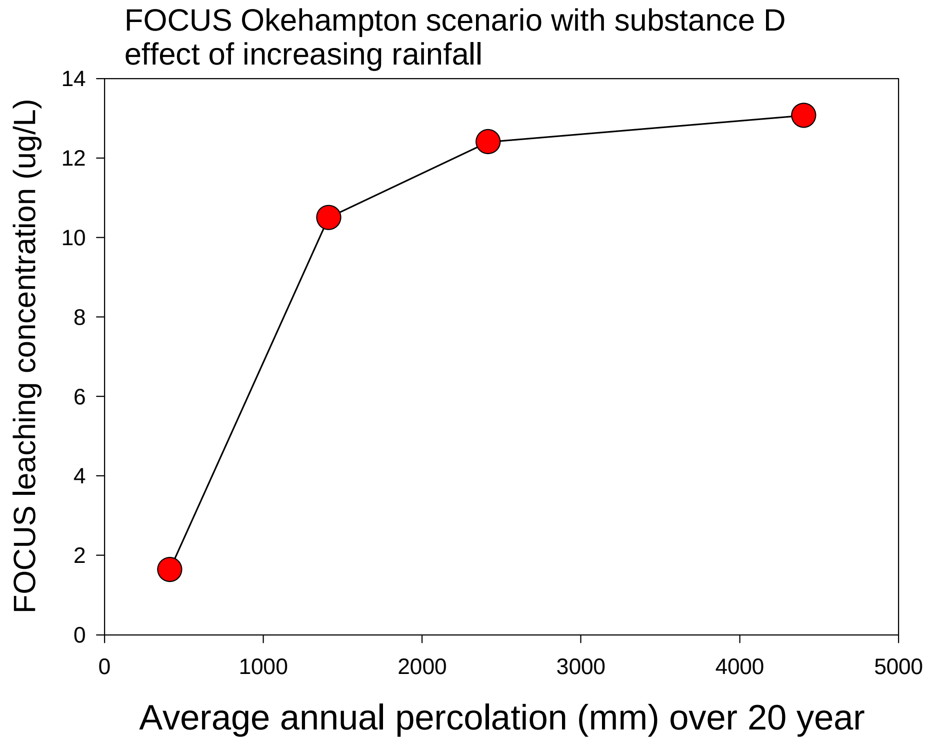
Consequences of extrapolating the EuroPEARL metamodel to Ethiopia

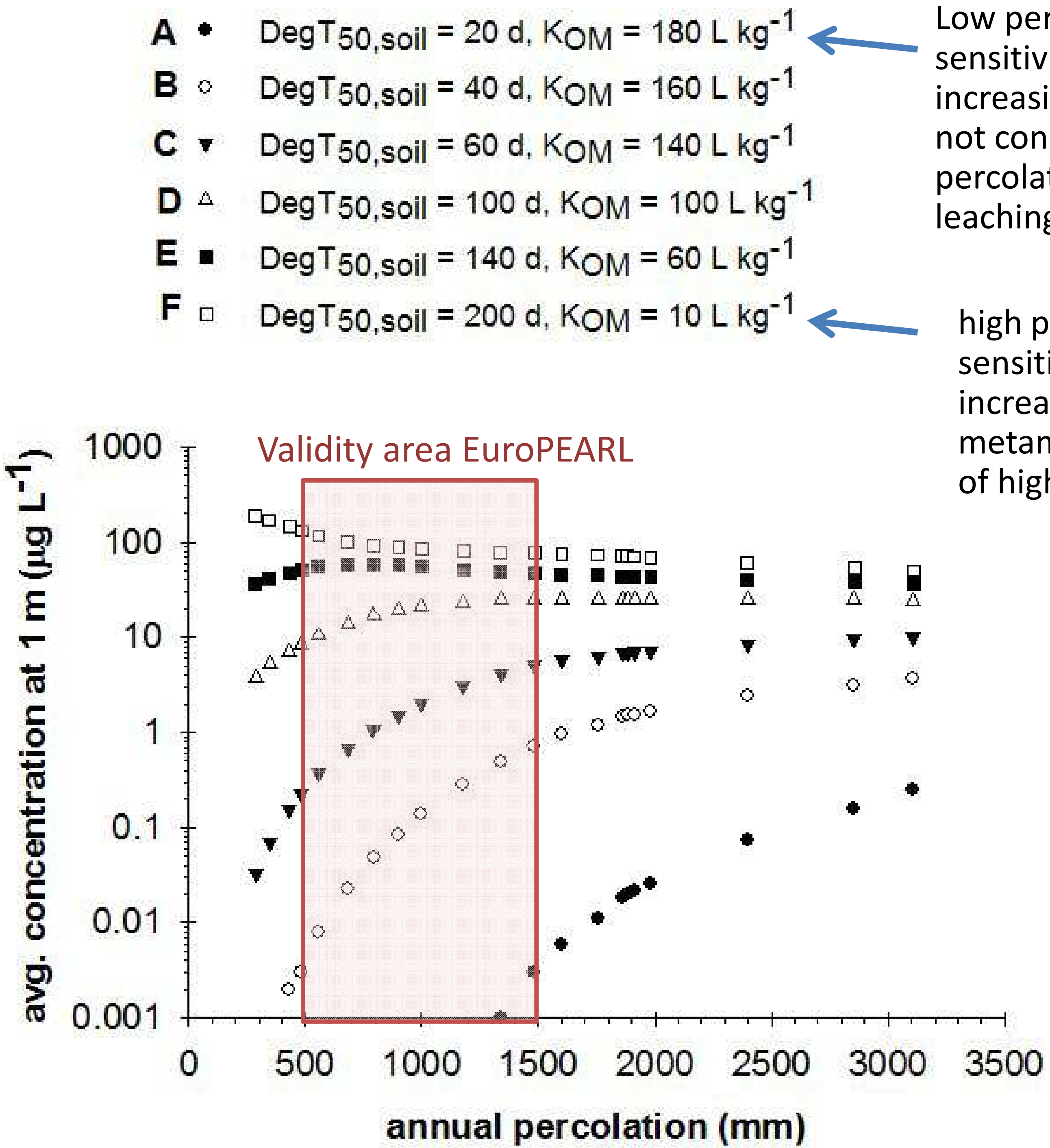
- Ethiopia → more wet and higher temperature
- Meta model → increasing q results in increasing concentration

Effect of percolation on PEC

- Experience for EU scenarios: concentration increases with increasing precipitation
- Leaching concentration reaches a plateau

- for huge percolation it may be the reverse for pesticides with high percentages of the dose that leach: more percolation may dilute:
  - This was investigated for a Chinese paddy rice scenario





Low persistence, low leaching sensitivity → conc. increases for increasing percolation →metamodel is not conservative in case of higher percolation, but substance is not leaching sensitive

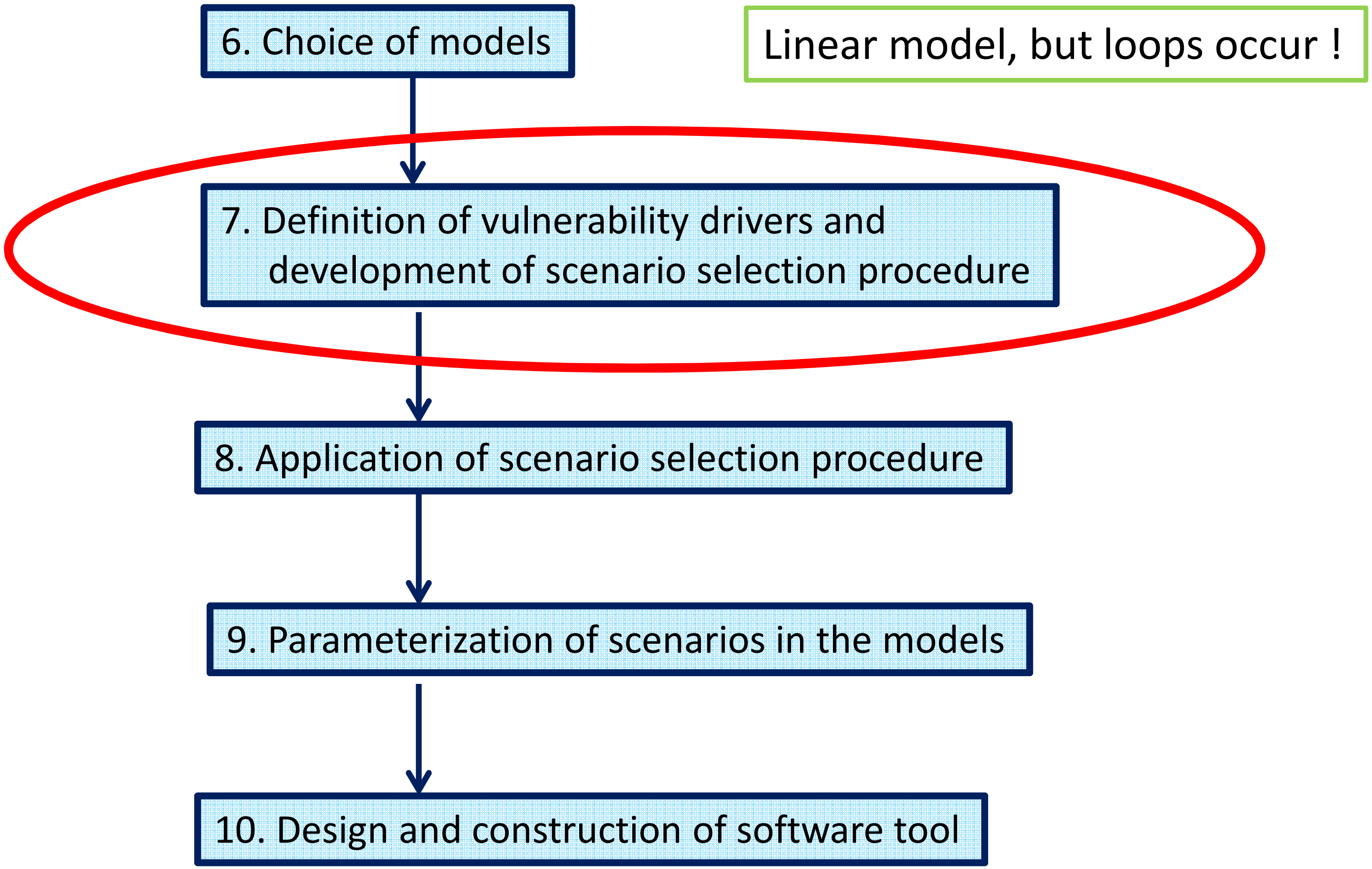
high persistence, high leaching sensitivity→ conc. decreases for increasing percolation → dilution → metamodel is conservative in case of higher percolation

Nanchang parameterised in PEARL

percolation was varied

All in all: defensible approach

Operationalising the groundwater protection goal



Groundwater protection goal

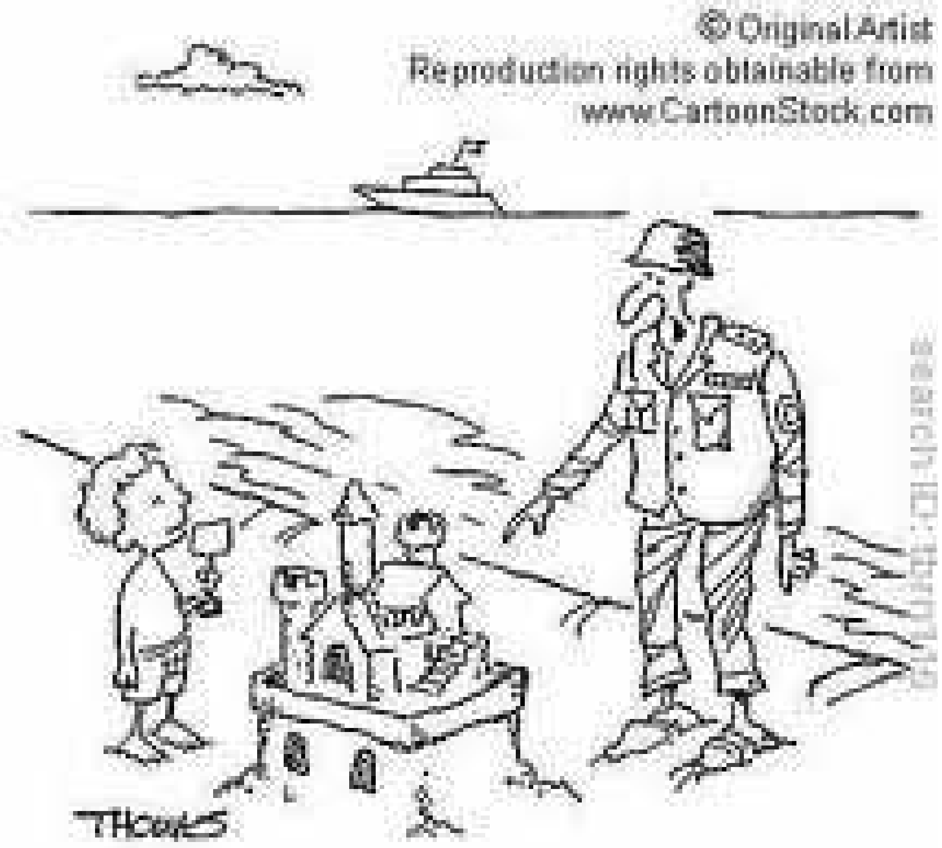
7. Definition of vulnerability drivers and development of scenario selection procedure

Vulnerability:

The predisposition of a protection goal to be at risk for exposure to pesticides.

Scenarios should be protective

→ therefore **vulnerability concept**



"Not bad kid, but you'd be vulnerable to attacks here and here."

Groundwater protection goal

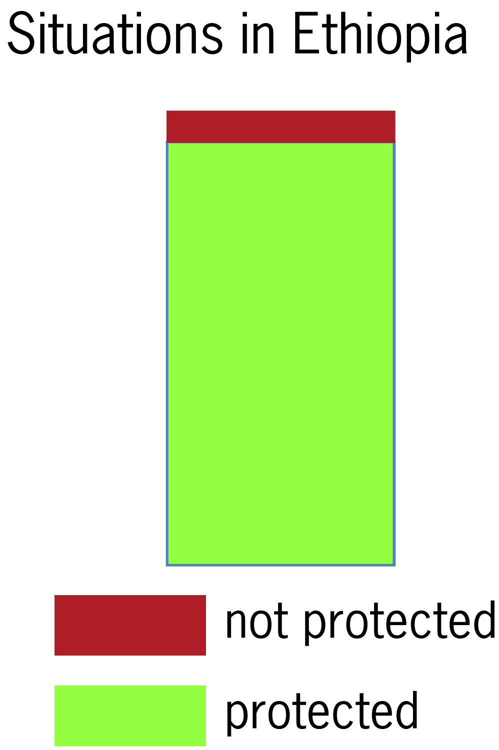
7. Definition of vulnerability drivers and development of scenario selection procedure

Scenarios should be protective

x % of in reality existing situations (in time and space) in Ethiopia are protected

50% means half of all situations in Ethiopia are protected = general situation

90% means that 90% all situations in Ethiopia are protected = EU translation of "realistic worst case situation"



Groundwater protection goal

7. Definition of vulnerability drivers and
development of scenario selection procedure

- EU leaching scenarios standard: 0.1 µg/L
- Coupled to 90^{th} –ile of probability in time and space of leaching concentration
- So in 10% of all situations in the EU standard of 0.1 µg/L is exceeded !

Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- Ethiopian leaching scenarios
  standard: human-toxicological

- Generally >> 0.1 µg/L (10-100 µg/L)
  e.g. (dimethoate: 6 µg/L, imidacloprid: 360 µg/L, chlorpyrifos: 60 µg/L)

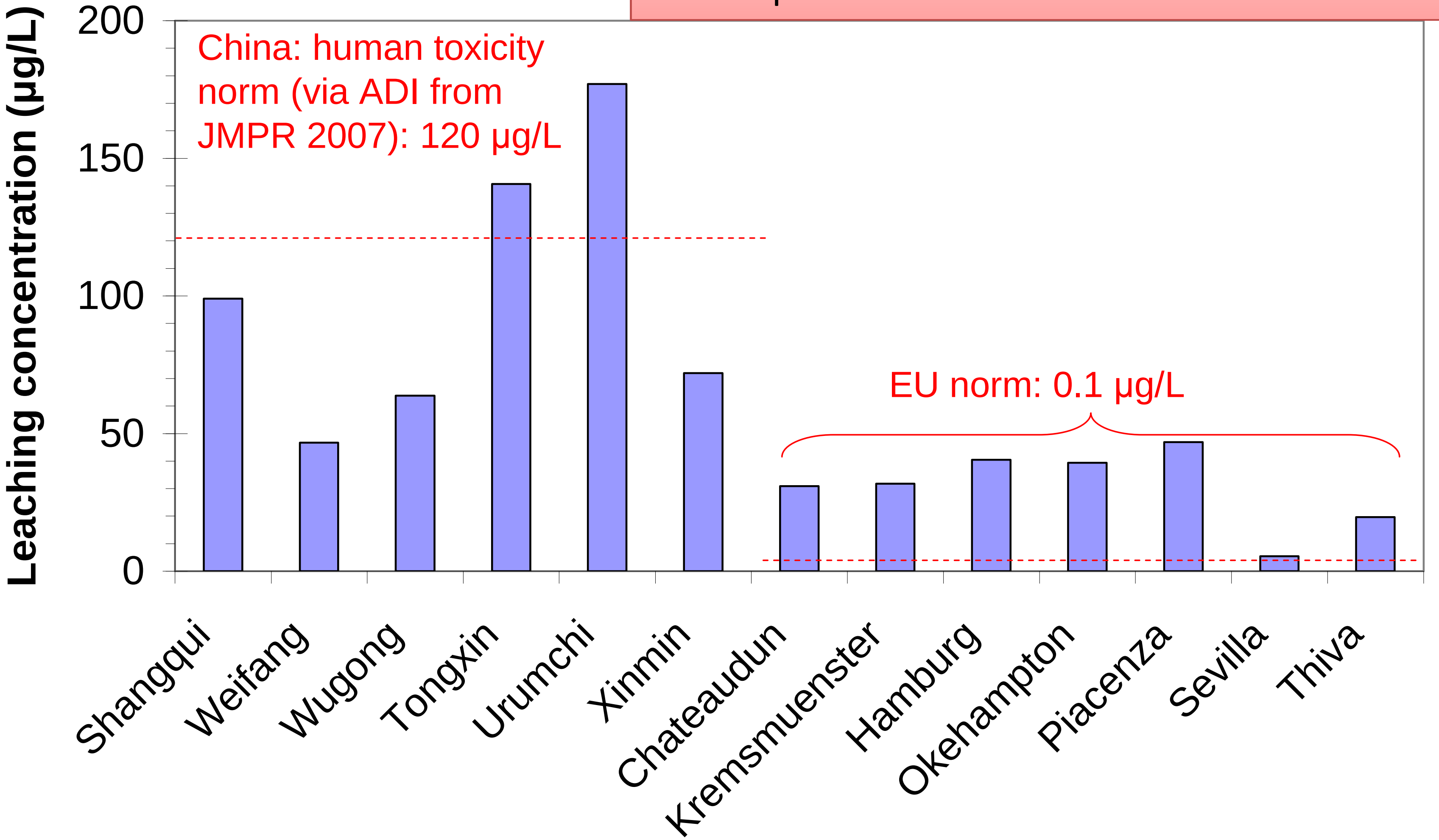
- Couple to 90th –ile of probability in time and space of leaching concentration?
  → 10 % cases tox effects on humans; you accept this can happen

- **We propose 99th-ile, i.e. 1% exceedance for Ethiopia**

Groundwater protection goal

EU standard 0.1 µg/L versus human toxicity standard
Example Atrazine

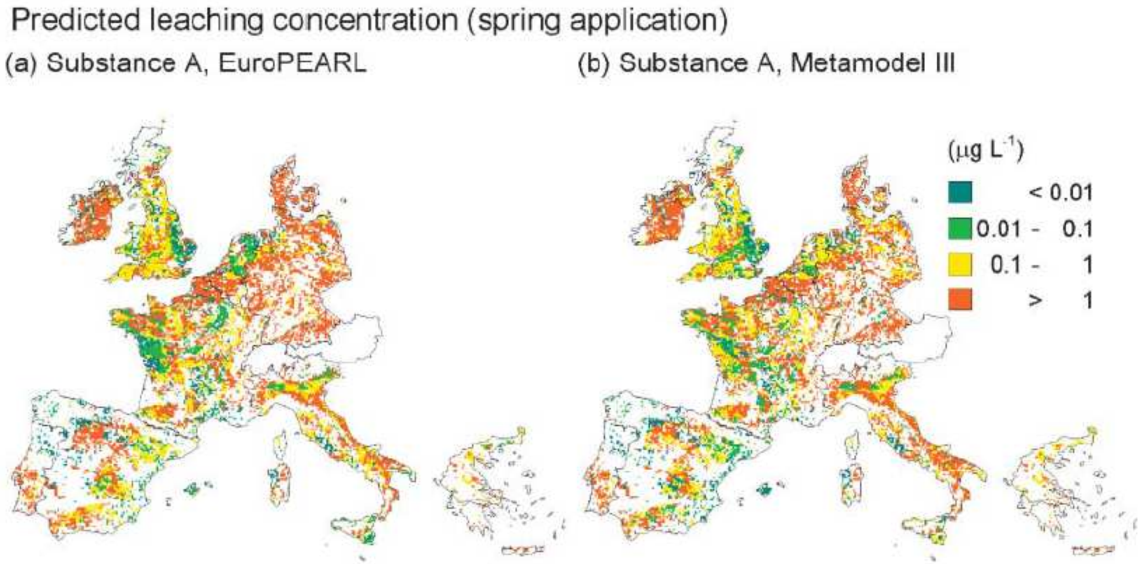
- 99th percentile conc. Chinese scenarios
- 90th percentile conc. EU scenarios



Groundwater protection goal

7. Definition of vulnerability drivers and
development of scenario selection procedure

- Mapping vulnerability (on output): theoretical correct approach → parameterised spatial distributed model like EuroPEARL needed

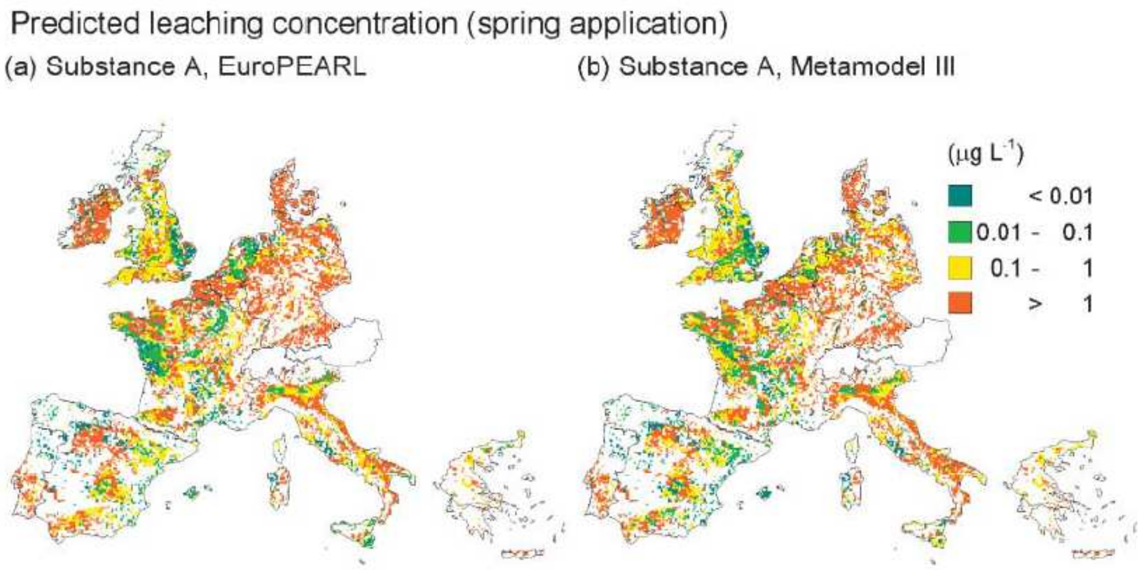


- Vulnerability drivers are parameters in the model

Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- Same approach possible for PRRP using the EuroPEARL metamodel and spatial distributed data (rain, om, bd) of Ethiopia.



Selection criteria scenario zone per protection goal

Protection goals: alluvial aquifers along small rivers and volcanic aquifers on shallow wells

→grid points > 1500 m

Protection goal: alluvial aquifers in Rift Valley margins

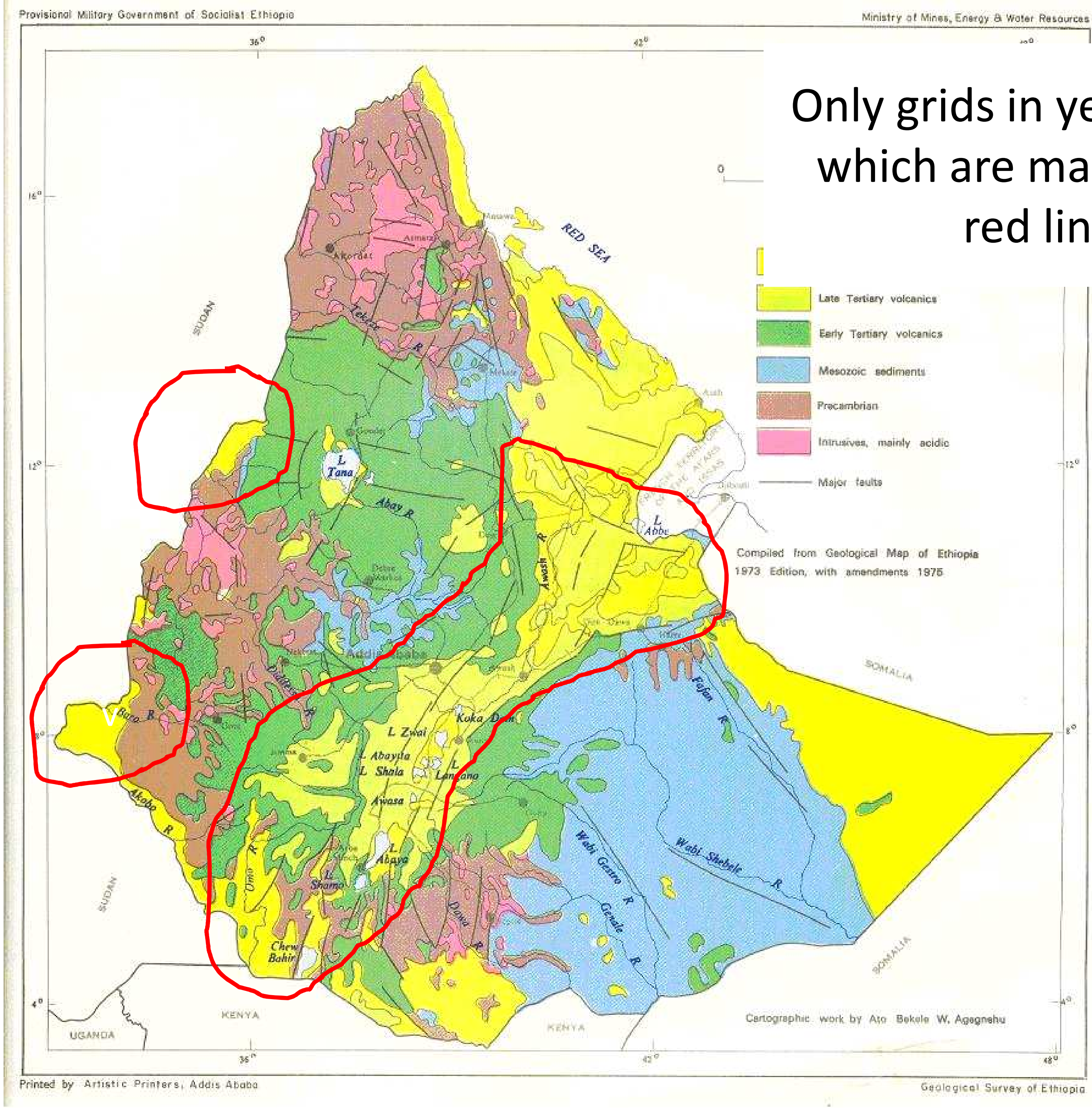
A. Just gridpoints in marked areas map next slide

Divide these grid points over 2 zones:

A.1 grid points < 1500 m

A.2 grid points > 1500 m but < 2000m

Only grids in yellow areas which are marked with red lines



Procedure for scenario selection (per scenario zone)

- Calculations for a range of different substances (PPP)

1. Metamodel calculation for each grid point using org.mat. and avg. percolation over ca 30 years in mm/d → $c_{leaching \rightarrow suppose\ 200}$ grids → 200 $c_{leaching}$
2. For each substance rank 200 $c_{leaching}$
3. Assign to each grid point a leaching percentile
4. Plot the leaching percentiles in the map (1) of Ethiopia
5. Select from each map (per PPP) locations with 98-99-100 percentiles and plot them in new maps (2)

Procedure for scenario selection

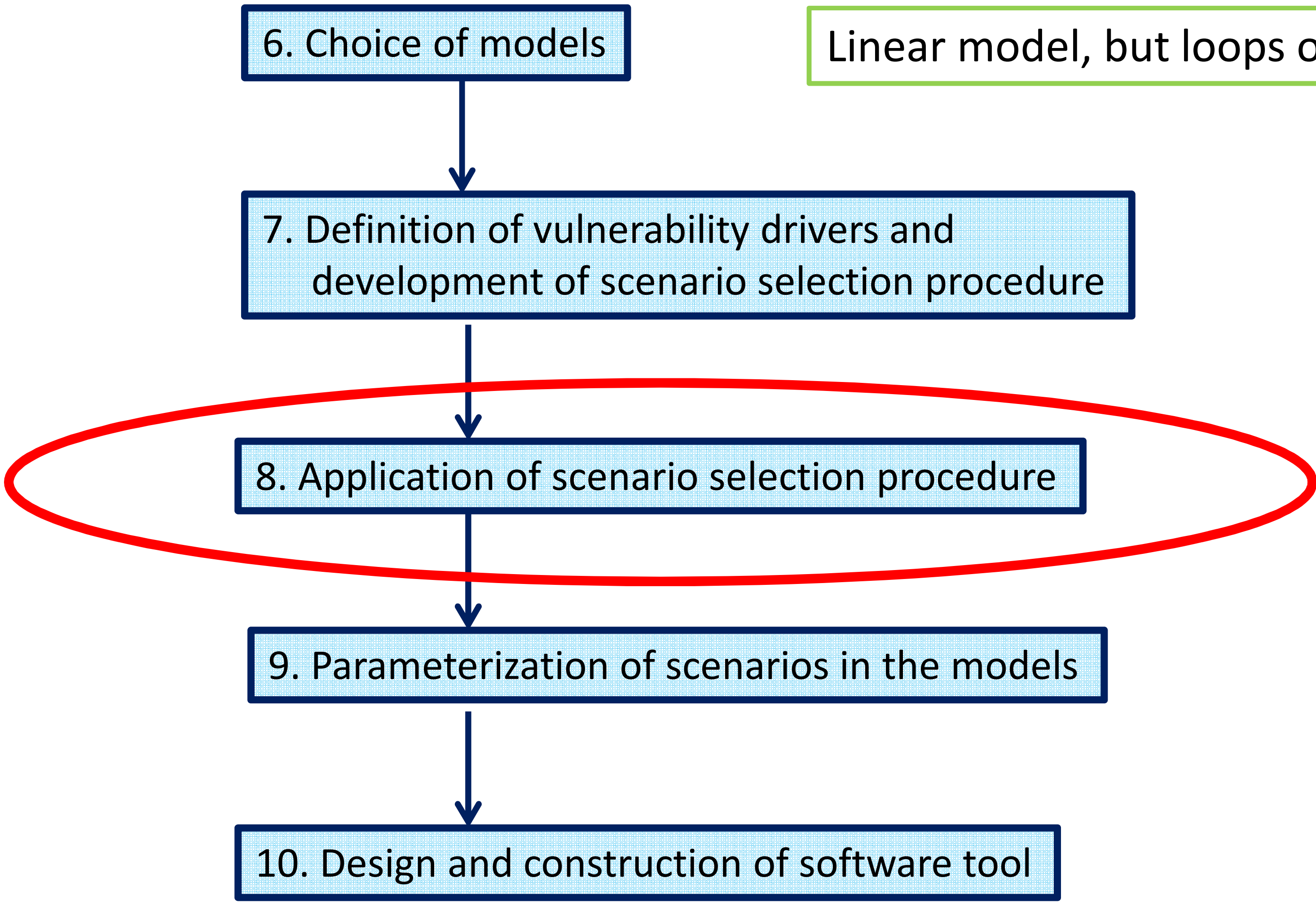
6. Make overlays of the maps (2) of the different PPPs and select those locations (candidates) that are common in all maps.
7. Plot selected locations in a map (3) and indicate for each grid: elevation, om%, $P_{ave,year}$, check that they cover arable land (no forest, desert etc)

In case a large number of candidate locations remain the selection can be narrowed down

→ Org. mat of candidate locations should be within 1% of the mean of the org. mat. Content of all candidate locations

Operationalising the groundwater protection goal

Linear model, but loops occur !



Groundwater protection goal

8. Application of scenario selection procedure

- Once procedure entirely defined, we can apply it
- Defined procedure to be applied by Mechteld on Thursday
- Hopefully on Friday a map showing candidate locations for groundwater → choose from candidates

Operationalising the groundwater protection goal

Groundwater protection goal

Calculation of human toxicology standard
= Drinking water Standard (DWS) in Primet

$$DWS = \frac{ADI \cdot bw \cdot P}{Cons_{water}}$$

DWS = Drinking Water Standard (µg/L)

ADI = Acceptable Daily Intake (µg/kg d)

bw = body weight (60 kg for adults)

P = fraction of ADI allocated to drinking water (default 0.1)

$Cons_{water}$ = daily drinking water consumption (default 2 L/d for adults)

	ADI	P	$Cons_{water}$	DWS
Atrazine	20	0.2	2	120
Atrazine	20	0.1	2	60
Atrazine	20	0.1	3	40

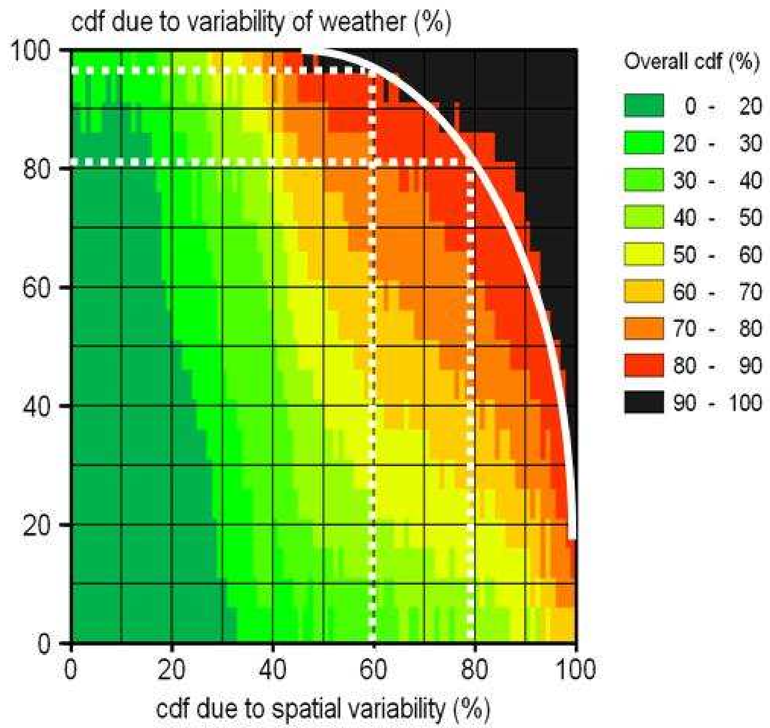
Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- 90[th] om + 90[th] rain = 99[th] overall vulnerability in time and space
- We do not know if this is true. It is a guess.
- However EuroPEARl and GeoPEARL → 90+90 ≈ 90-100 overall

Laatste bullet checken bij Jos!
Plaatje van WG blootstelling
Heeft Jos iets van EFSA soil?

Output of a spatially distributed model would be needed to map the contribution of vulnerability due to rainfall and vulnerability due to organic matter



Groundwater protection goal

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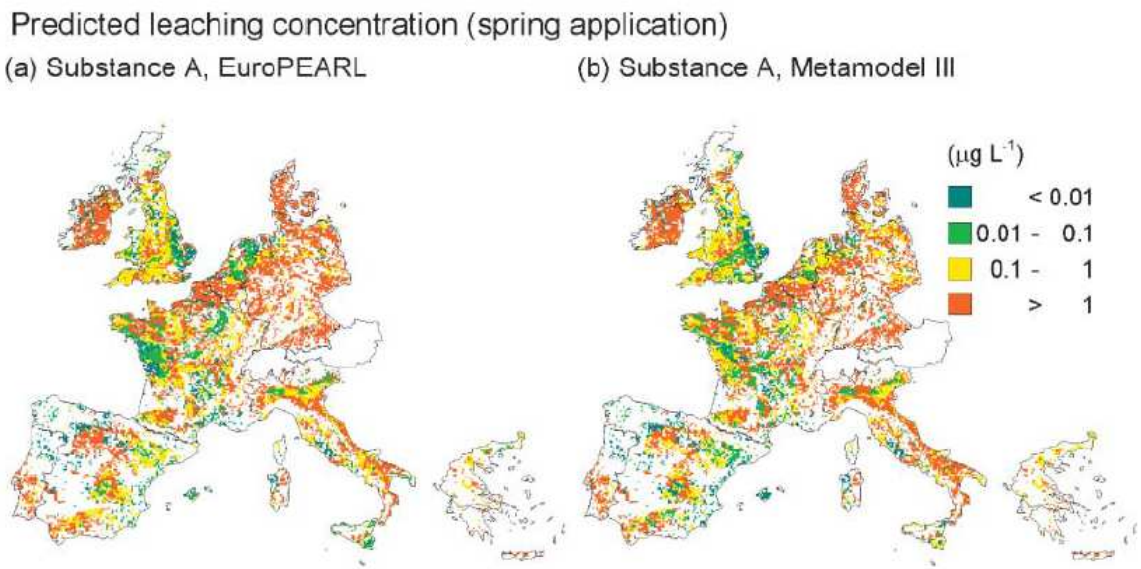
- Mapping vulnerability (on output): theoretical correct approach → parameterised spatial distributed model like EuroPEARL needed



- However, too high ambition level for PRRP → therefore more practical approach (EU-Focus Grondwater, GW scenarios China)

Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- Practical approach: distribute vulnerability between the most important drivers (=input)

- Drivers are a combination of model parameters (determined by e.g. sensitivity analysis) and expert judgement of other factors (e.g. land use at intake area of groundwater wells)

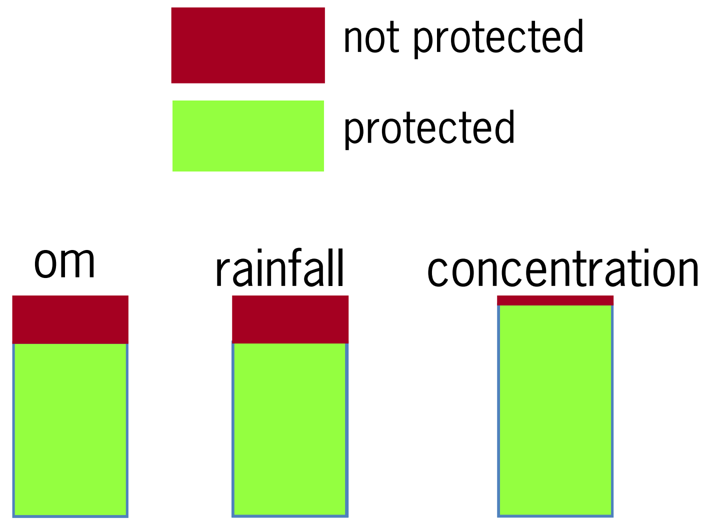
- Scenario selection procedure combines vulnerability drivers in such a way that overall 90th percentile for leaching concentration is obtained

Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- Most important drivers for leaching:
  - Organic matter of the soil
  - Percolation

    (driven by rainfall, unless irrigation is very important like in paddy rice)

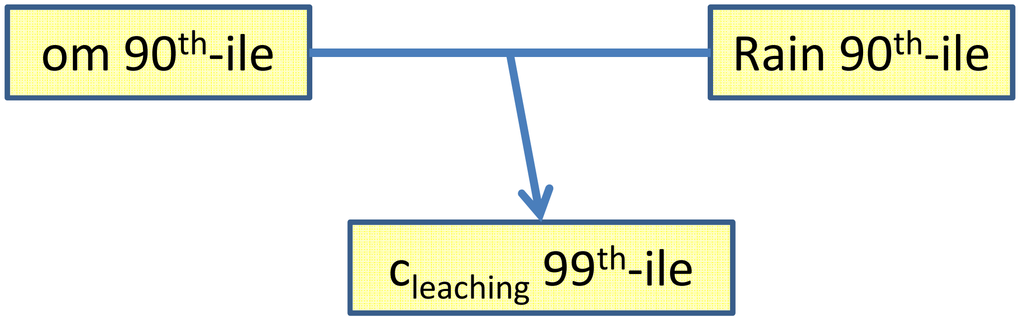


Groundwater protection goal

7. Definition of vulnerability drivers and development of scenario selection procedure

- Proposal: split vulnerability evenly between om and rainfall

- 90^{th} om + 90^{th} rain = 99^{th} overall vulnerability in time and space



- 90^{th} rain = 90^{th} location in scenario zone (of which 50^{th} in time) is selected via simulation with model for about 20 yrs

- Or: om*dry bd is driver? JOS ??
  - not in EU because bd is calculated via pedotransfer (then bd(om))
  - How about bd data Ethiopia? Ask ISRIC

Method for the calculation of the overall 99th percentile vulnerability