

Spatial planning for adapting to climate change

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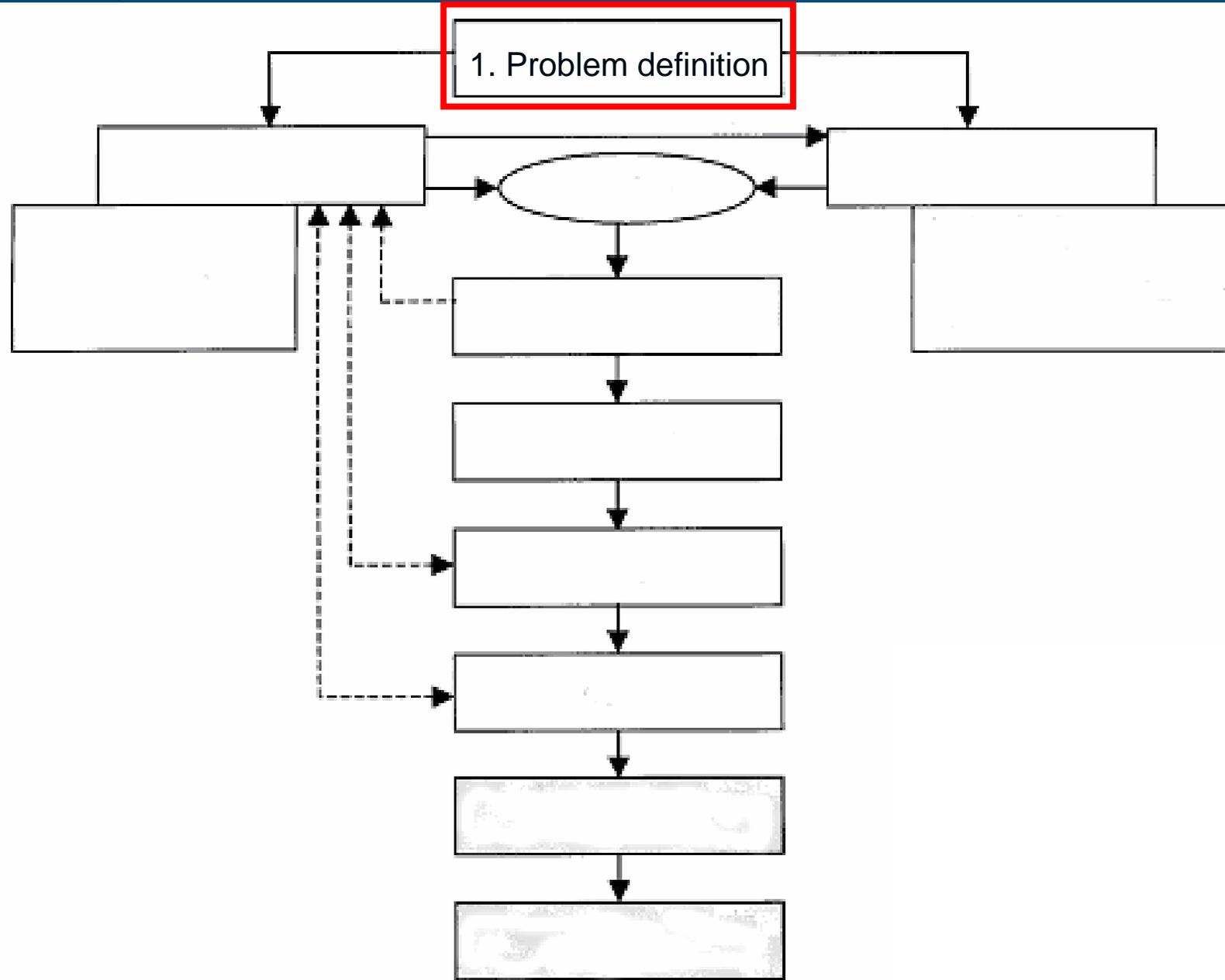
+ ...

Pilot study/ methodology

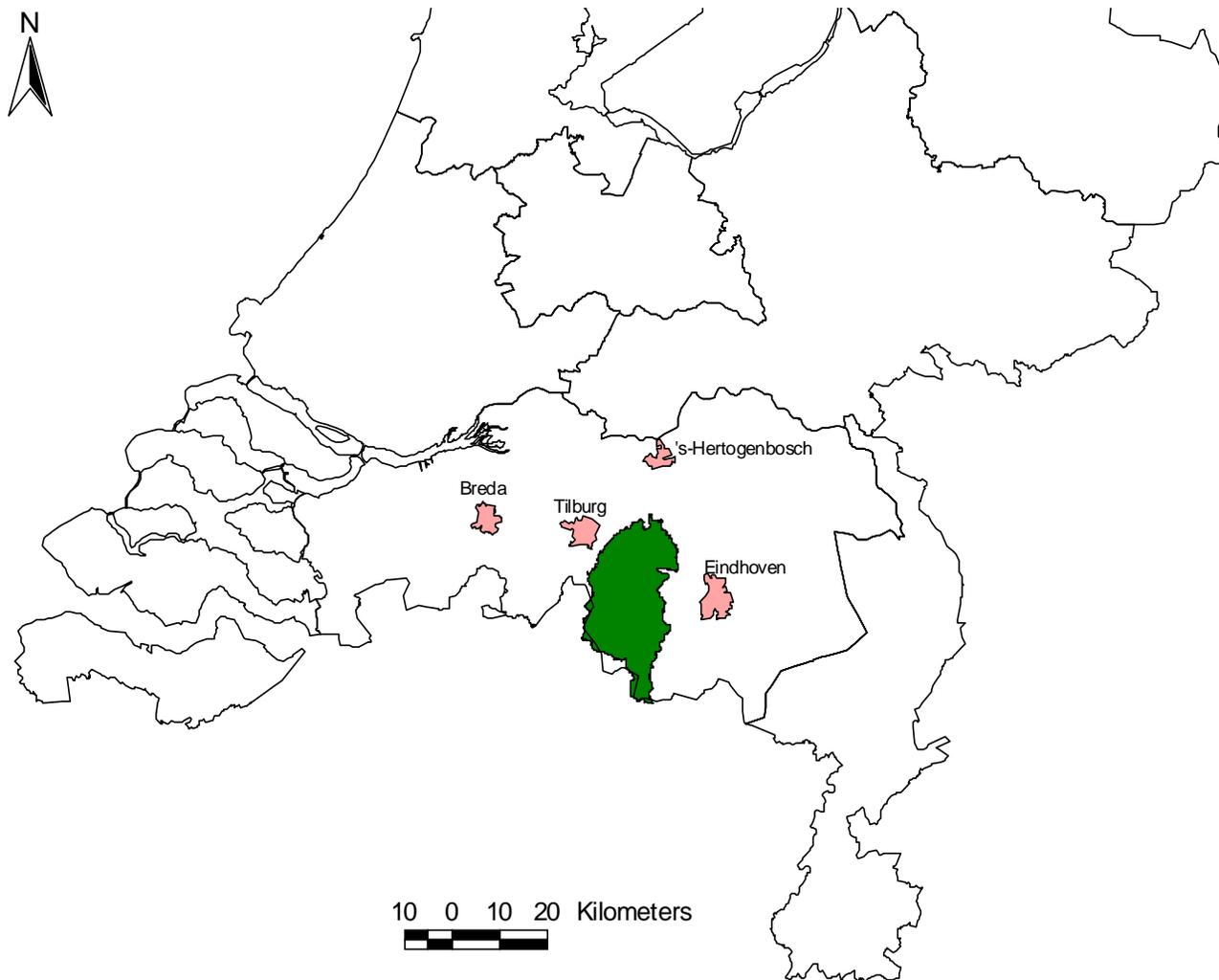


What are we talking about ?

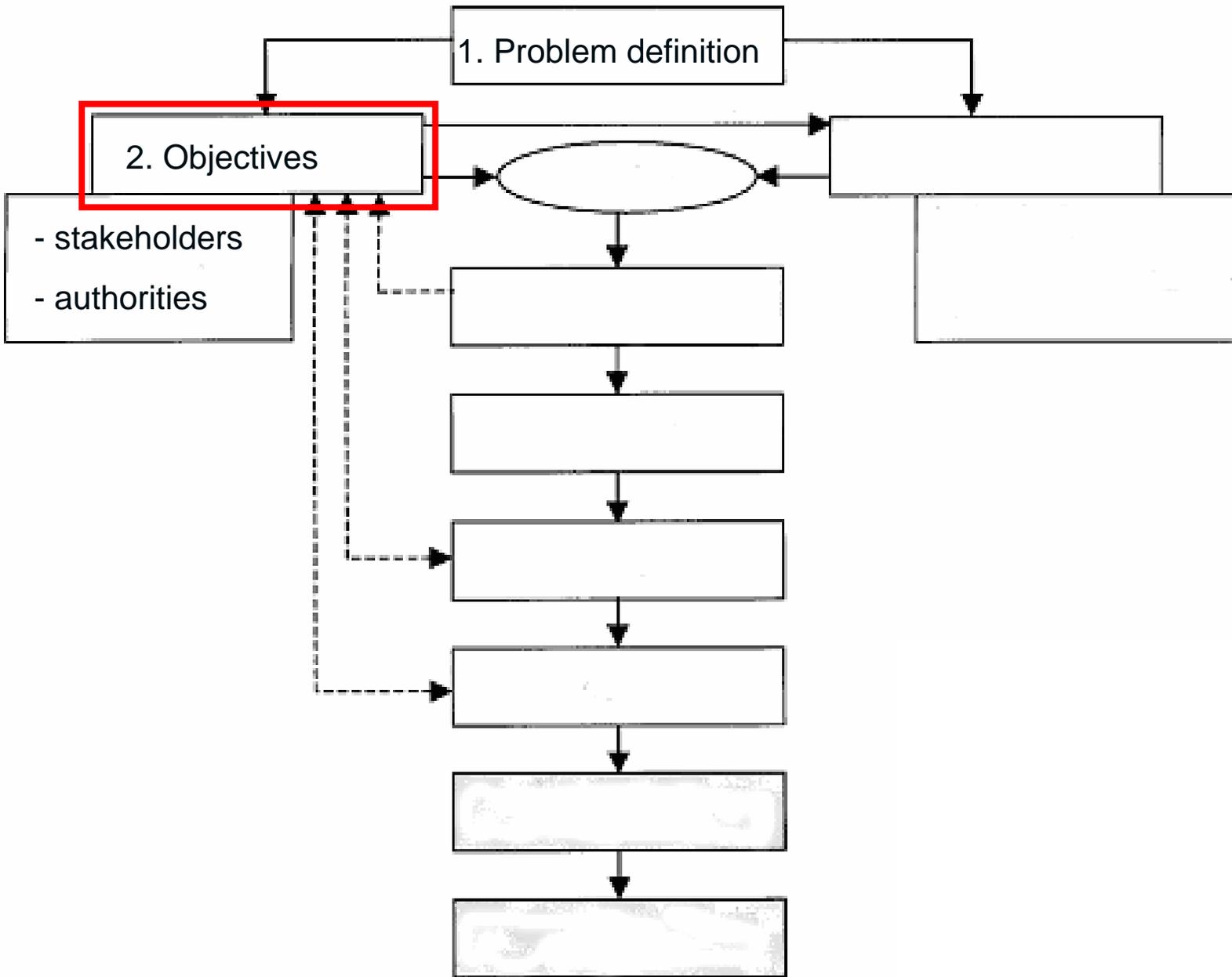
1. Problem definition



Pilot area Beerze & Reusel



What are the stakeholder objectives ?

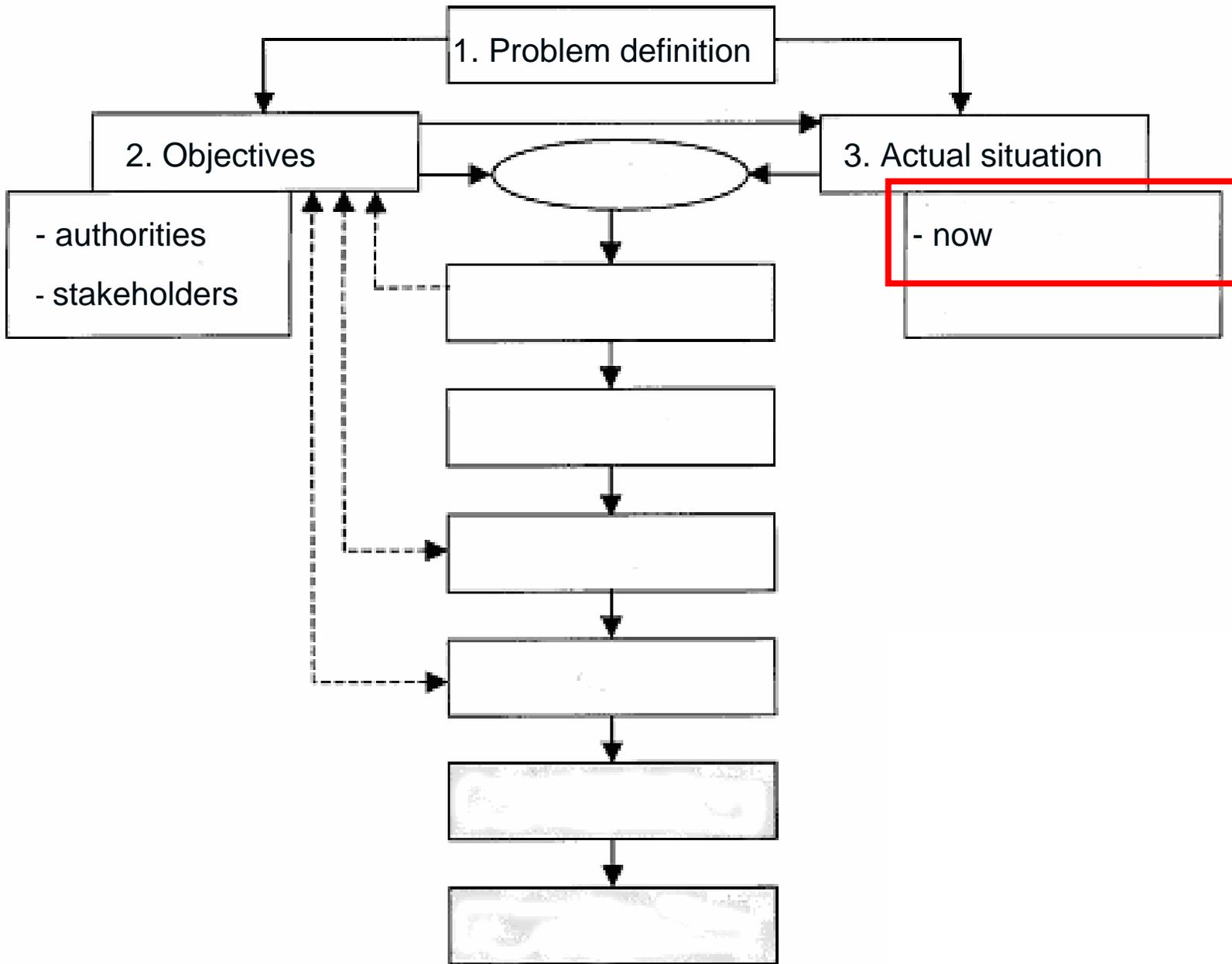


Objectives

- reduce flood risk / climate change
- reduce desiccation of nature areas
- reduce nitrogen and phosphorous loading on groundwater & surface water
- minimize loss of income from agriculture



Where are we now ?

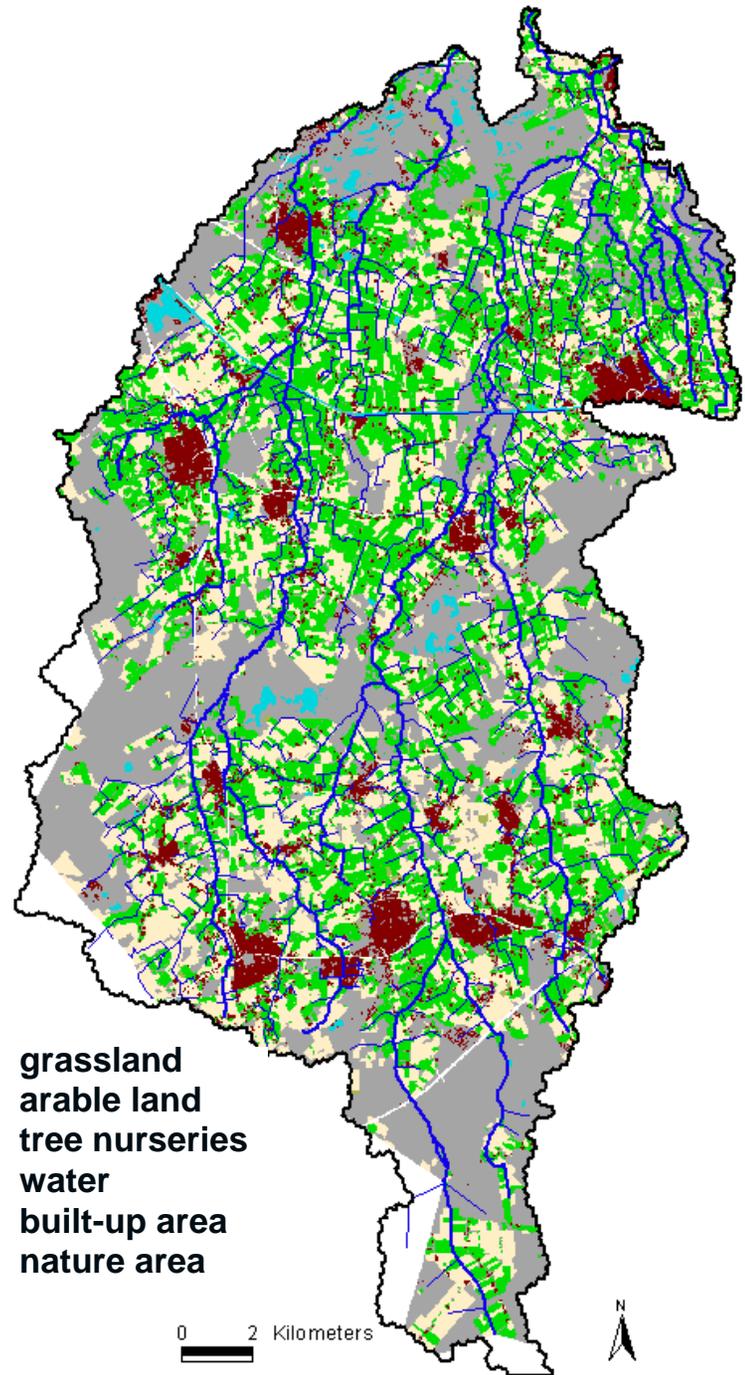


Situation Now

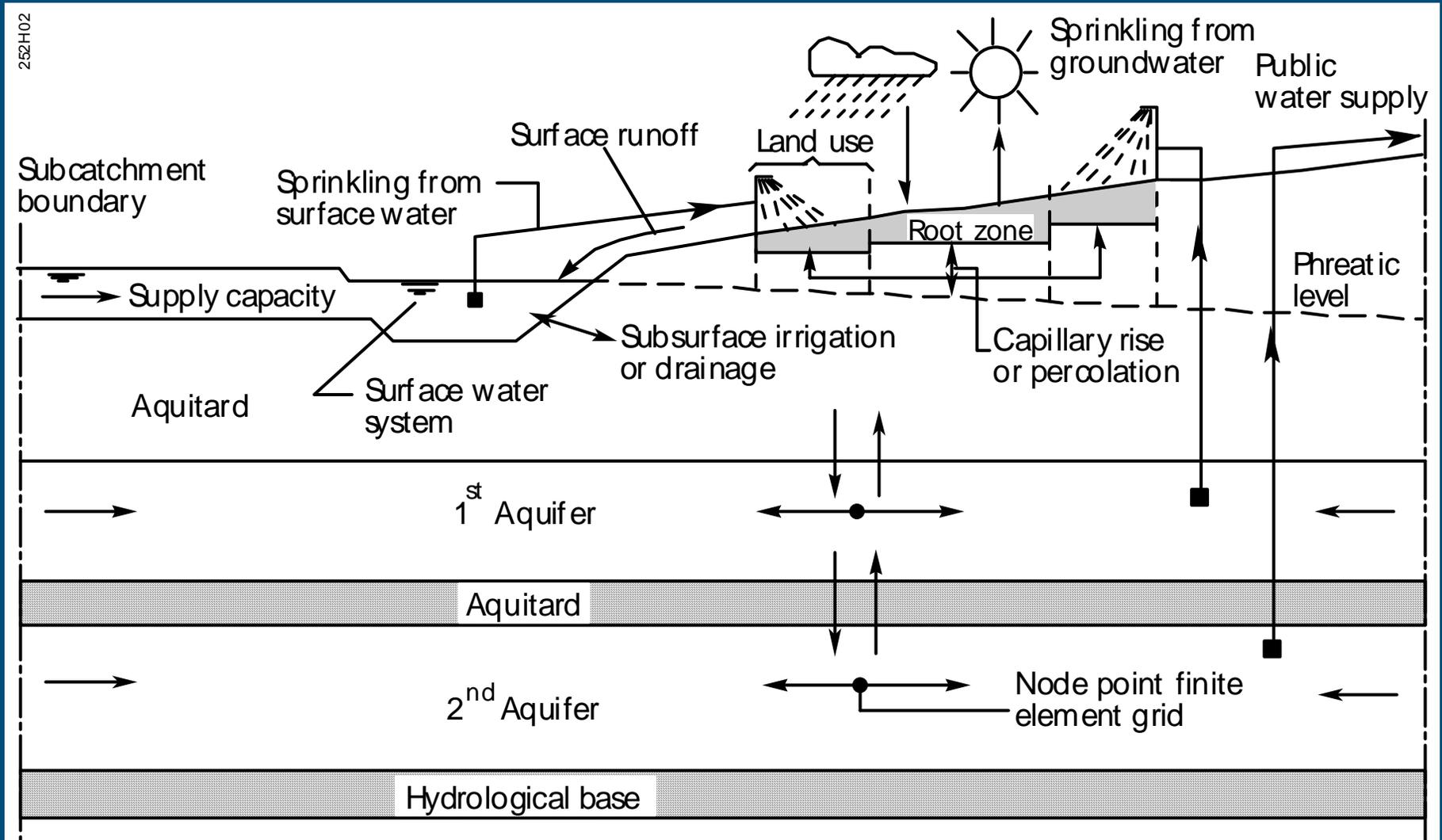
land use

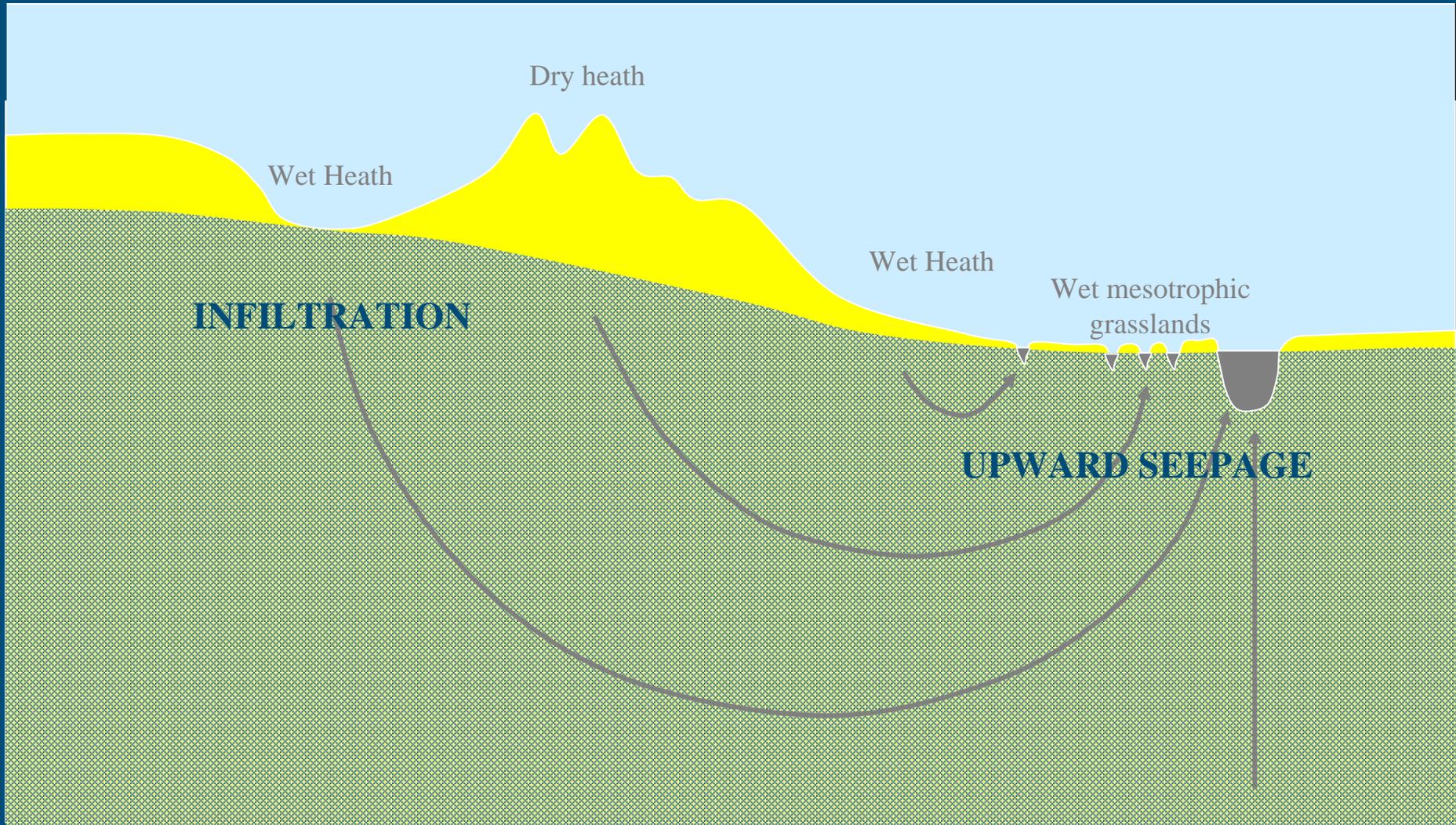


0 2 Kilometers



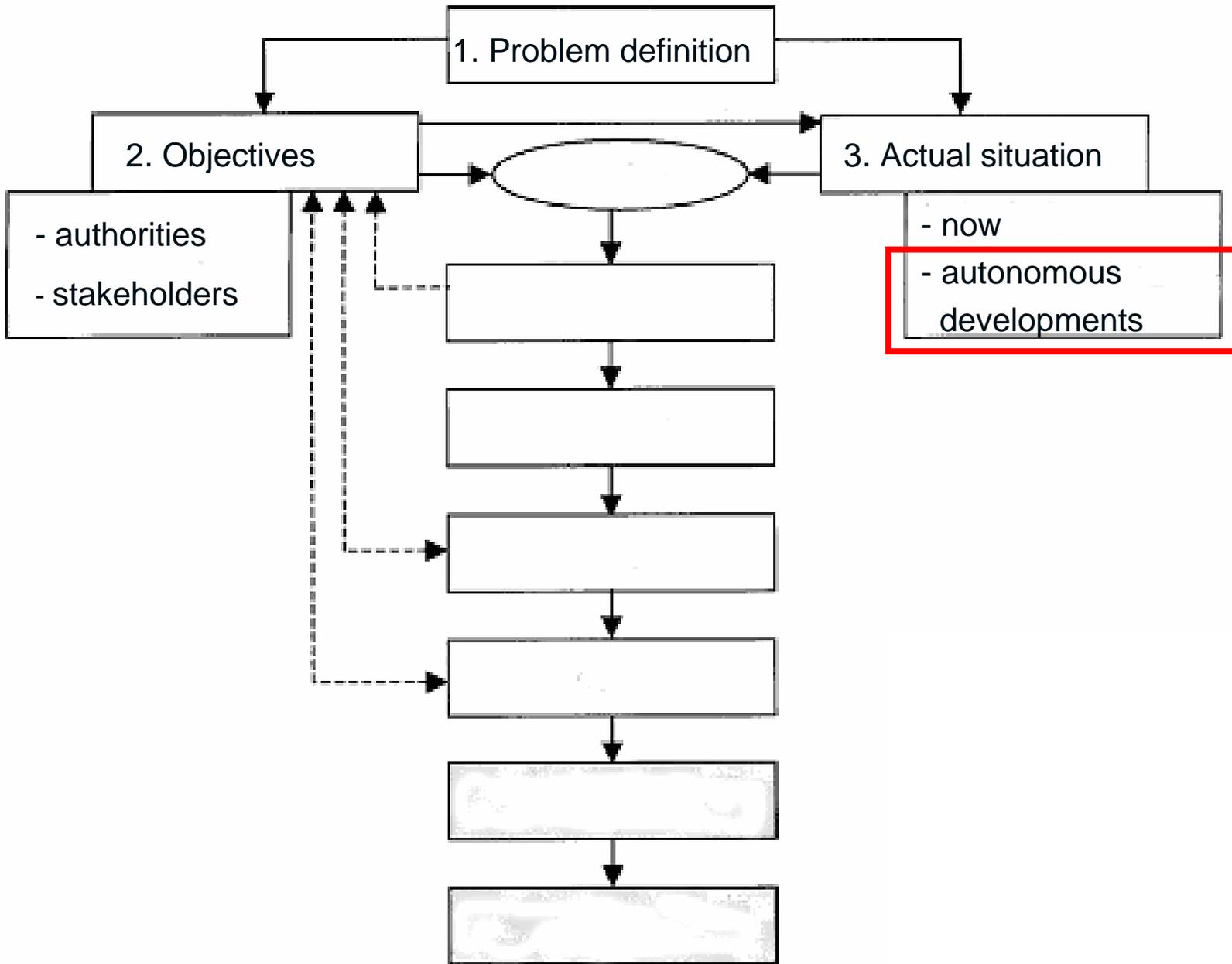
SIMGRO (MODFLOW++) for the regional hydrology







Where are we heading ?

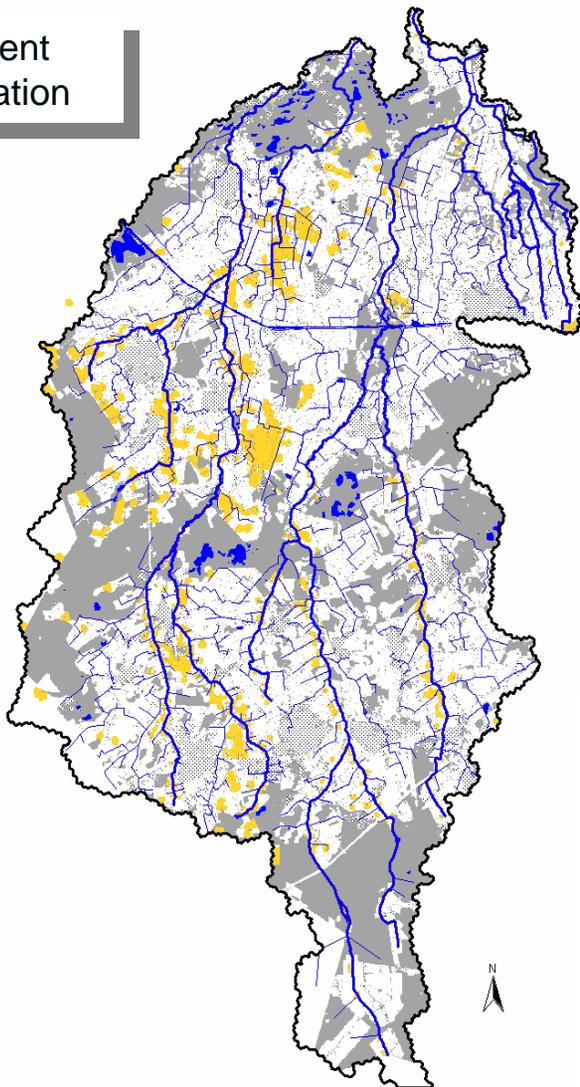


Climate scenario

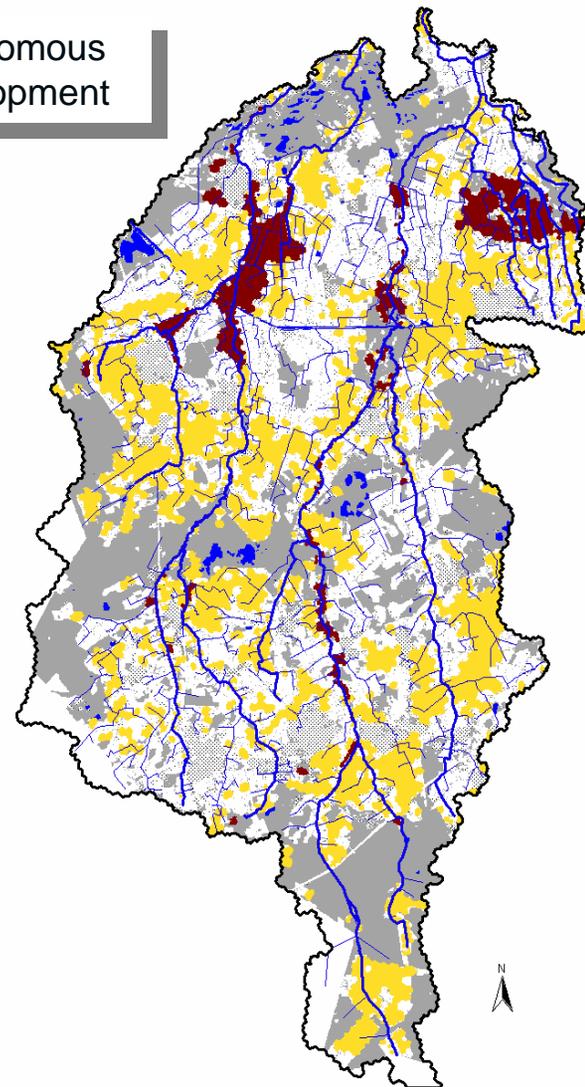
- Hadley 1998 (+2.8 °C in 2100)
- $E_{\text{summer}} + 5\%$
- Precipitation:
 - 'downscaled' to regional level
 - precipitation adjustment according to rule-of-thumb of KNMI $\rightarrow P_{\text{winter}} + 17\%$

Autonomous developments: drainage & nature

Current Situation



Autonomous development



Non-agricultural landuse

-  Water
-  Built-up
-  Forest
-  Natural grasslands (new)

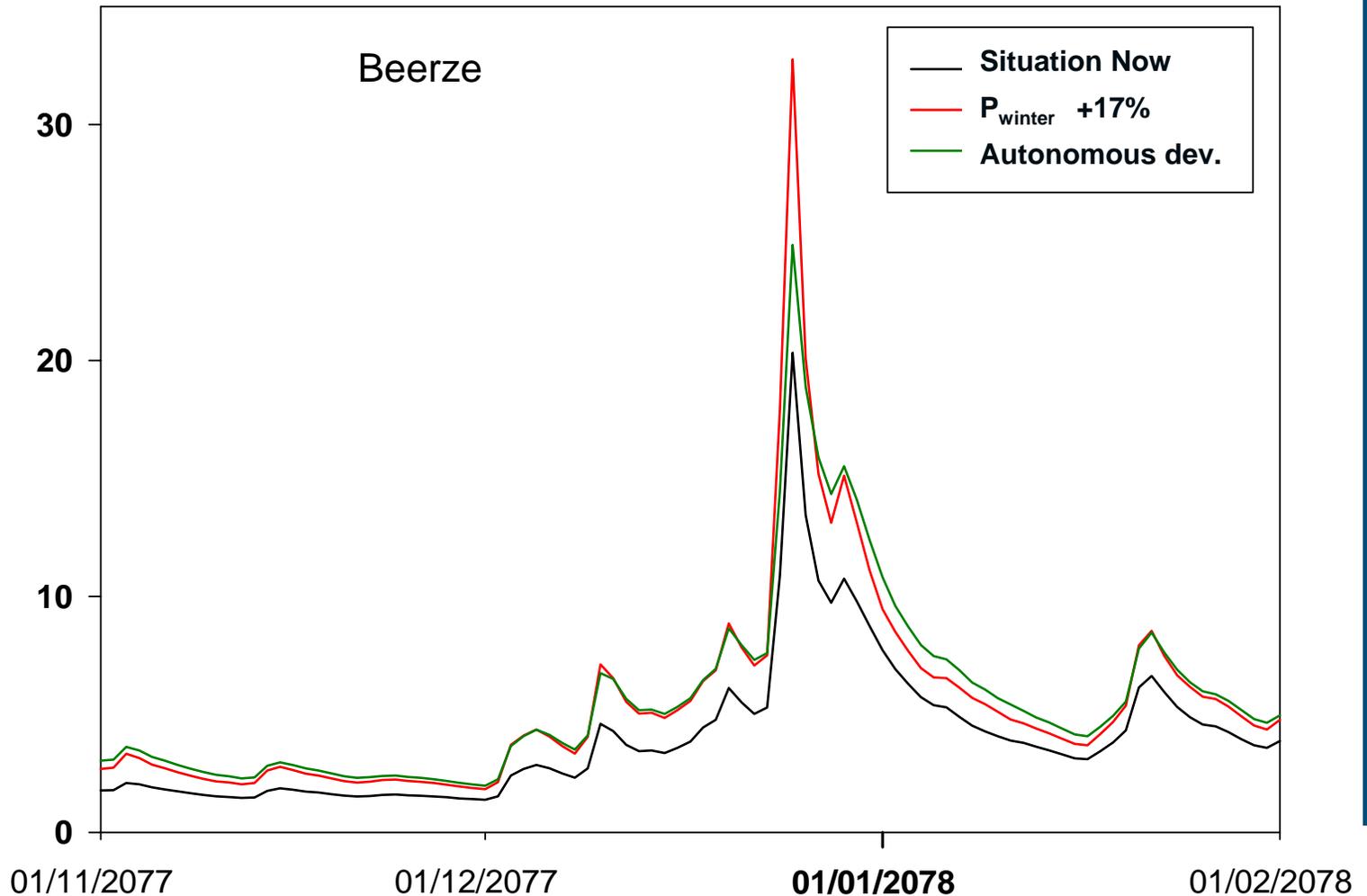
Agricultural land-use

-  Field drainage

Development of desiccated area

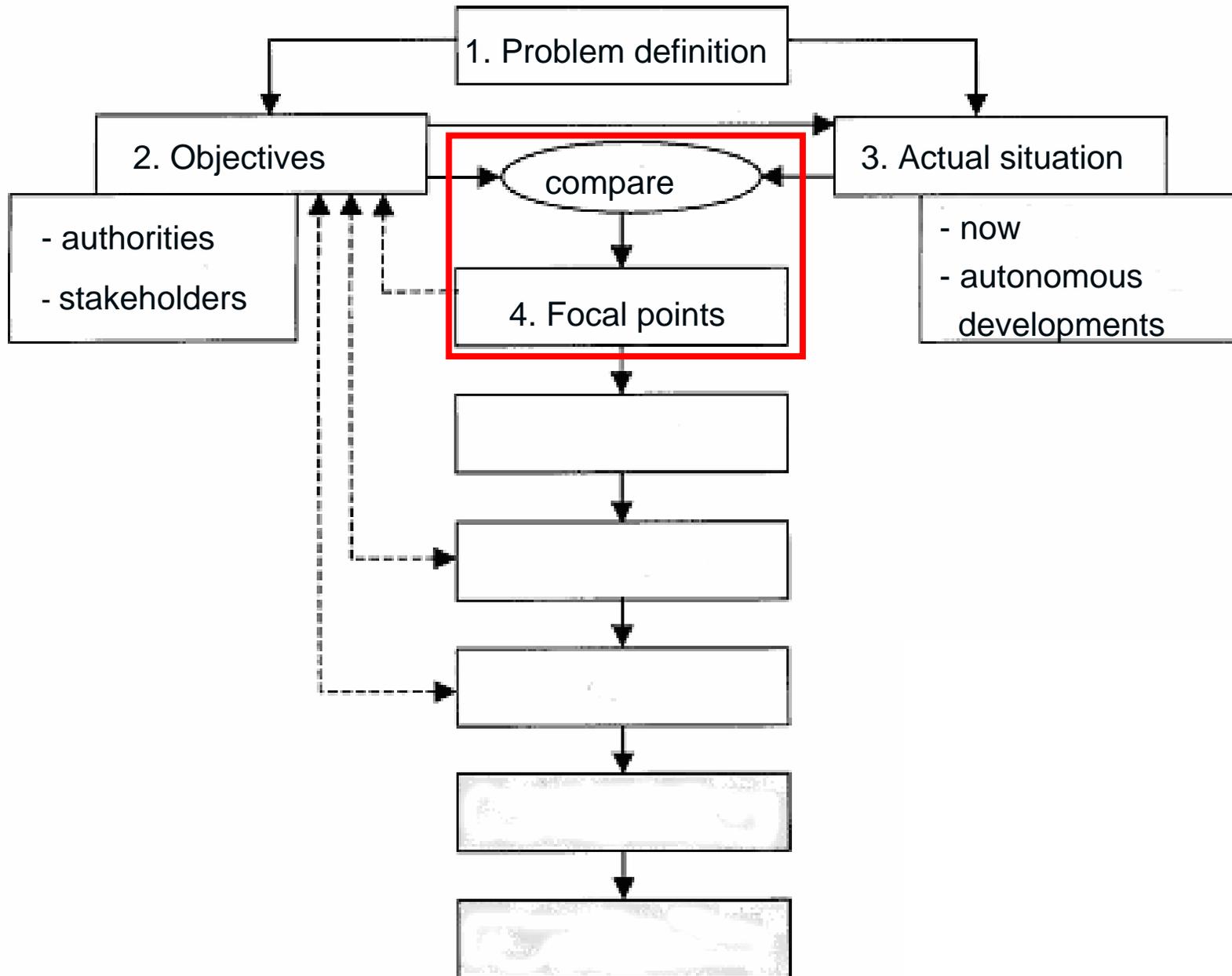
Situation	Desiccated area (%)
Now	73
After implementation of national ecological network	68
Climate scenario	51
Autonomous development of agriculture	57

Developments of peak discharges



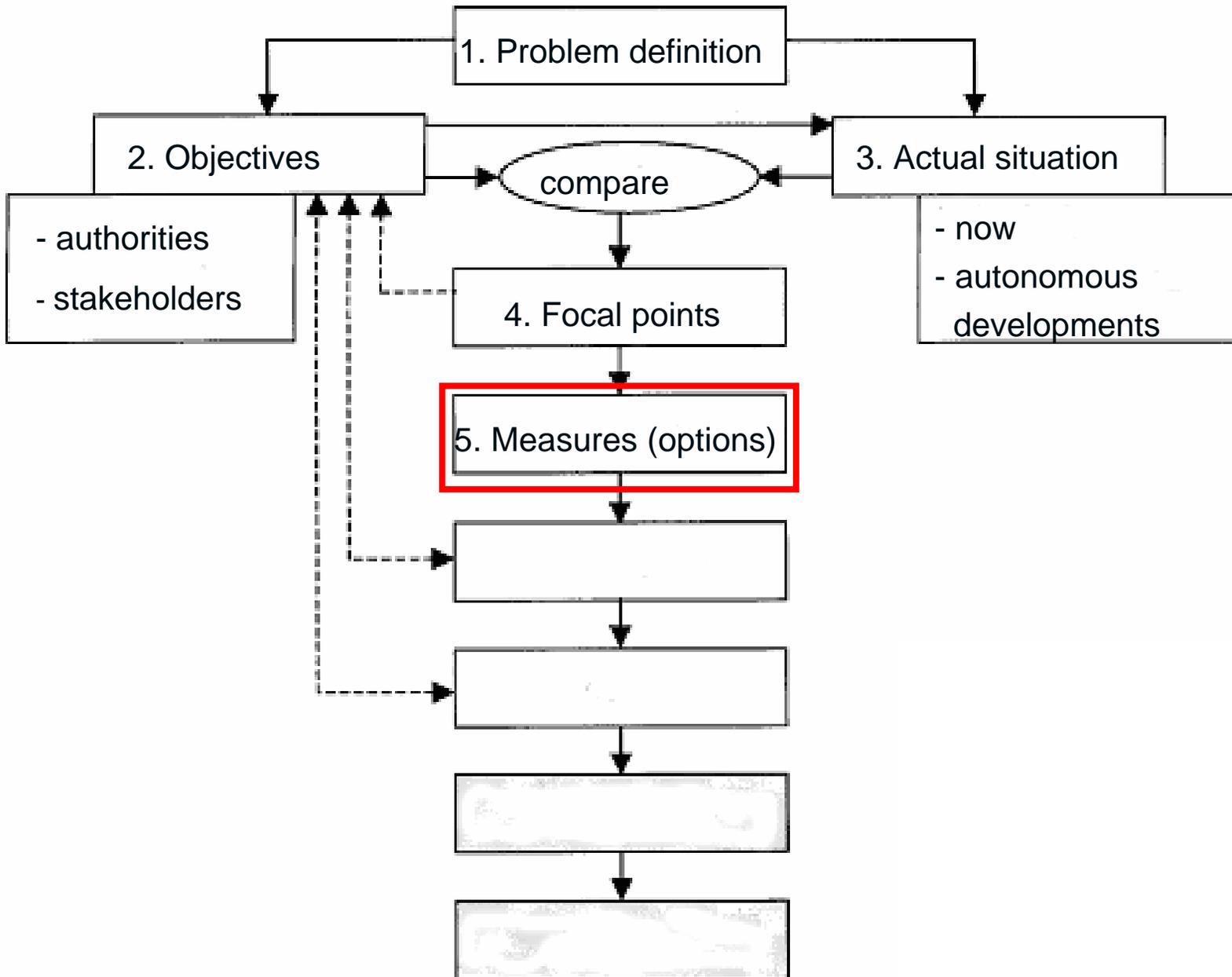


What should we focus on ?





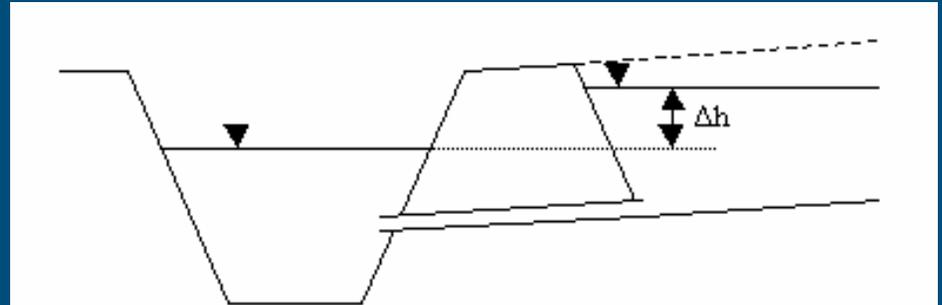
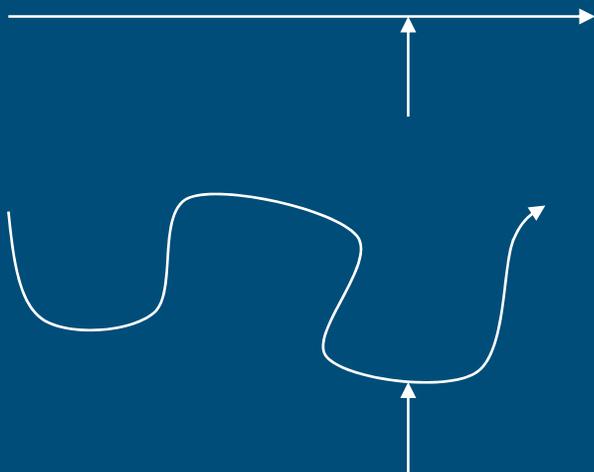
What are the options ?



Measures

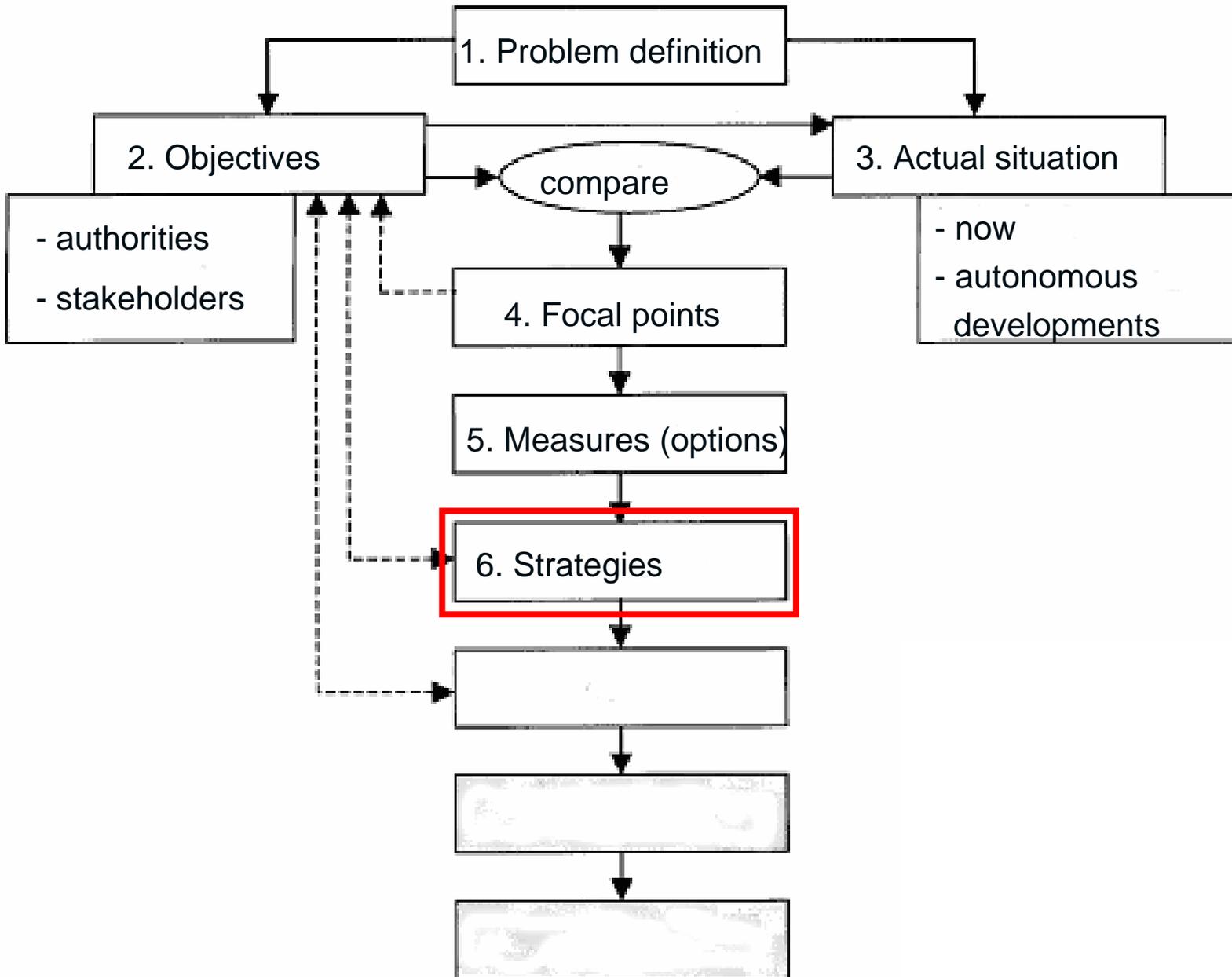
(options)

- land use
- water management : a.o. flow retardation





What is the best strategy ?



Decision support, inverse approach



communication

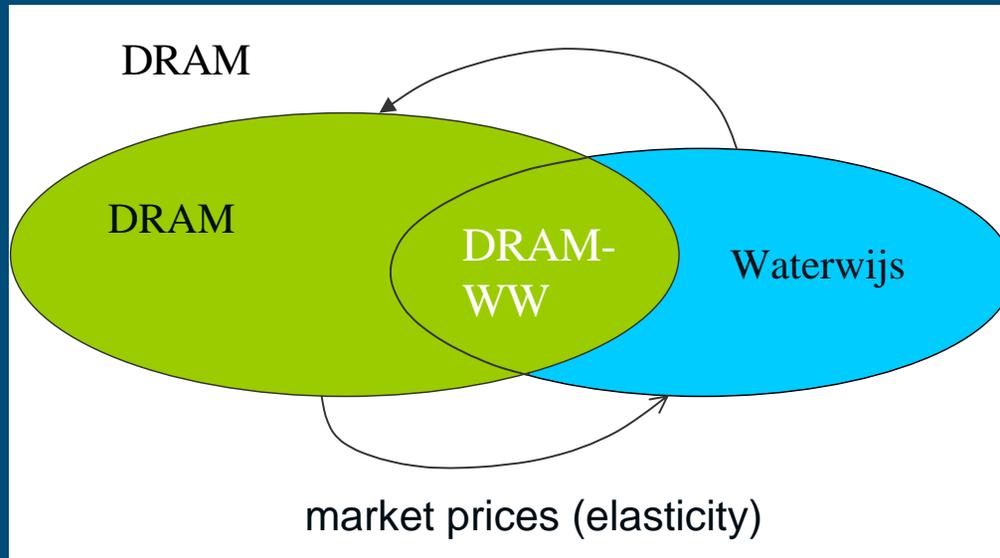
measures



optimization

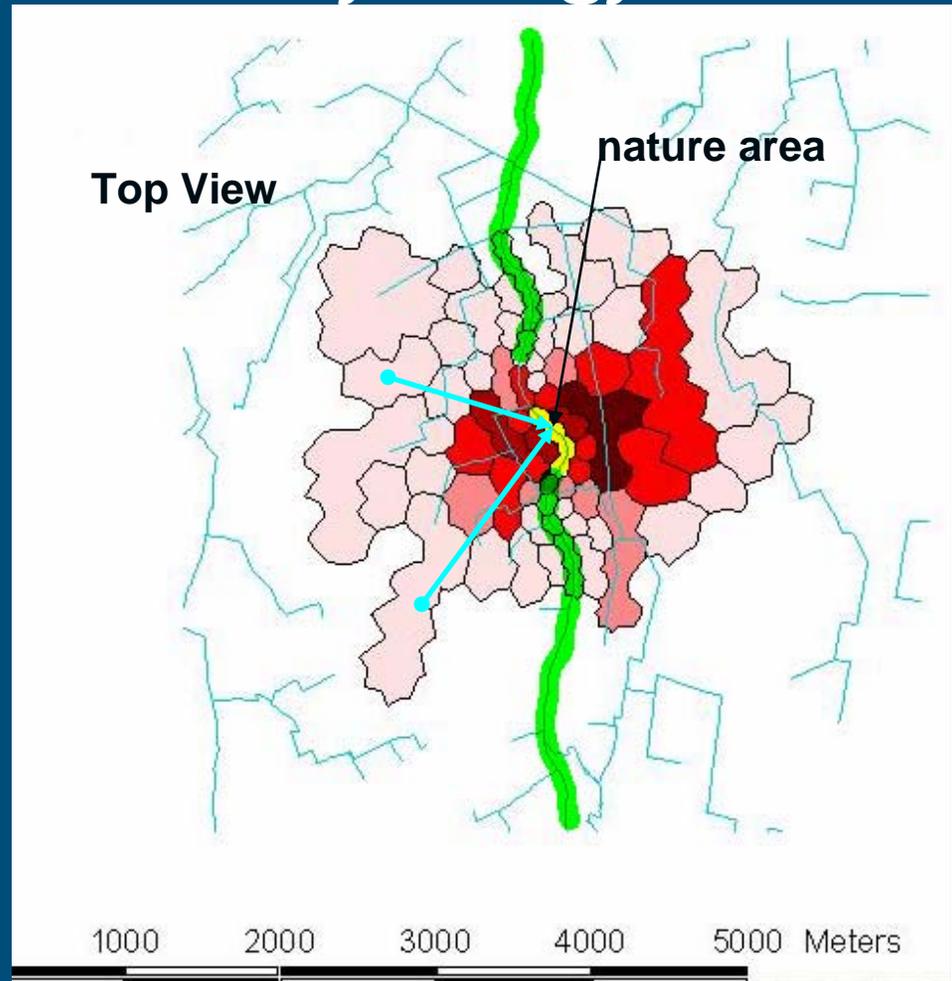
- Stakeholders:
- targets on objectives
 - *options* for measures

Integration with agricultural model DRAM

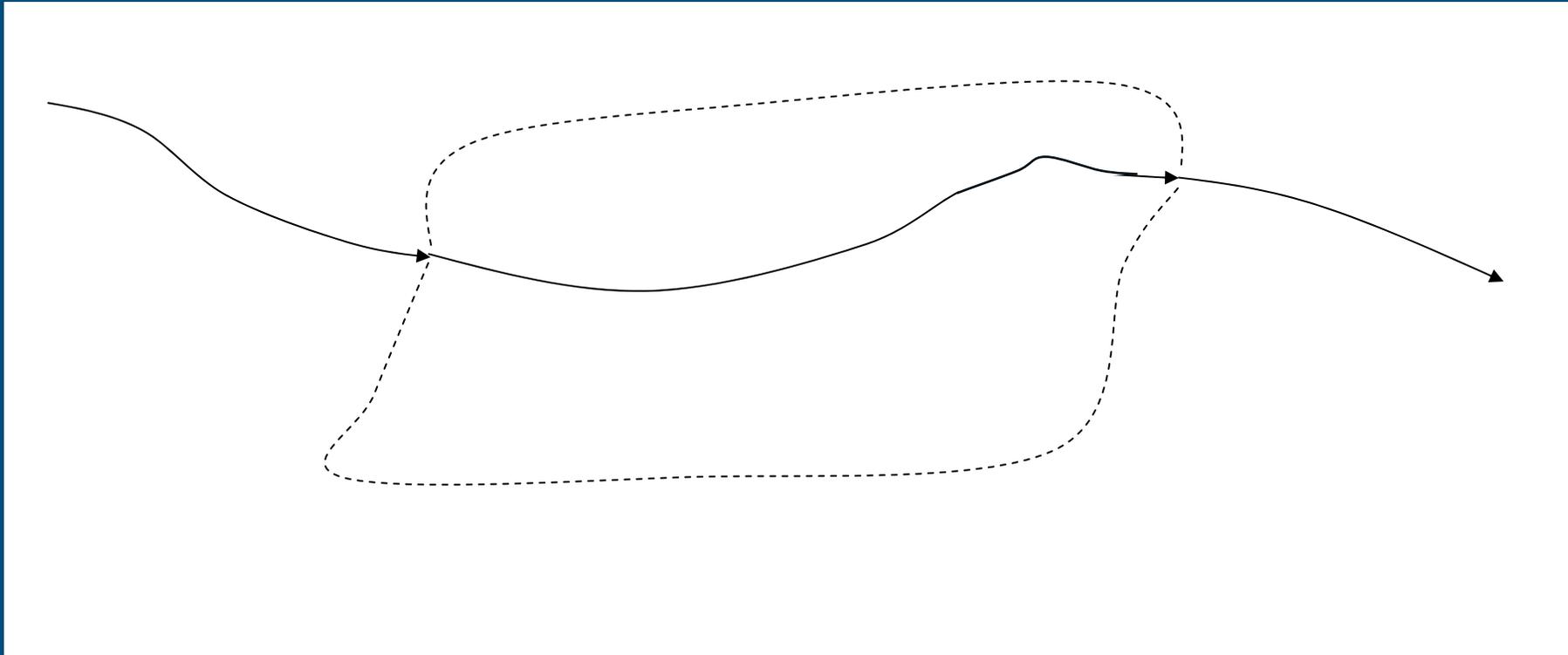


Building a simplified model for hydrology

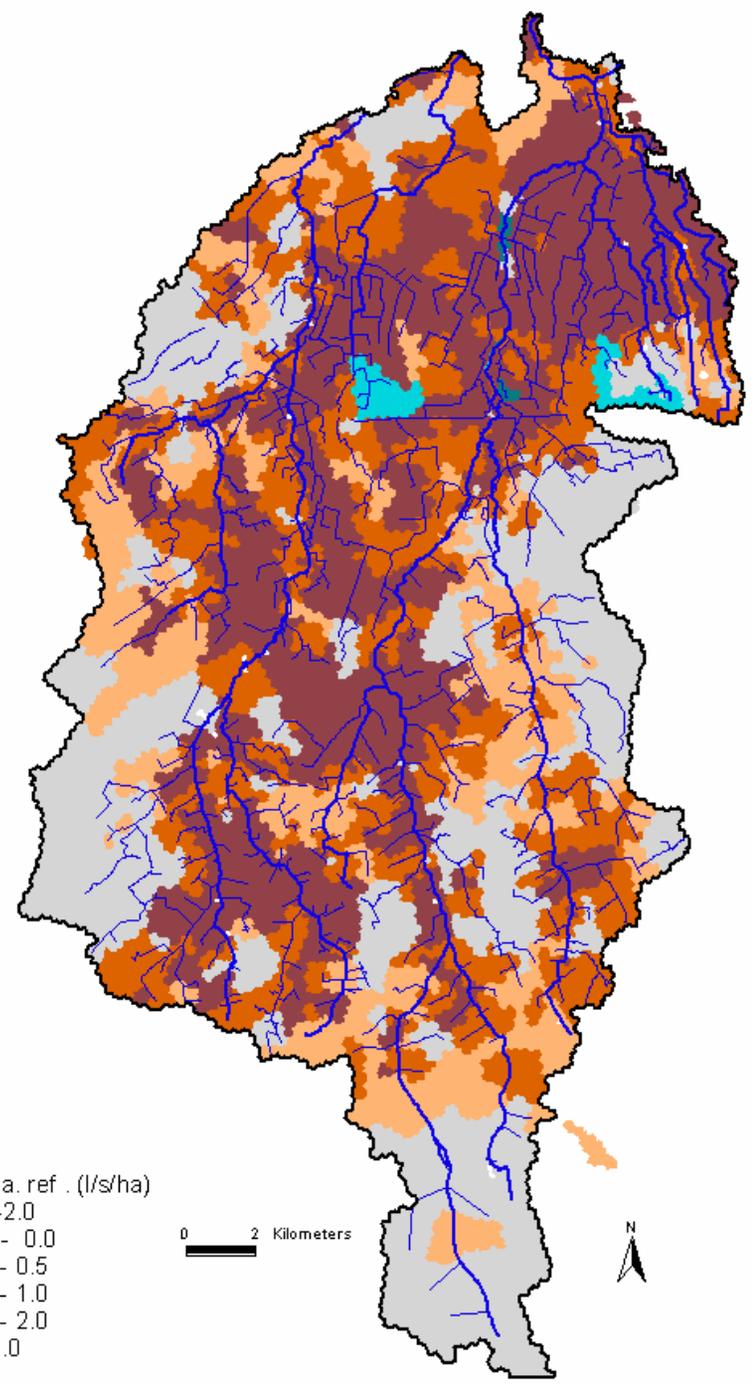
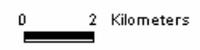
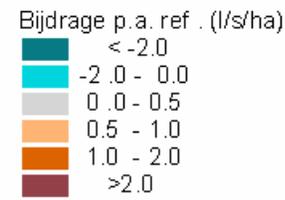
- influence matrix for spatial interaction



Contribution to peak flow, per subcatchment



Contribution to peak flow in reference run



Simplified integrated modelling with optimization

- x_1, x_2, \dots vector of decision variables \mathbf{x}
 $x_i = 0$: NO
 $x_i = 1$: YES
- $g_{11}x_1 + g_{12}x_2 + \dots$ objective functions $g\mathbf{x} \rightarrow \mathbf{max}$
- $g_{21}x_1 + g_{22}x_2 + \dots$
- $a_{11}x_1 + a_{12}x_2 + \dots < b_1$ boundary conditions
 $\mathbf{Ax} < \mathbf{b}$
- $a_{21}x_1 + a_{22}x_2 + \dots < b_2$

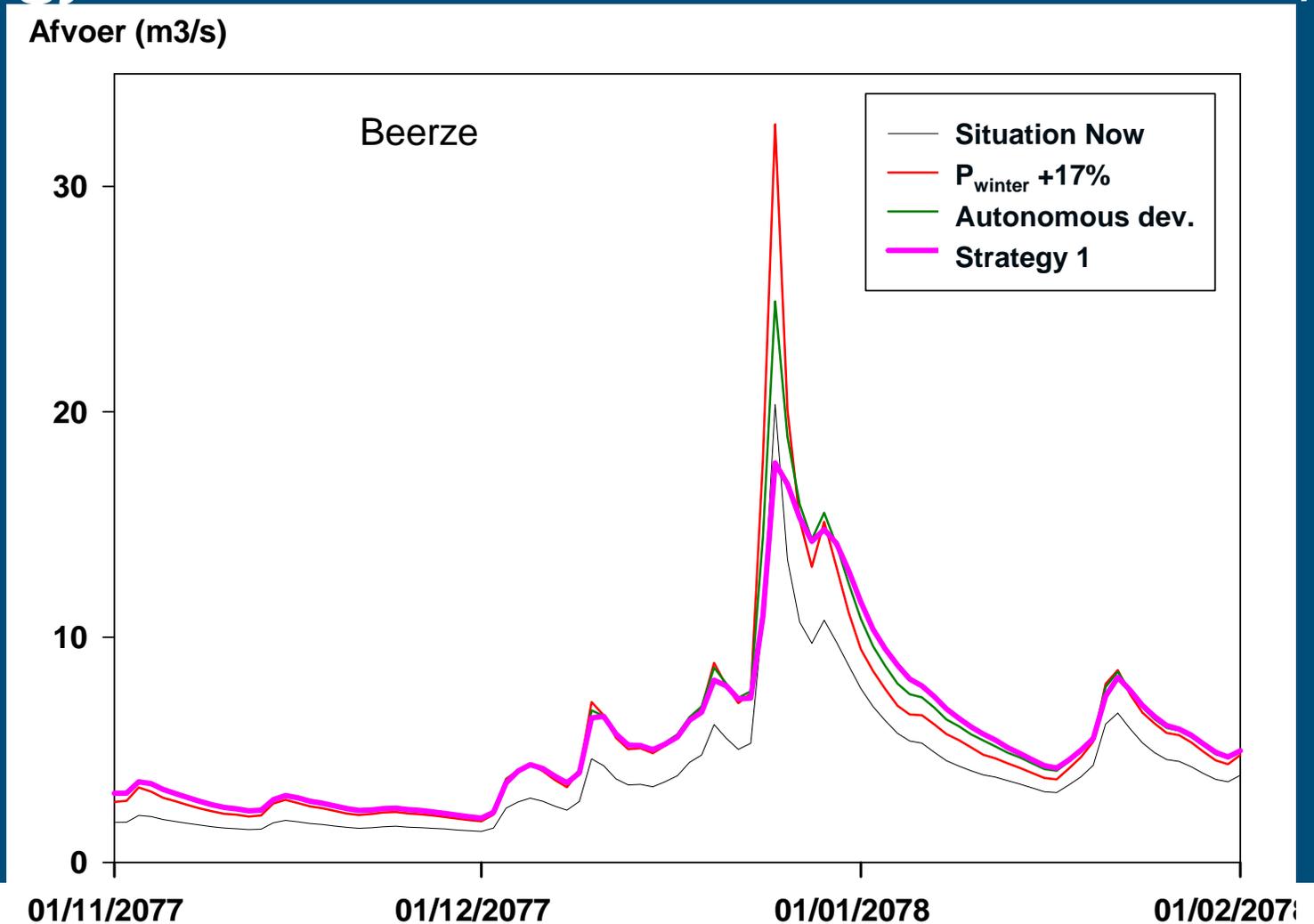
Optimization-model (Beerze-Reusel)

- 60 000 constraints
- 200 000 decision variables
- 2 million non-zero coefficients in the matrix

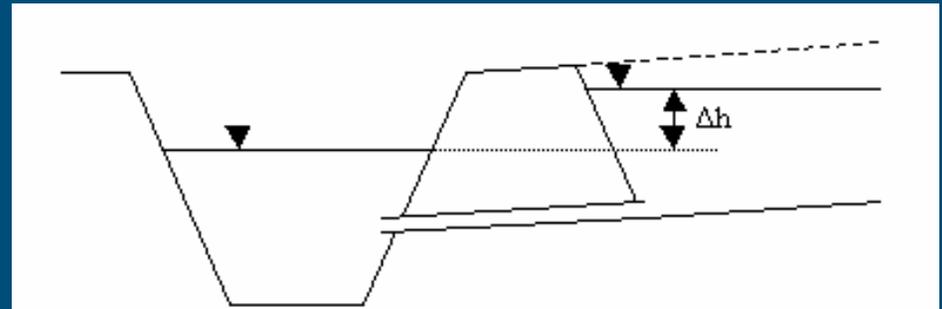
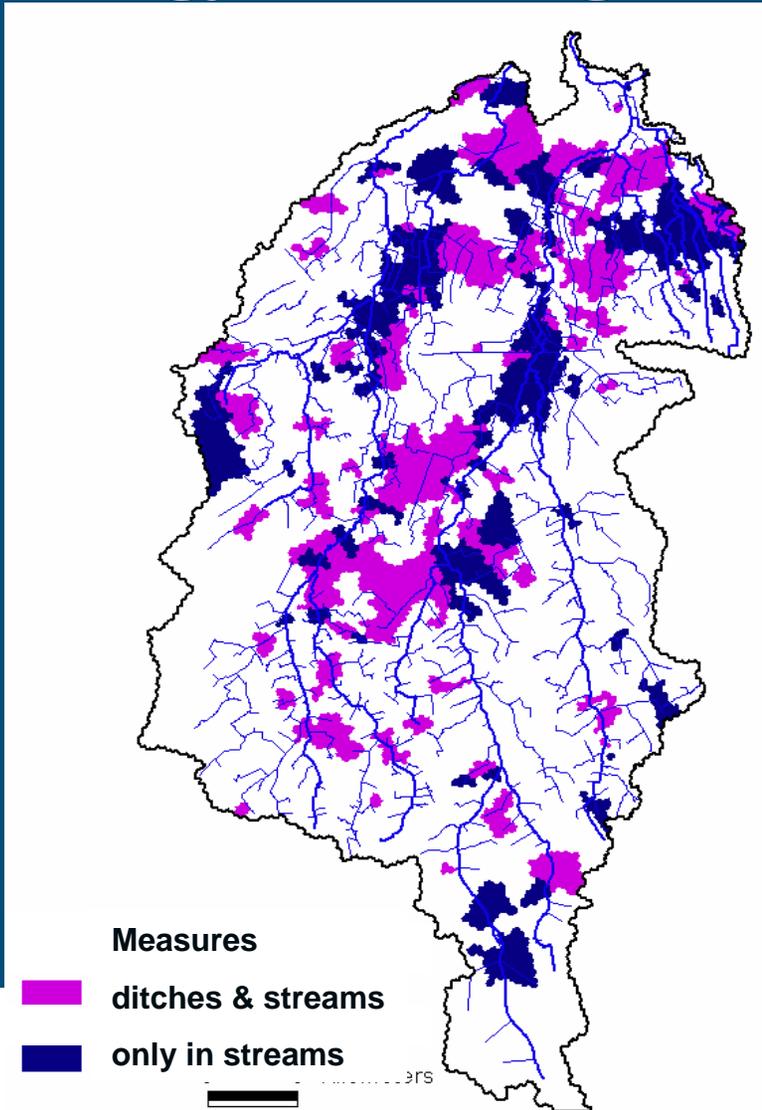
- CPU-time ~0.5 hour on a P4-2.4Mhz

Strategy 1 : flood risk ↓

$dY = -1.2M\$/y$



Strategy 1 (ctd) : generated pattern of measures



Strategy 2b:

- desiccation → 47%

Situation	Desiccated area (%)
Now	73
After implementation of national ecological network	68
Climate scenario	51
Autonomous development of agriculture	57

$$dY = - 0.7 \text{ M\$/y}$$

$$dN = 250 \text{ ha}$$

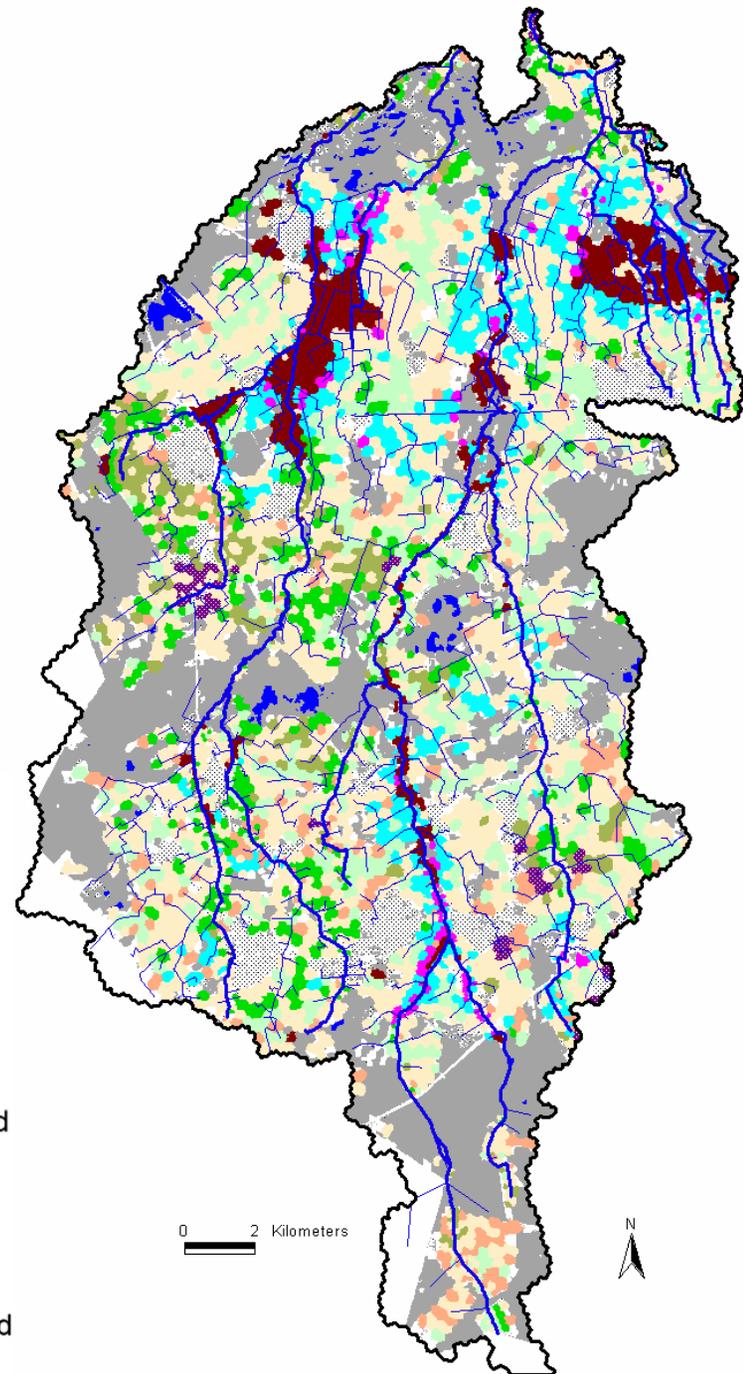
Existing landuse

-  Water
-  Built-up
-  Nature (forest)

Natural grasslands

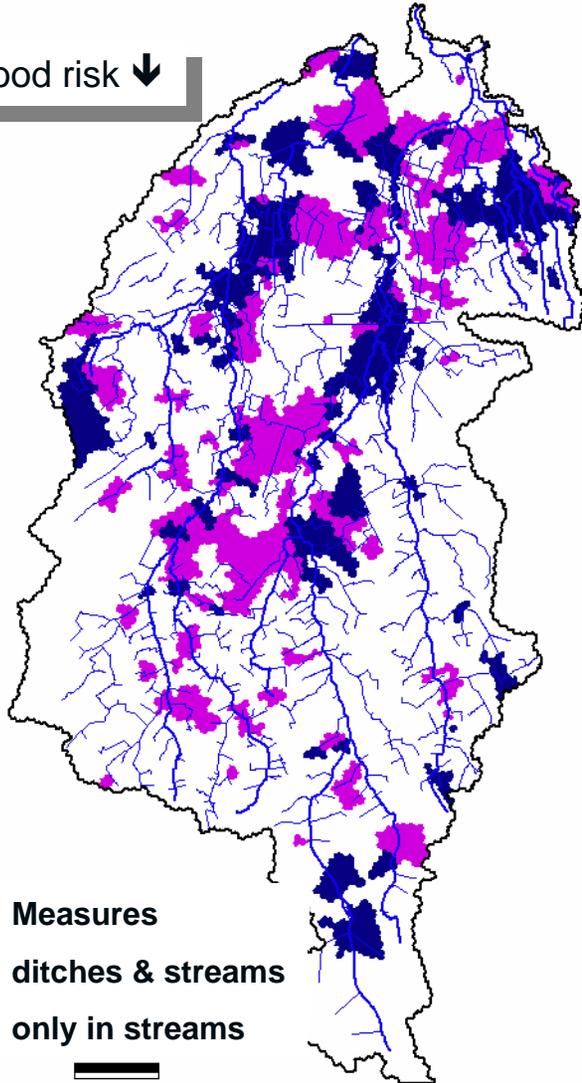
Generated landuse

-  Extensive grassland
-  Medium int. grassland
-  Intensive grassland
-  Arable land
-  Horticulture
-  Tree nurseries
-  New Forest
-  New natural grassland
-  New built-up areas



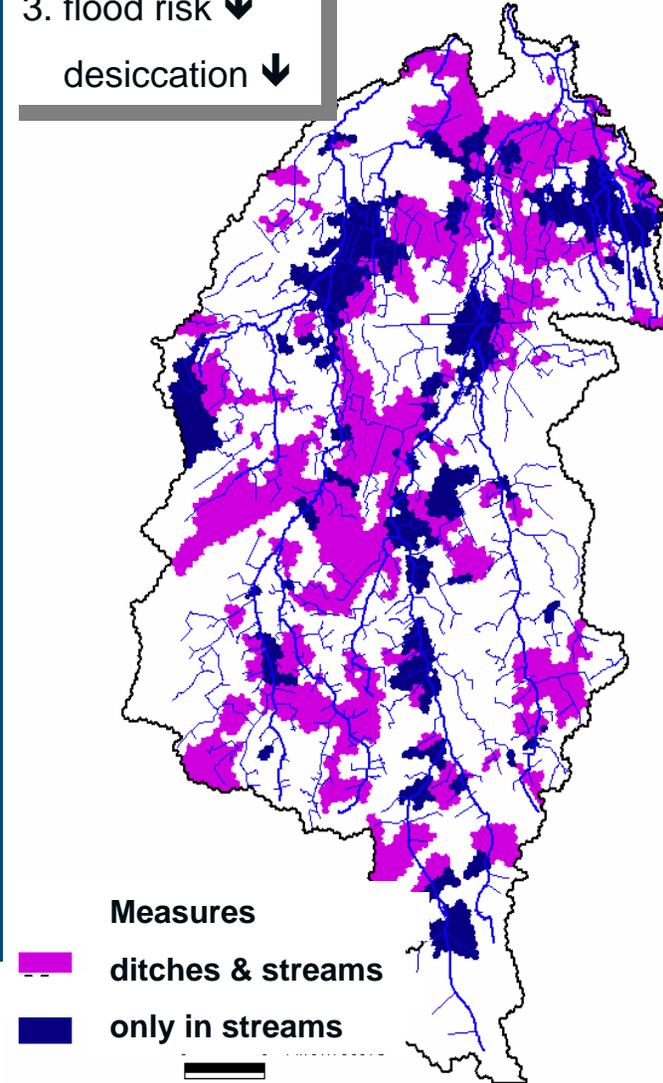
Strategy 3: combined targets of 1 & 2 $dY = -3.3M\$/y$

1. flood risk ↓



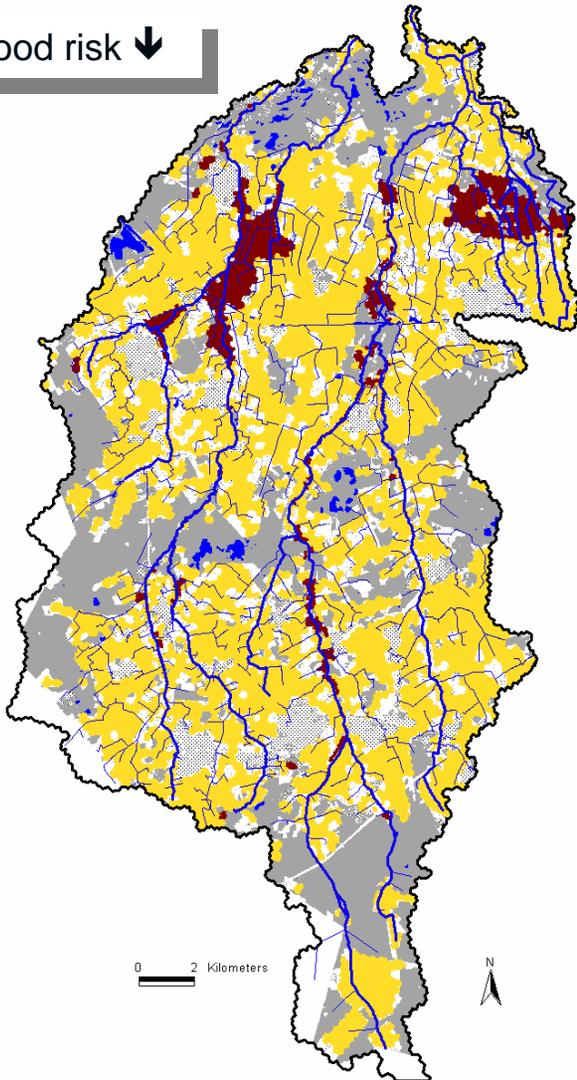
3. flood risk ↓

desiccation ↓



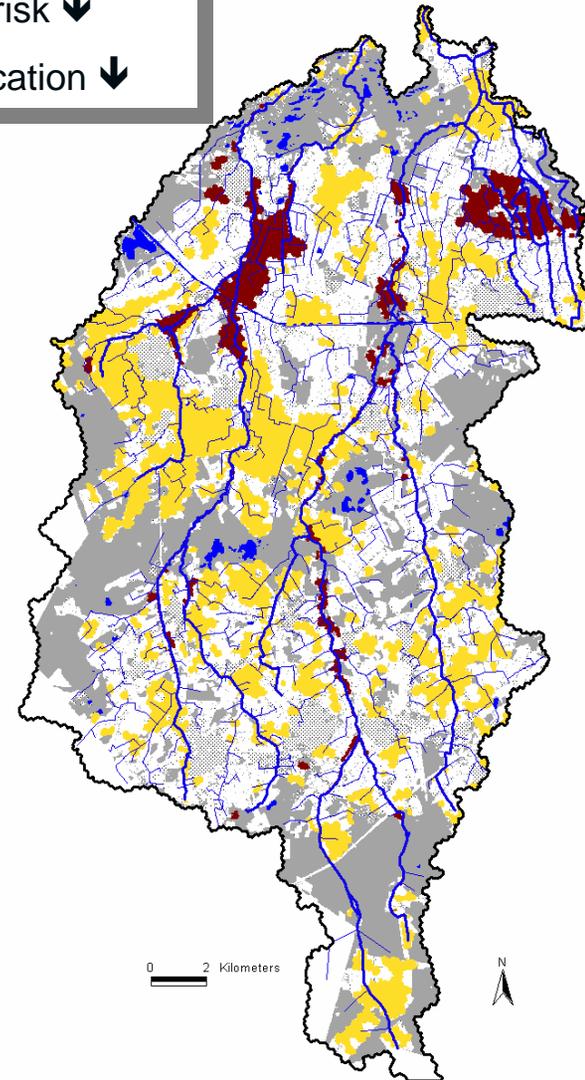
Strategy 3 (ctd.) : field drainage

1. flood risk ↓



3. flood risk ↓

desiccation ↓



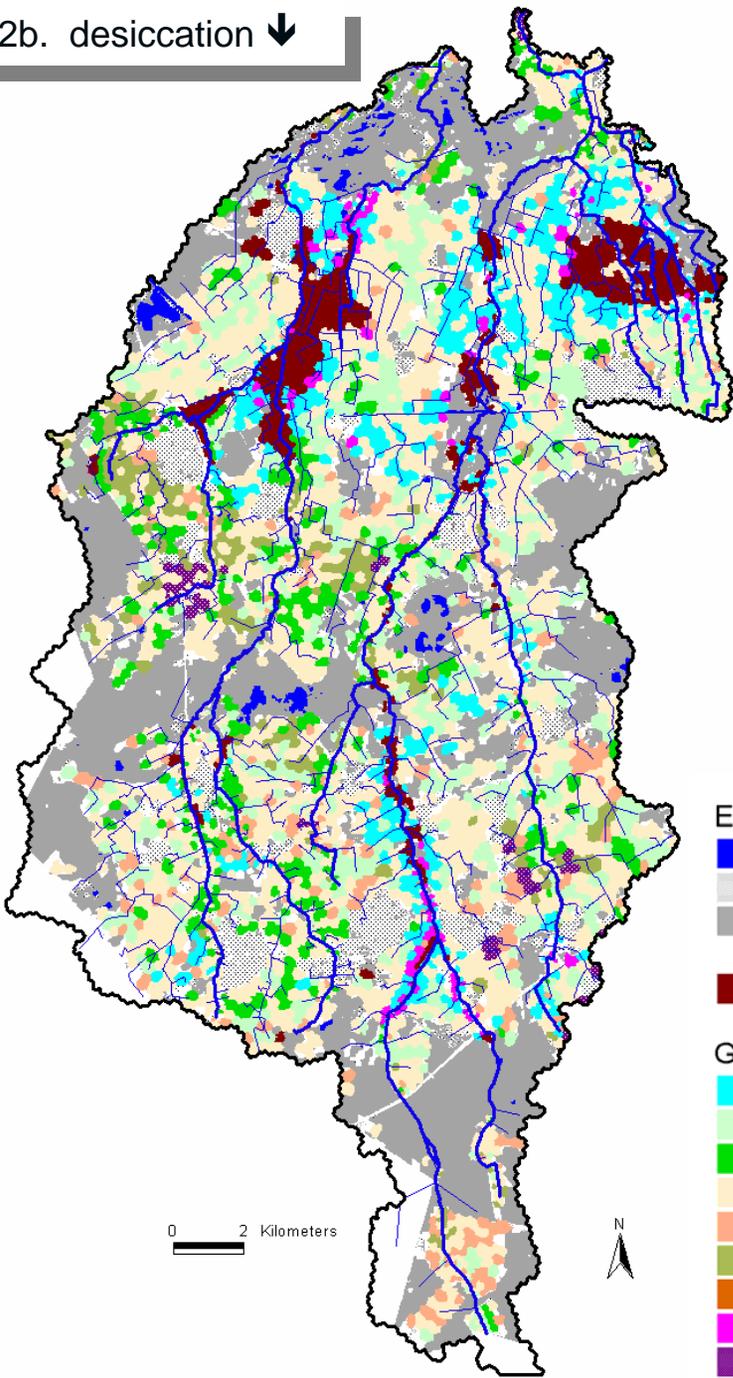
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Agricultural land-use

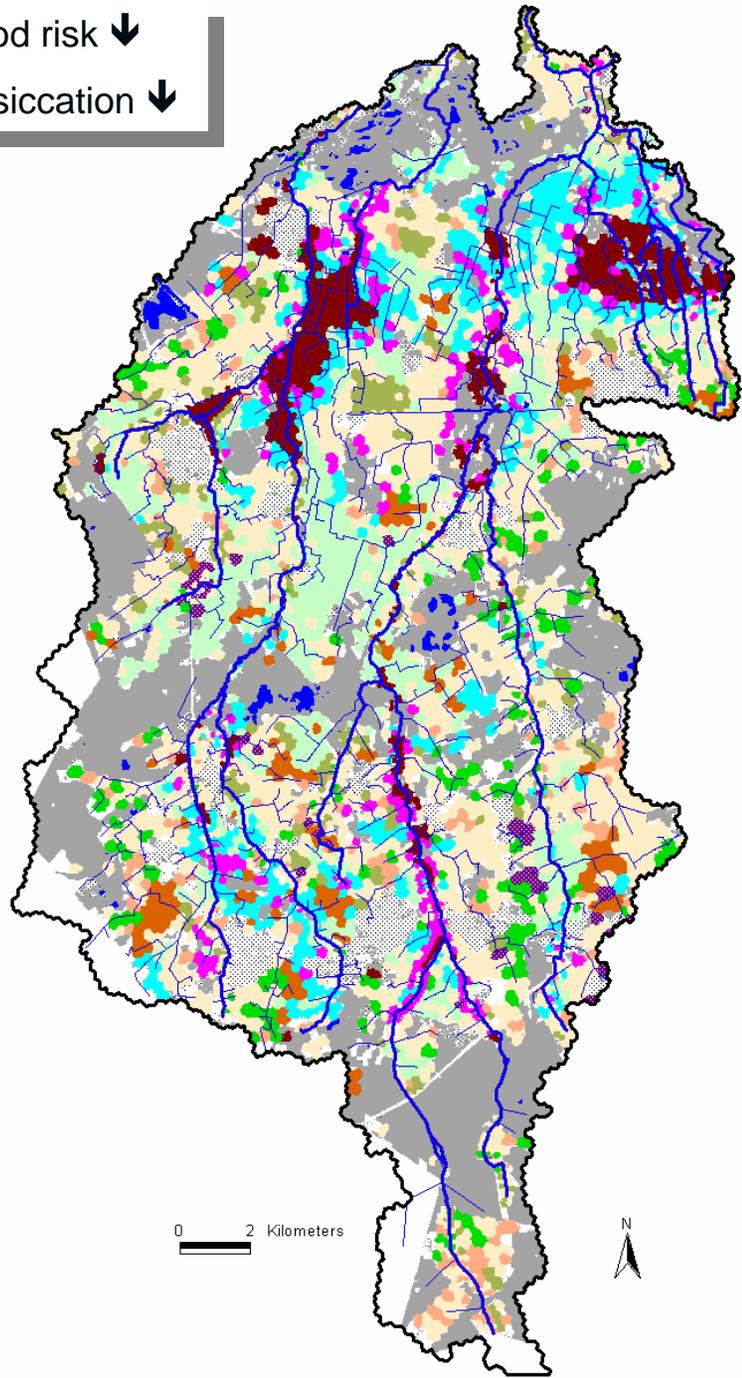
-  Field drainage

2b. desiccation ↓



3. flood risk ↓

desiccation ↓



Existing landuse

- Water
- Built-up
- Nature (forest)

Natural grasslands

Generated landuse

- Extensive grassland
- Medium int. grasdland
- Intensiive grasland
- Arable land
- Horticulture
- Tree nurseries
- New Forest
- New natural grassland
- New built-up areas

Implicit conflict: flood risk ↓ <> desiccation ↓

strategy	Loss of income (M€/year)
1	1.2
2b	0.7
total	1.9
combined strategy	3.3
synergy	-1.4

Strategy 4:

- flood risk ↓
- desiccation ↓
- N-loading SW ↓

$$dY = -17.5 \text{ M\$ /y}$$

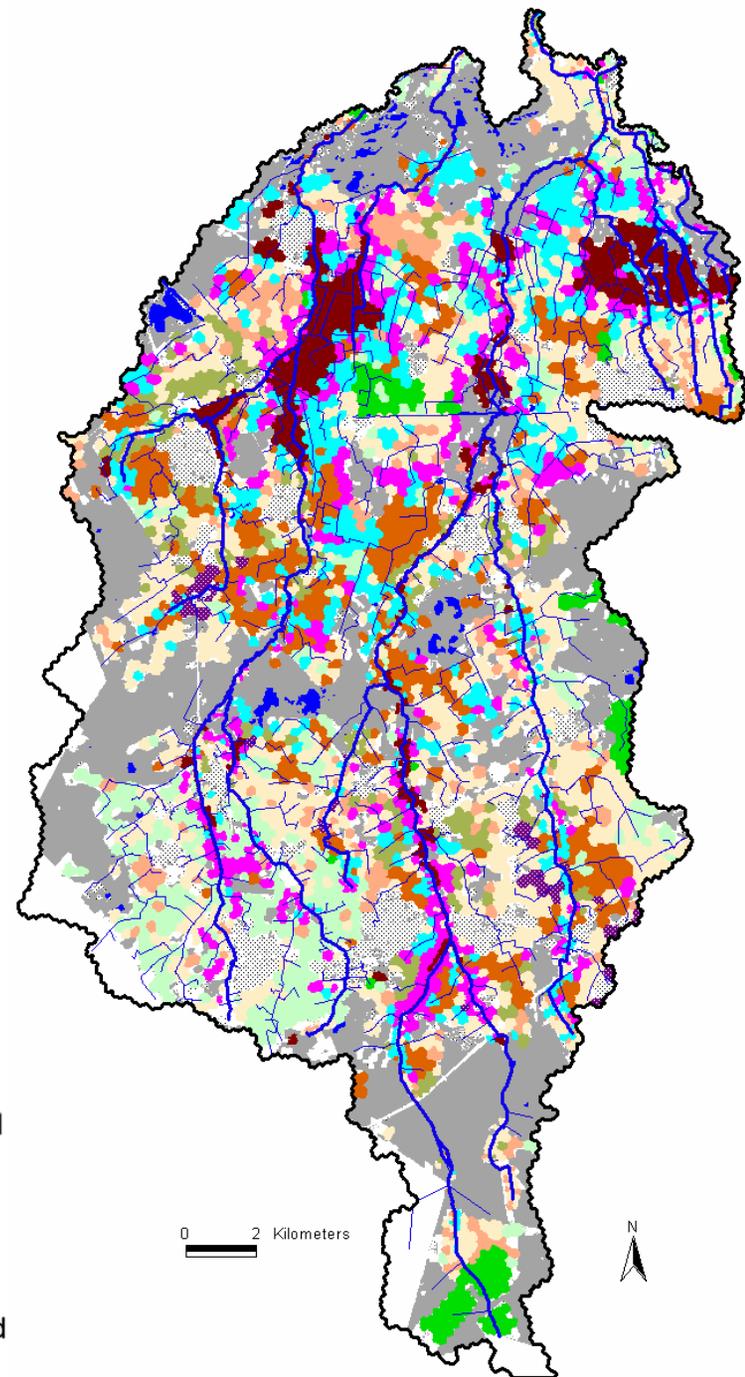
Existing landuse

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-  New built-up areas



Concluding remarks (modelling)

- integrated modelling of hydrology, ecology, and economy
- combined use of simulation & optimization
- turns the regional system 'inside-out'
- ideas for solutions, gives insight

Concluding remarks (climate change)

- climate change offers opportunities for reducing desiccation of nature areas
- requires anticipation of stakeholders on reaction of farmers to climate change
- peak flow control possible 'at source' but only at acceptable cost if housing estates are concentrated

NeWater

*New approaches to adaptive water management
under uncertainty*

*led by Claudia Pahl-Wostl (Osnabruck) &
Pavel Kabat (Wageningen UR)*

Transdisciplinary research project: 6th FP EU

Expected start, January 2005

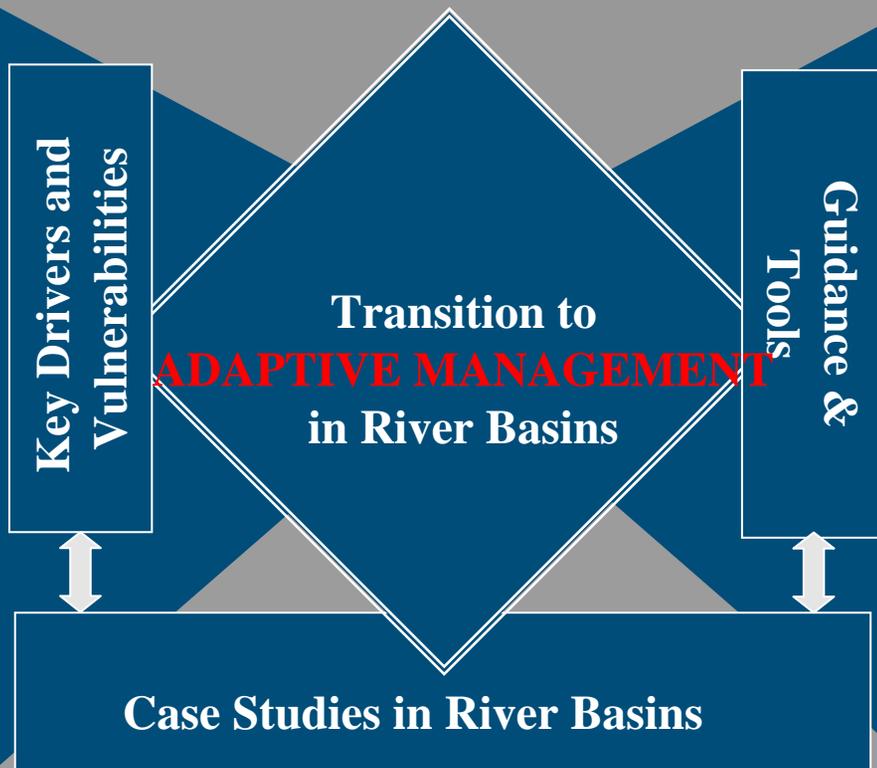
Duration of 4 years

12 Mio Euro Funding from the EU

Around 40 partners



International Expert- & Thematic Platforms



NeWater Project Coordination Platform

Structure of the NeWater Project



Case studies of Newater

