VULNERABILITY OF DRINKING WATER RESOURCES IN A CHANGING ENVIRONMENT

H.P. Nachtnebel, T. Senoner, J. Wesemann, M. Herrnegger
IWHW-BOKU

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A few facts

- About <100 % of Austrian population is supplied by groundwater and karstic springs
- <95% of the population is supplied by central water supply companies
- Groundwater is highly sensible to climate change (recharge and demand) and human activities (agriculture, industry, waste management,…)

Objective

- Objective: assessment of the vulnerabilty of water resources considering the role of ecosystem services
- An engineering approach for Austria and SEE (South Eastern Europe)

Structure of presentation

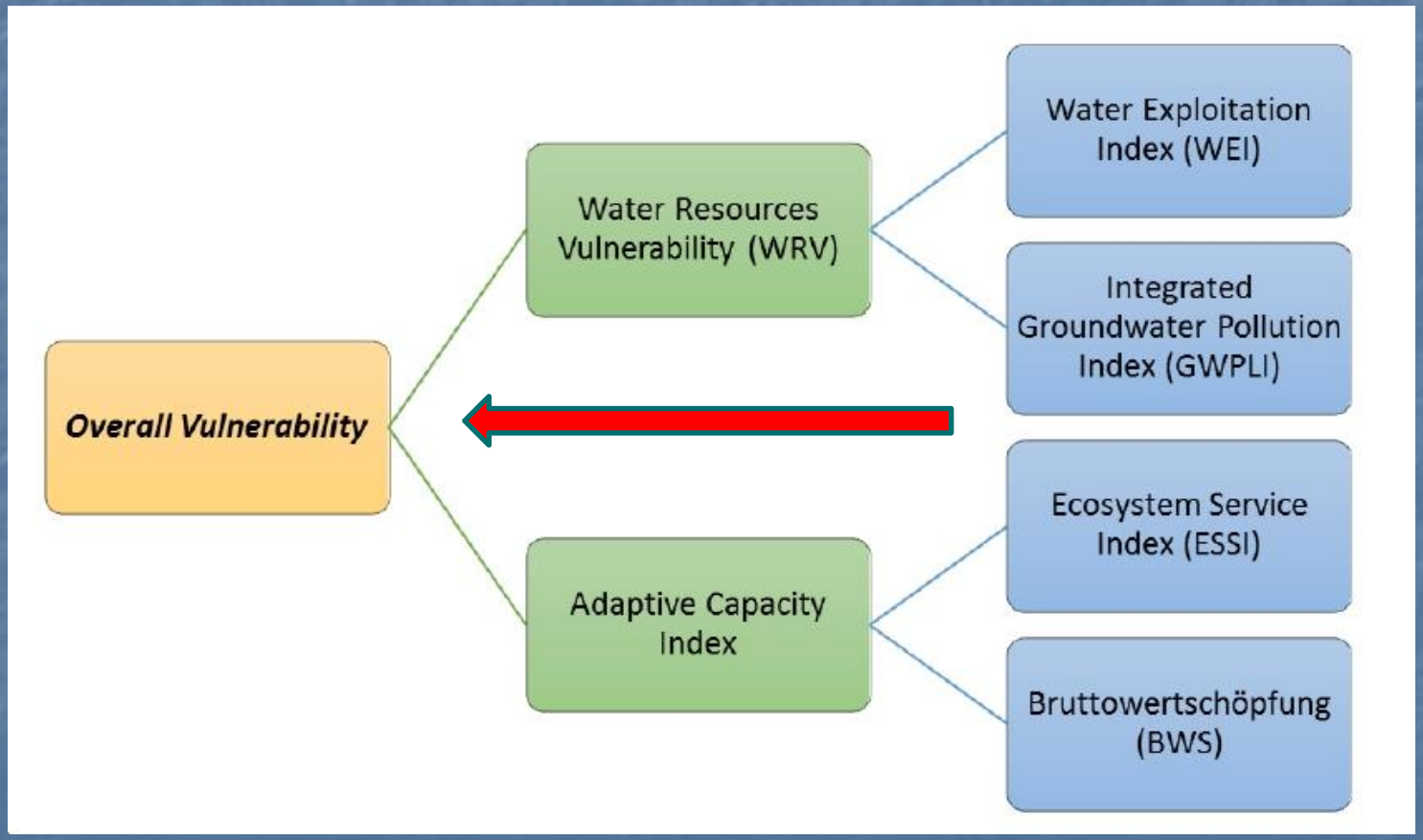
- Some definitions: vulnerability and ecosystem services
- Methodology
  - Indicators
  - Systems model
- Data base
- Application to Austria (and SEE)
- Summary and conclusions

Vulnerability

- When focusing on climate change, **vulnerability** is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change (UNEP, 2009)
- **Social vulnerability** refers to the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed.
- **Overall Vulnerability** of a society can be seen as an compound indicator considering
  - physical impacts (water quantity and quality)
  - changes in ecosystem services (ESS) and the
  - capacity of the society to respond to these impacts.

  - $V = Index_1 \oplus Index_2 \oplus Index_3 \oplus Index_4$

Overall Vulnerability



Water availability
Water demand

Land use
hydrogeology

Land use
hydrology

Population
economy

Indicators of Overall Water Resources Vulnerability

- Water availability WA: Local total runoff LTR
- Local total demand: LTD
- Local water quality index: LQI
- Ecosystem services: ESS
- Population density: POP and regional GDP

LWEI

Water Res. vulnerability

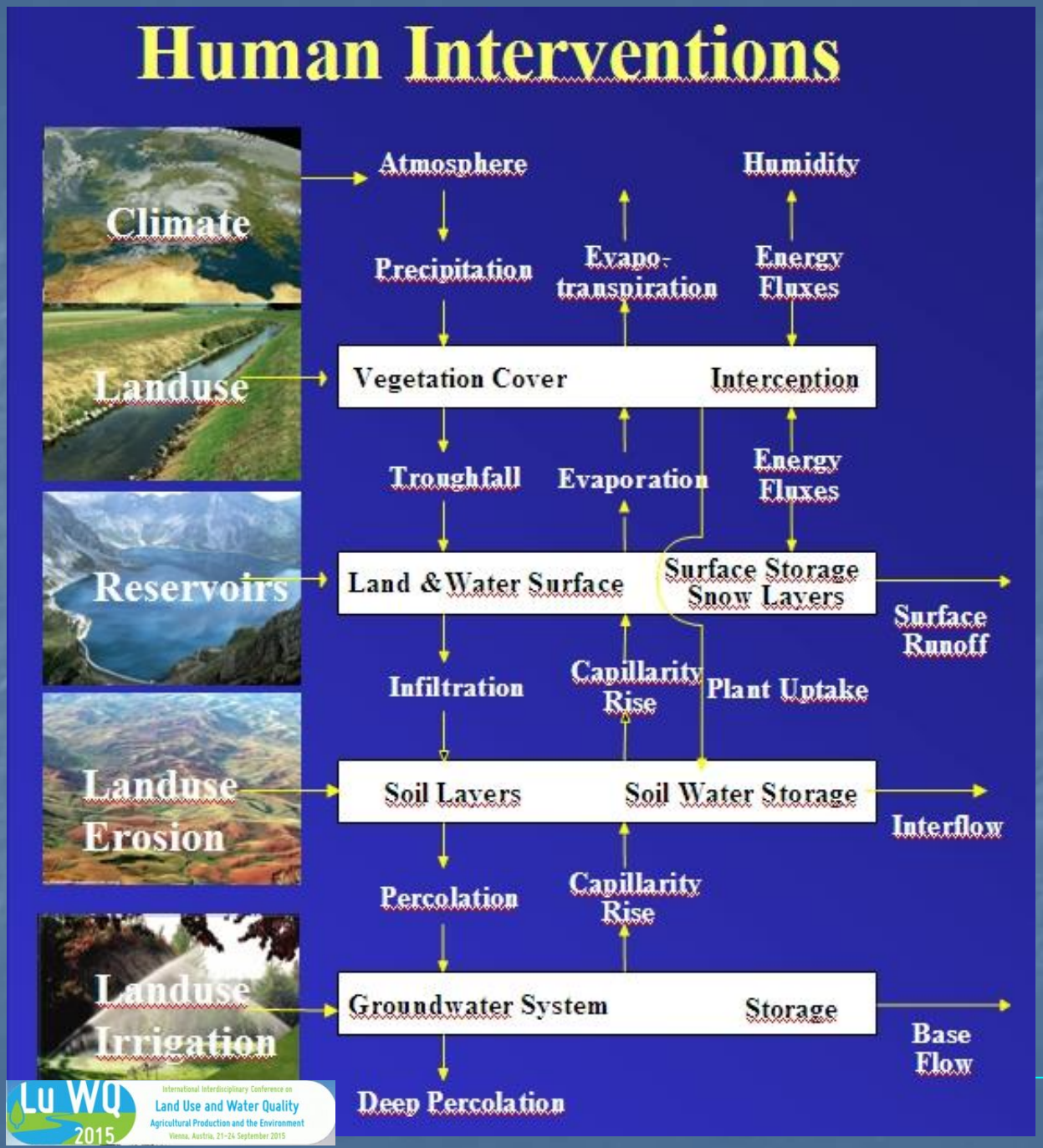
Adaptive capacity

Ecosystem services with respect to drinking water (Maes et al., 2011)

- **Freshwater provision** accounts for the availability of fresh water coming from inland bodies of surface waters for household, industrial and agricultural uses.

- **Water quantity regulation** refers to the influence ecosystems have on the timing and magnitude of water runoff, flooding and aquifer recharge, particularly in terms of water storage potential of the ecosystem.

- **Water quality regulations** refer to the capacity to trap, store and degrade nutrients (nitrogen loads), pollutants in ecosystems.



Climate impacts:

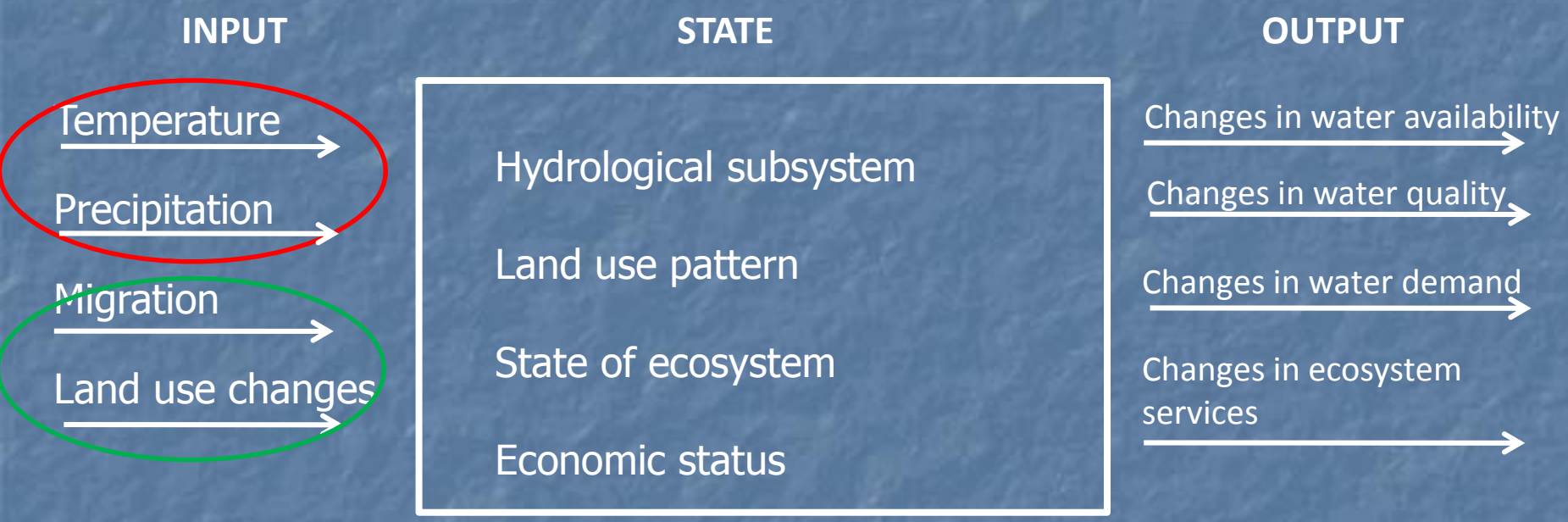
GHG increase changes
precipitation
energy fluxes

One of the consequences is a change of the vegetation pattern

Land use impacts:

Disapperance of wetlands
Implementation of reservoirs
Increase in erosion
Groundwater abstraction
Various pollution sources

Modelling the overall system



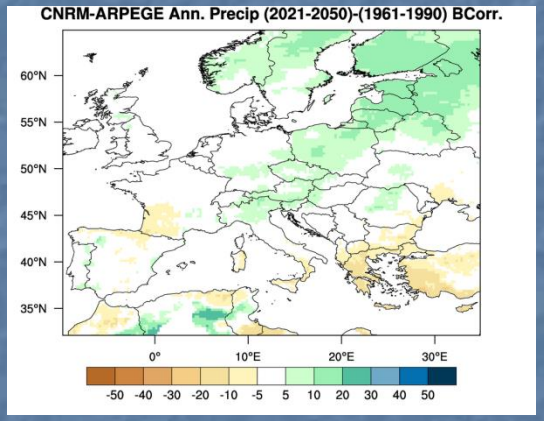
Data base

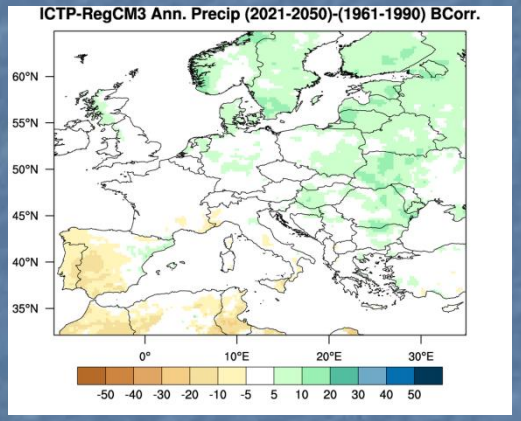
Drivers (or Input)

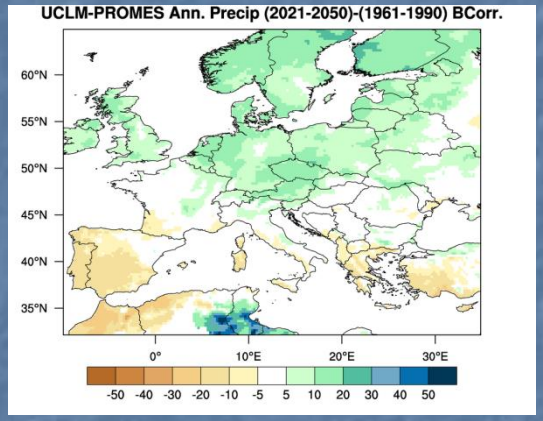
- Climate change: ENSEMBLES Project simulations
- Population changes: European (PRELUDE Project) and national demographic data
- Land use: Corine and scenarios from PRELUDE Project (EEA, 2007)

Expected climate changes until 2050

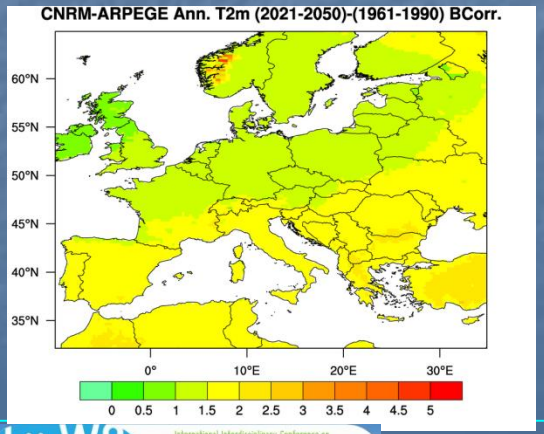
Annual precipitation changes from climate models

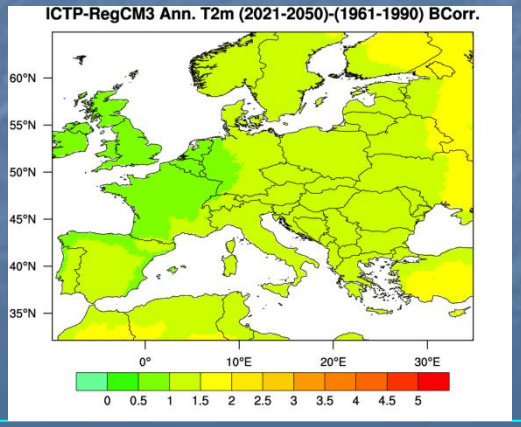


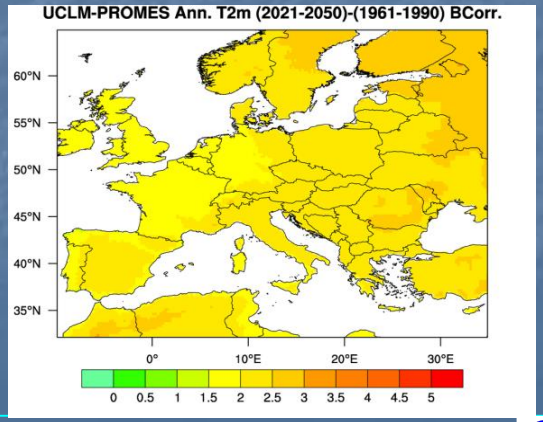




Mean annual temperature changes from climate models







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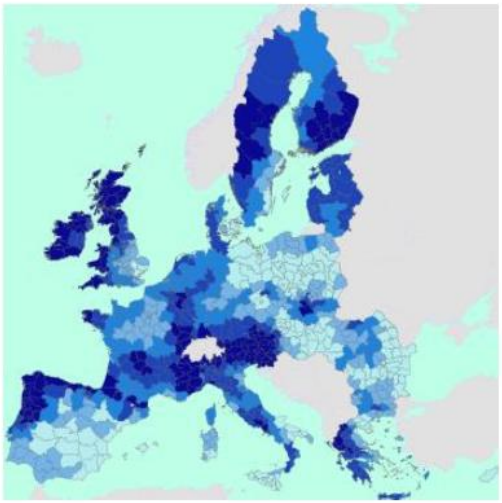
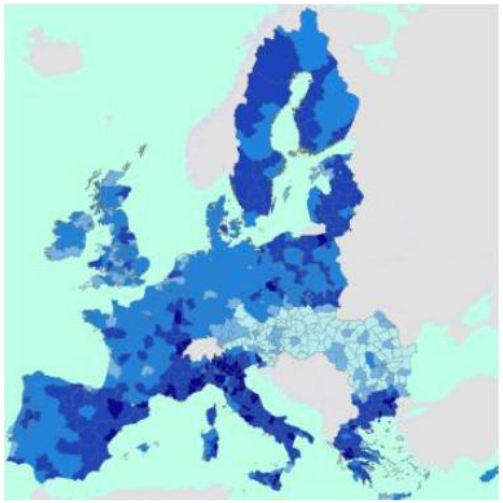
Capacity indicators (Maes et al., 2011)

Water provision capacity
Share of wetlands and water bodies (%)

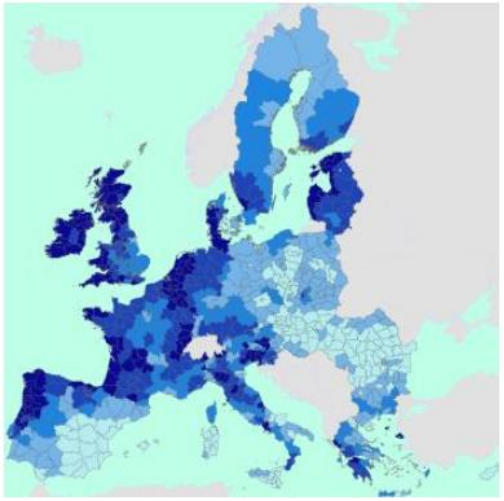
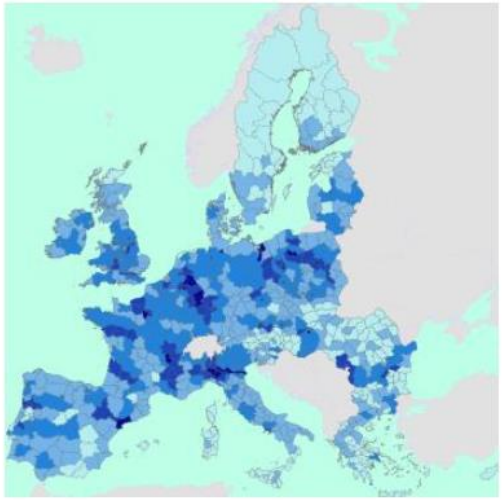
Water regulation capacity
Infiltration (mm)



Water purification capacity
Nitrogen retention (%)



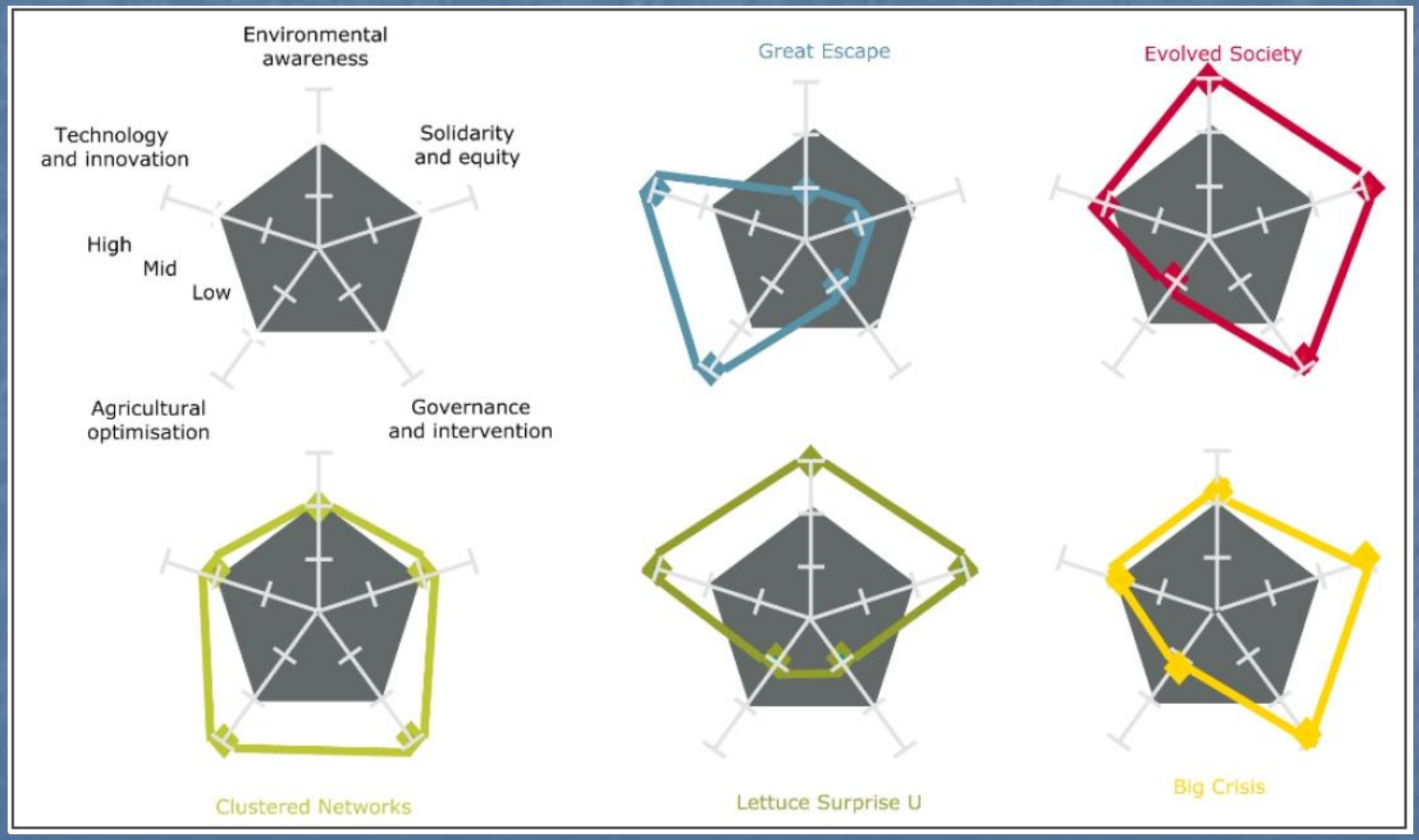
Flow indicators (Maes et al., 2011)

Water flow available from aquatic ecosystems Surface water flow (m^3 $year^{-1}$)	Water flow regulated by terrestrial ecosystems Sub surface water flow (m^3 $year^{-1}$)	Removal of pollutants In-stream nitrogen removal (ton $year^{-1}$)
		

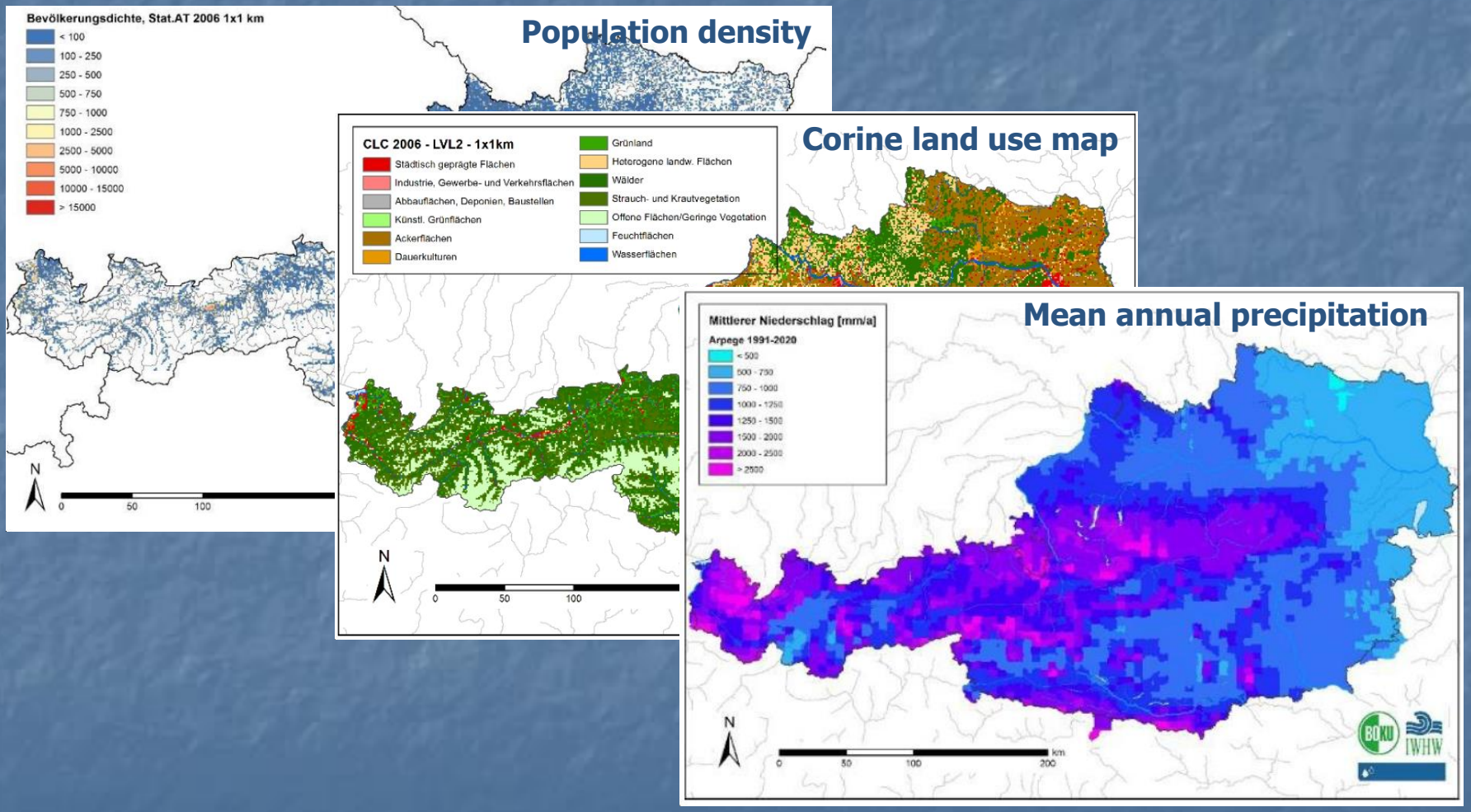
Land Use Changes
Scenarios from PRELUDE Project (2007)

- Scenario 1 : The great escape (Europe of contrast)
- Scenario 2: Evolved society (Europe of harmony)
- Scenario 3: Clusters of European networks (Europe of structures)
- Scenario 4: Lettuce Surprise U (Europe of innovation)
- Scenario 5: After the Big Crisis (Europe of cohesion)

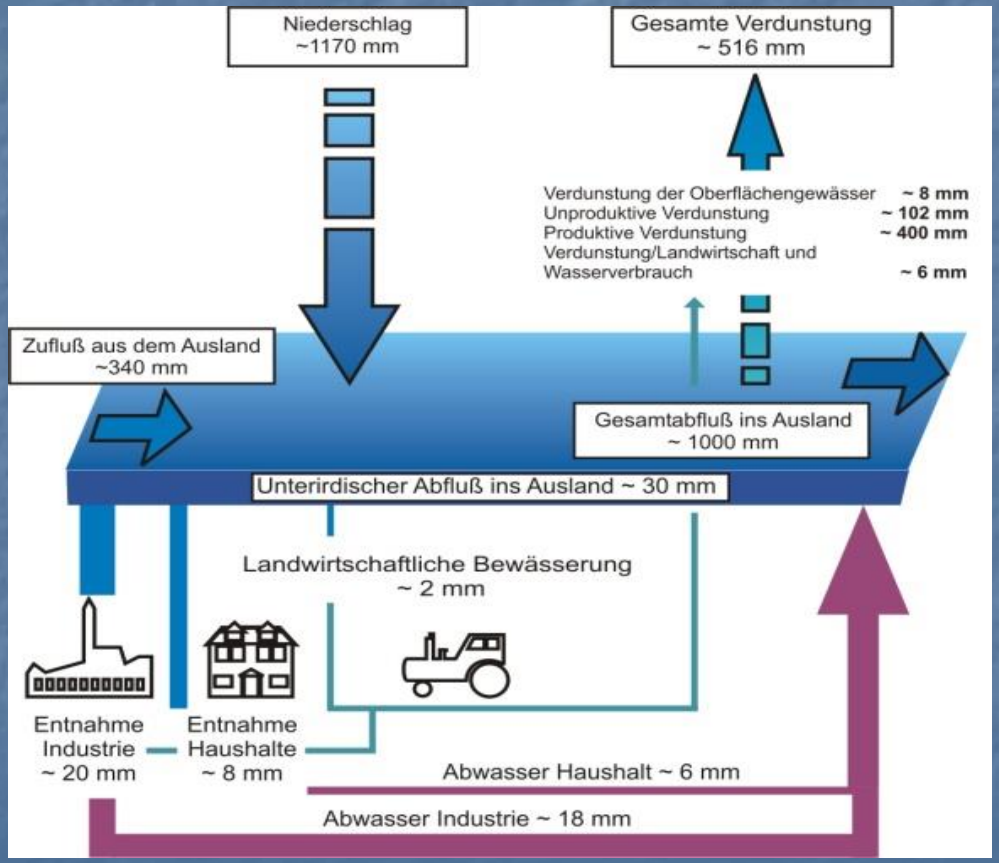
Prelude scenarios (EEA, 2007)



Recent status in Austria



Water balance for Austria



P mean 1170 mm/a
EVAPmean 516 mm/a

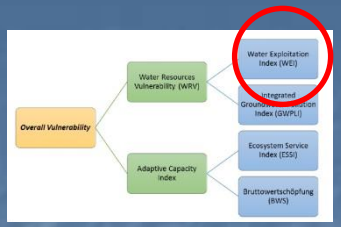
Industries: 20 mm/a
Households: 8mm/a
Irrigation 2mm/a

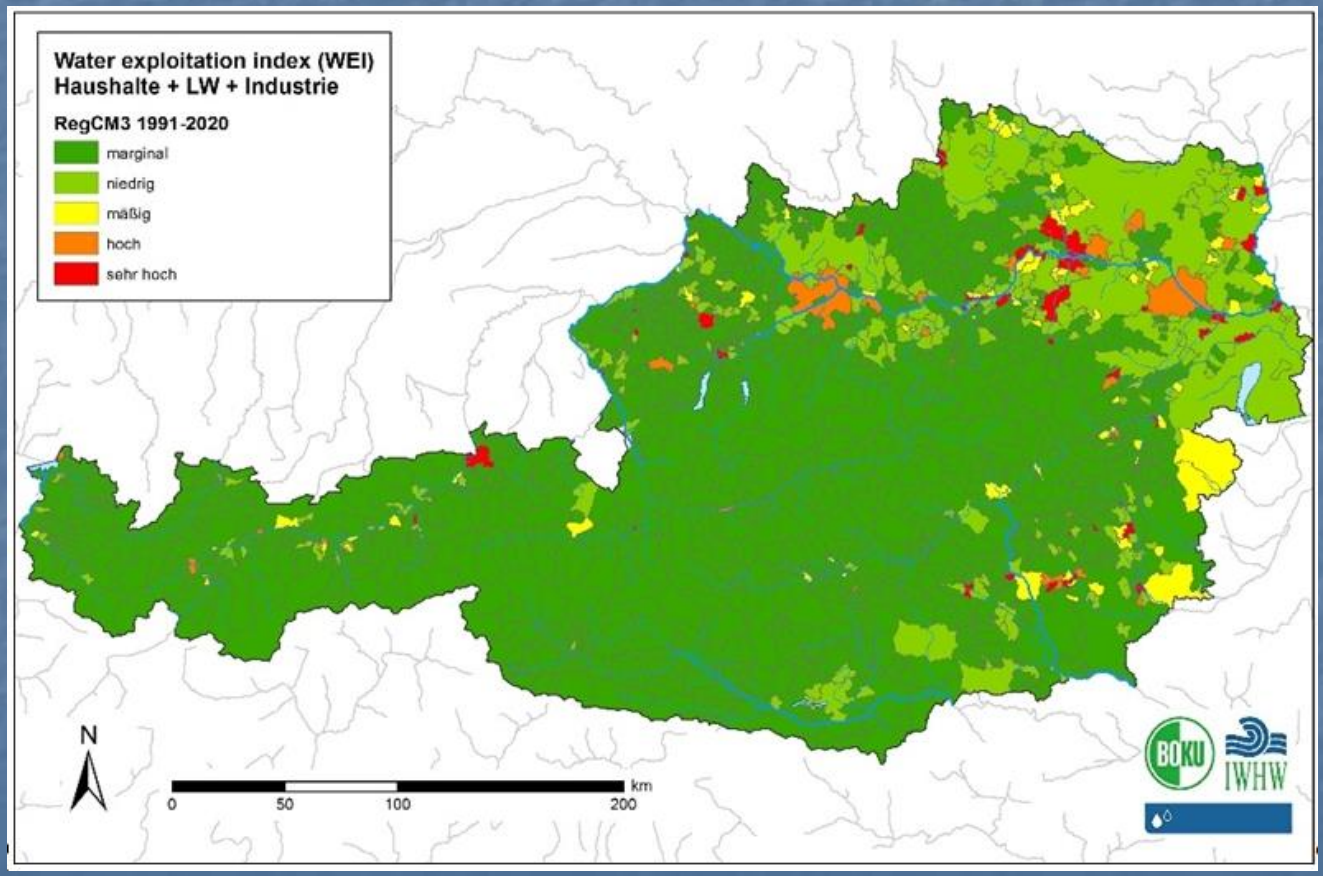
1961-2000
HZB (2005)

Methodology

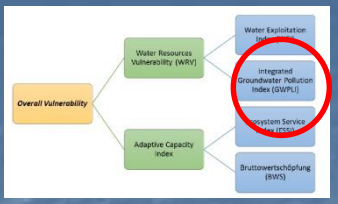
- Quantitative continuous hydrological model at 1 km grid scale
- Simulations from 1960-2065 (runoff, erosion, groundwater recharge…) for 3 climate models and 5 land use scenarios
- Assess impacts of land use on ESS and water quality
- Aggregating the outputs to the level of water supply associations
- Mapping of the outputs on a qualitative scale for the various indicators (very low, low, medium, high, very high)
- Integration of indicators to obtain overall vulnerability
- Assessment of uncertainties by analysing the range of outputs for each element (5 land use scenarios and 3 climate change models)

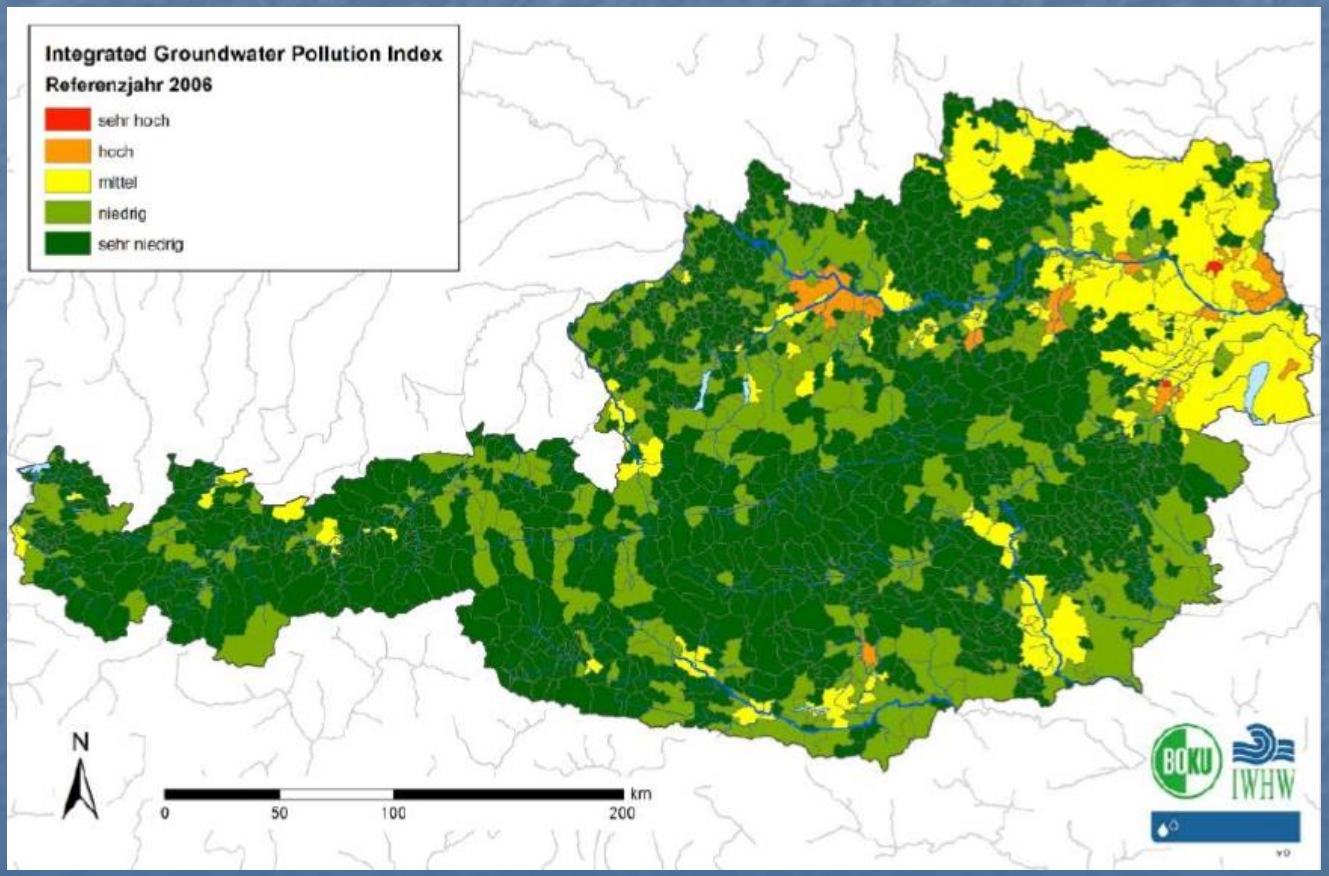
Water Exploitation Index





Groundwater Pollution Load 2006





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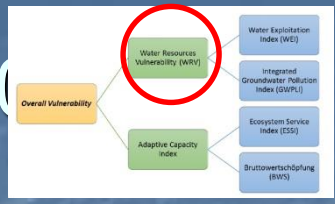
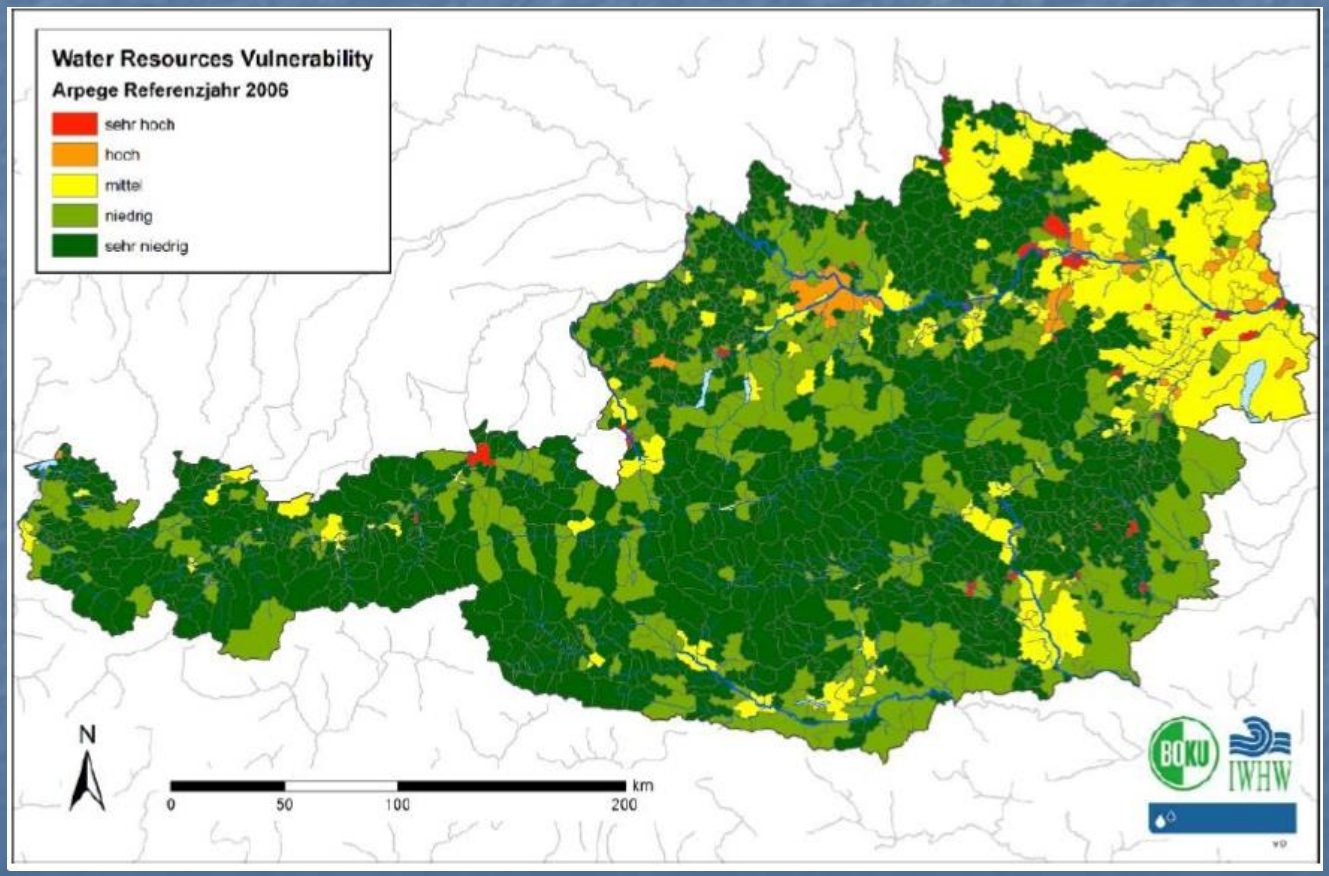
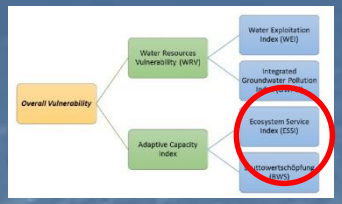
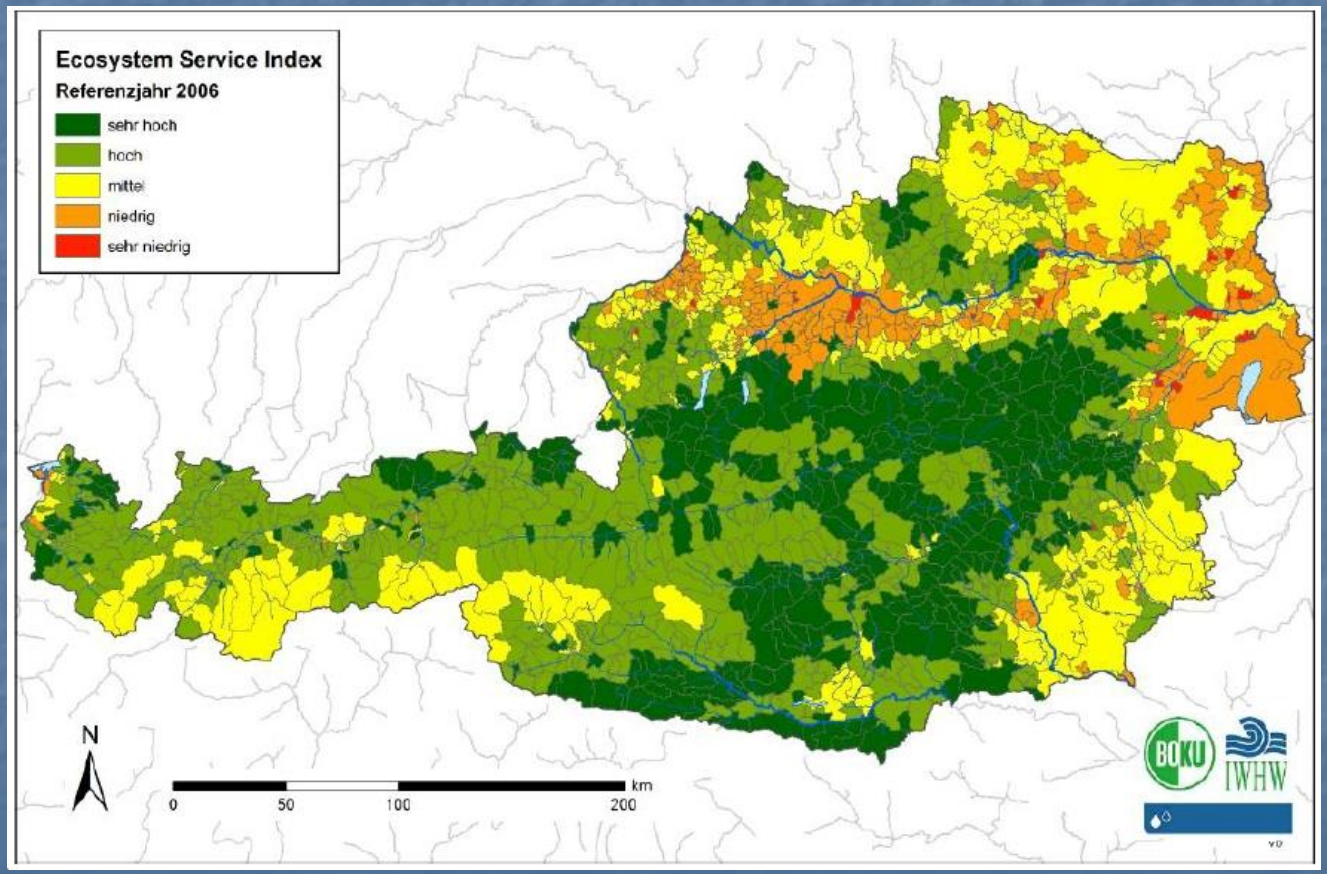
Water Resources Vulnerability 20



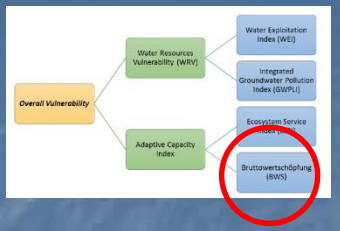


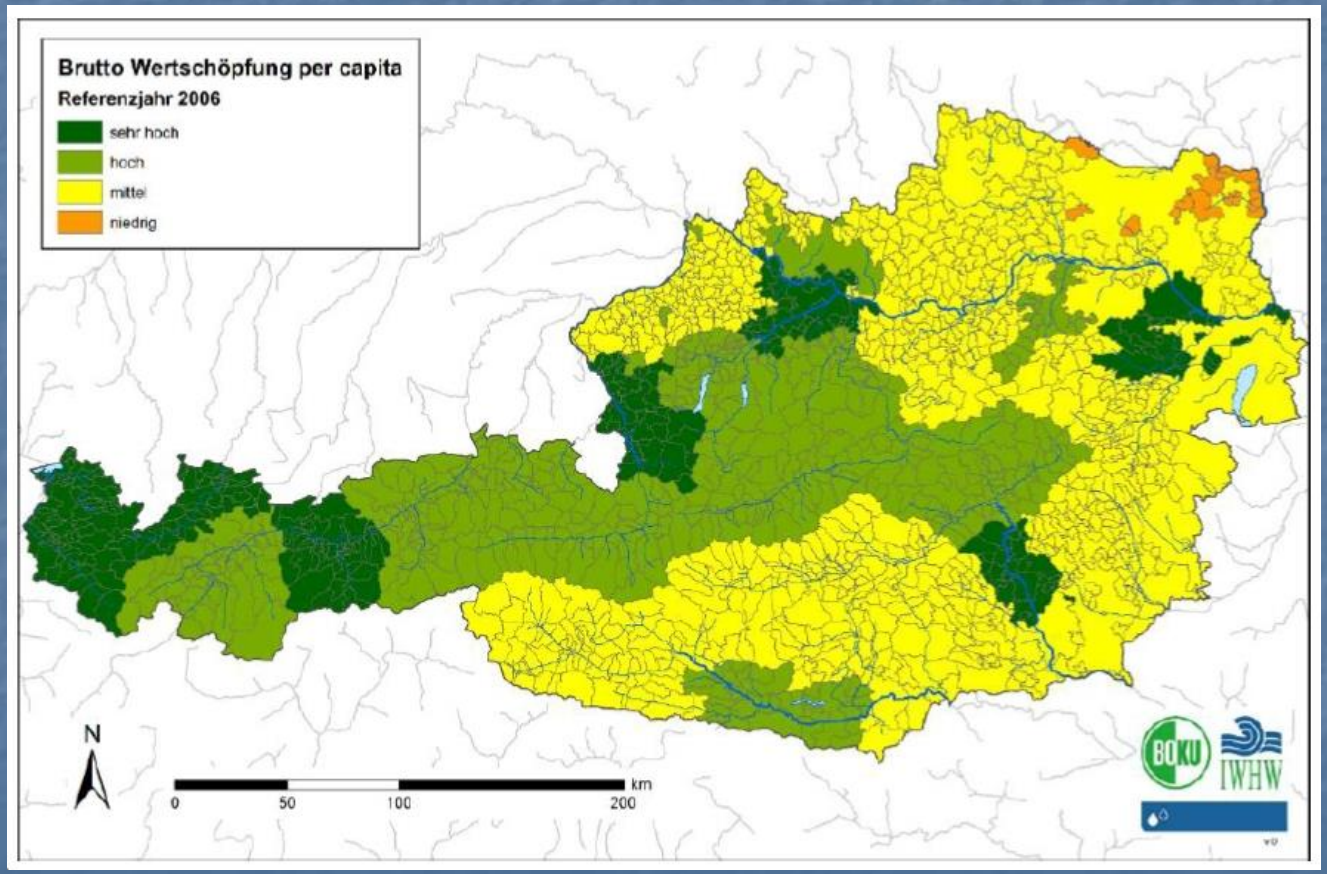
ESS 2006


Overall Vulnerability
Water Resources Vulnerability (WRV)
Adaptive Capacity Index
Water Exploitation Index (WEI)
Ecosystem Service Index (ESSI)

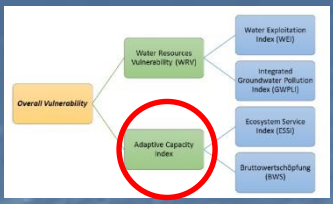

Ecosystem Service Index
Referenzjahr 2006
sehr hoch
hoch
mittel
niedrig
sehr niedrig
N
0
50
100
200
km
BOKU
IWHW

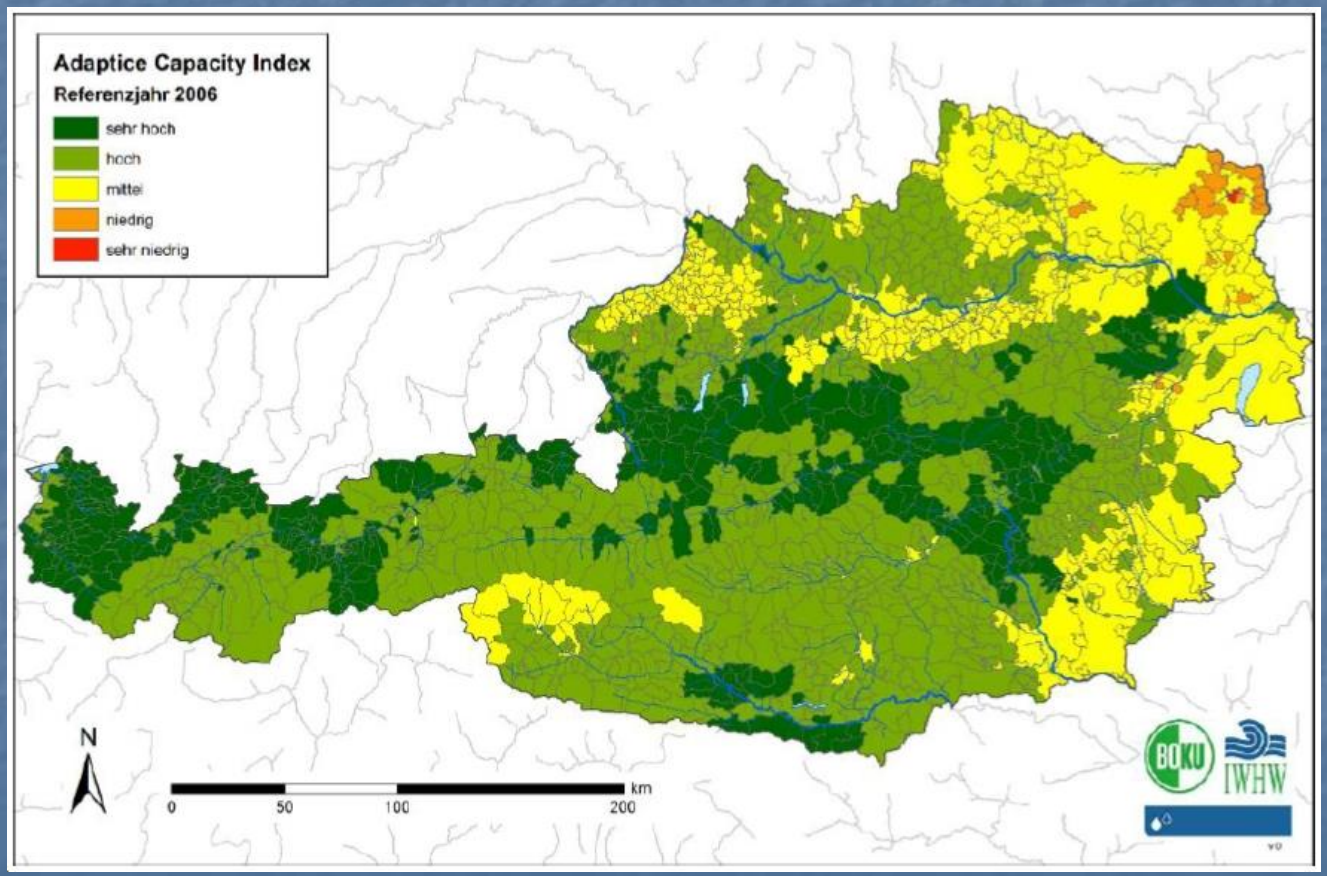
GDP 2006


Overall Vulnerability
Water Resources Vulnerability (WRV)
Adaptive Capacity Index
Water Exploitation Index (WEI)
Integrated Groundwater Pollution Index (GWPLI)
Ecosystem Service
Bruttowertschöpfung (BWS)

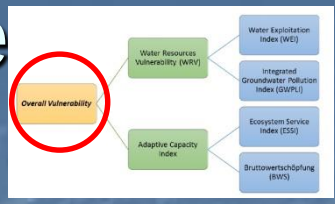

Brutto Wertschöpfung per capita
Referenzjahr 2006
sehr hoch
hoch
mittel
niedrig
N
0
50
100
200
km
BOKU
IWHW

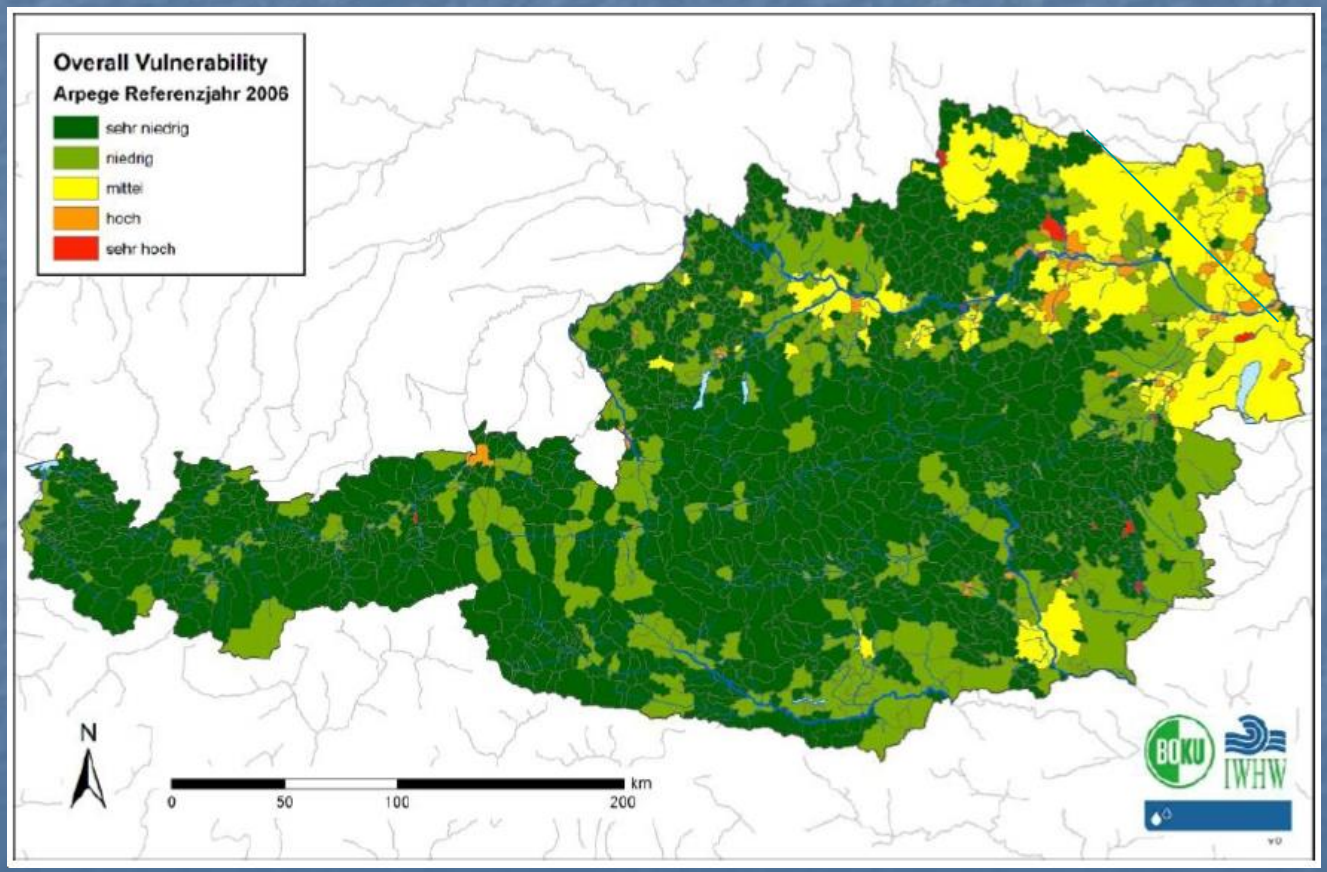
Adaptive Capacity (2006)





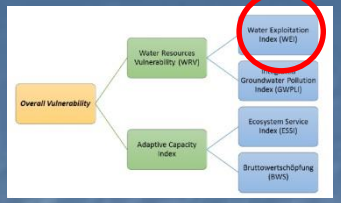
Results: Overall Water Resource Vulnerability

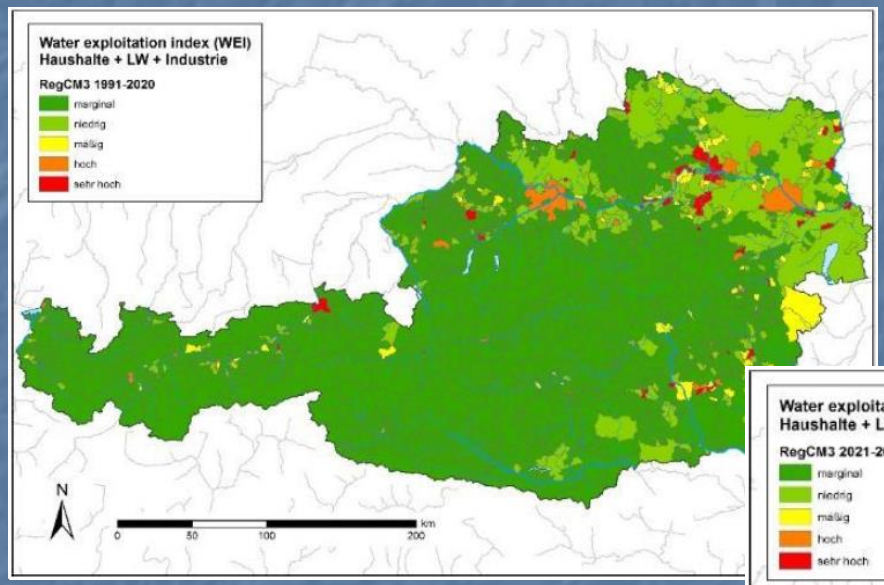




What could we expect by 2035 ?

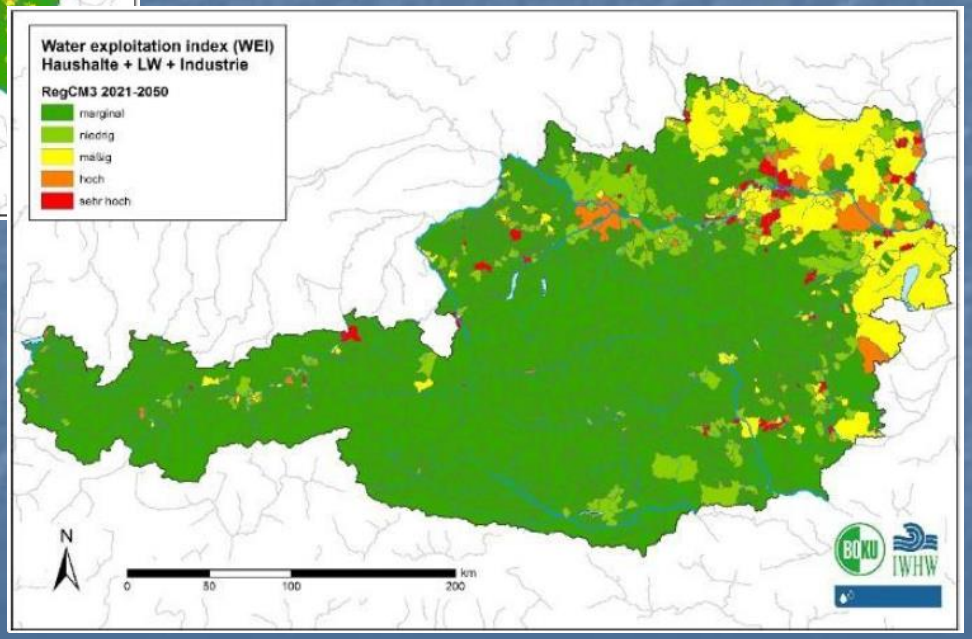
Water exploitation index



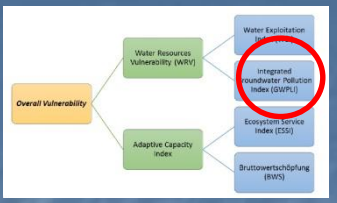


today

2035



Groundwater pollution indicator



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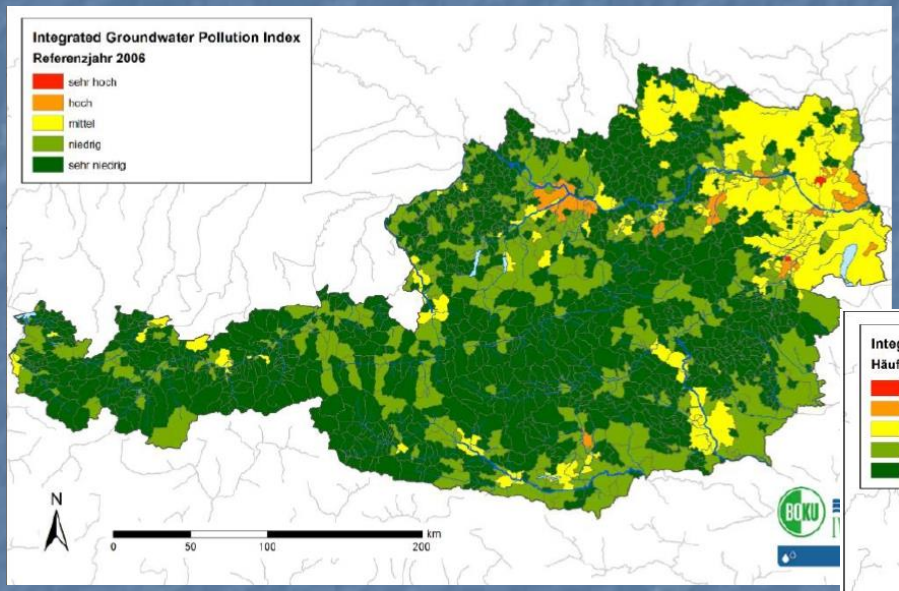
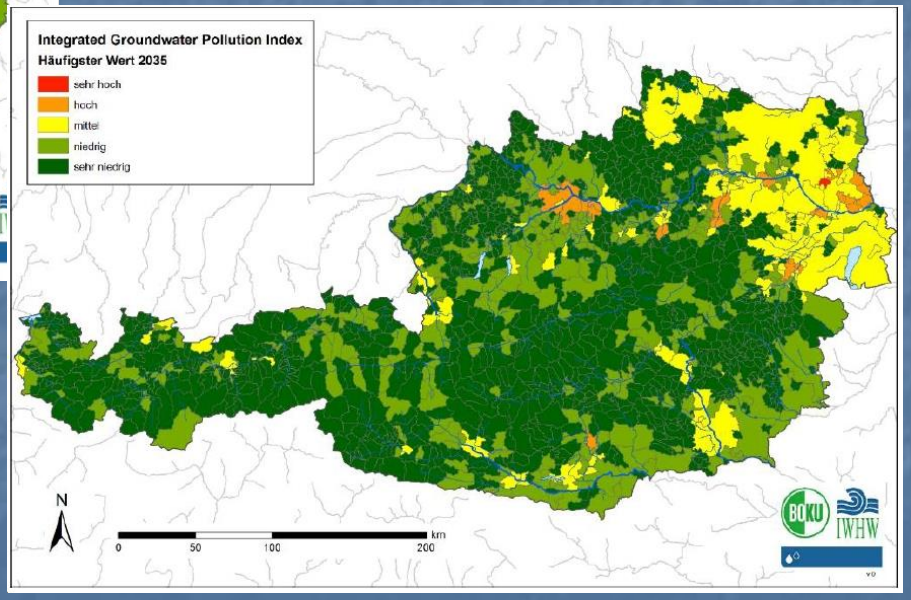
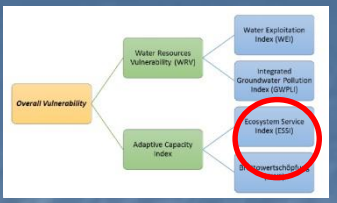


2035



ESS indicator



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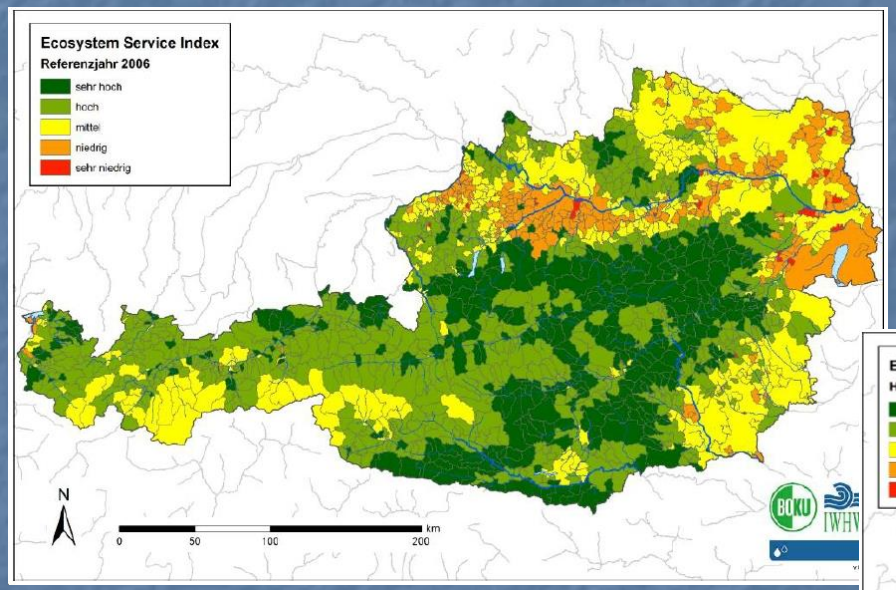
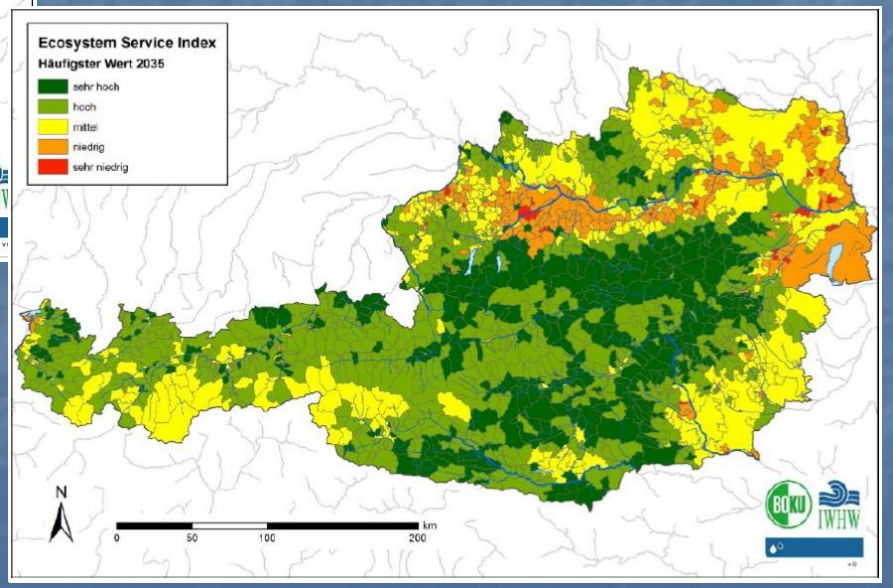
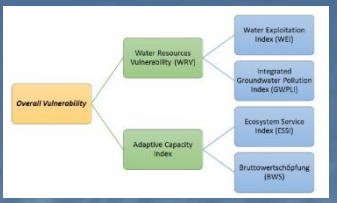


2035



Population changes



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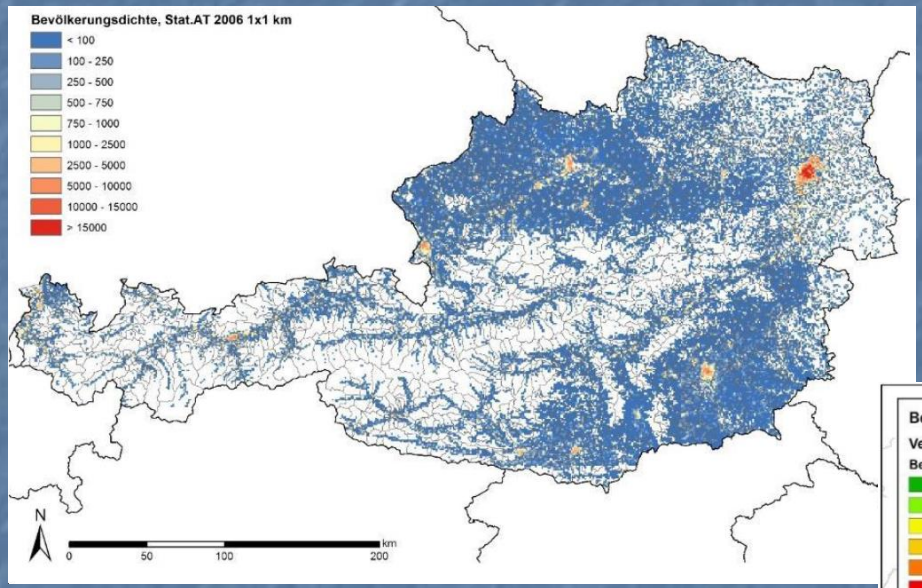
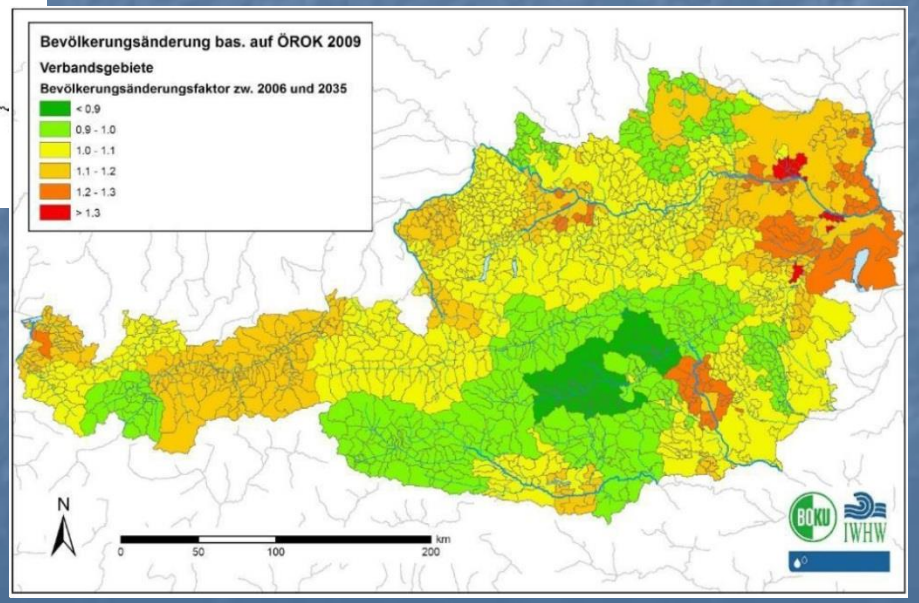
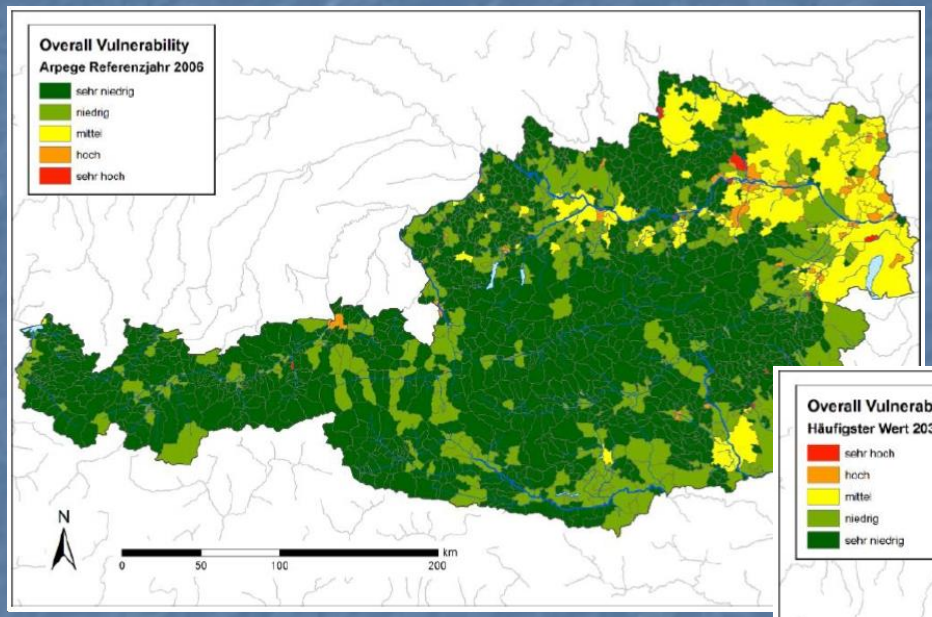


2035



Overall Water Resources Vulnerability



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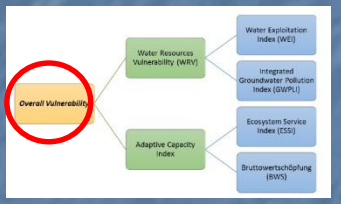
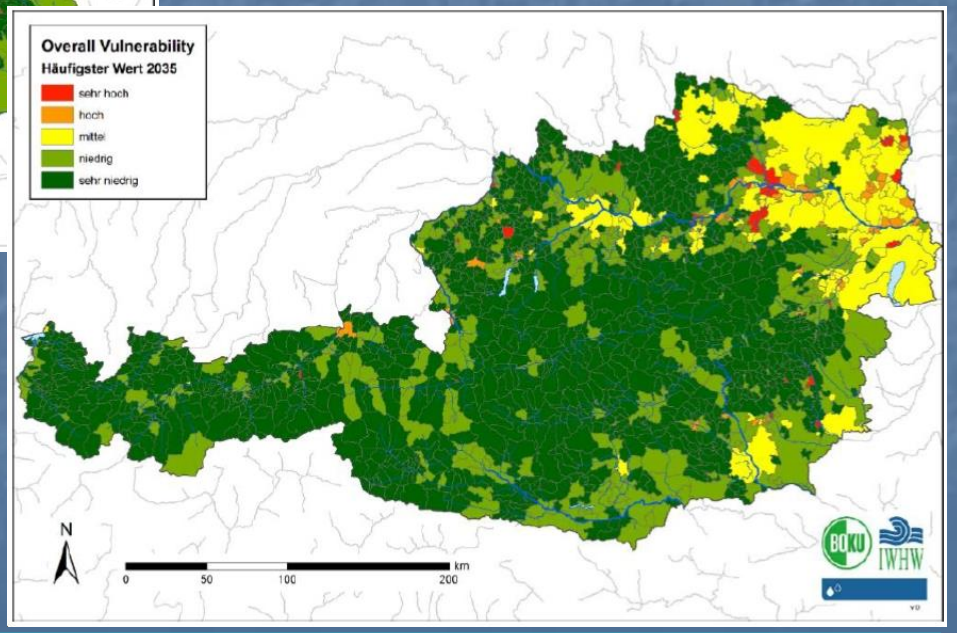
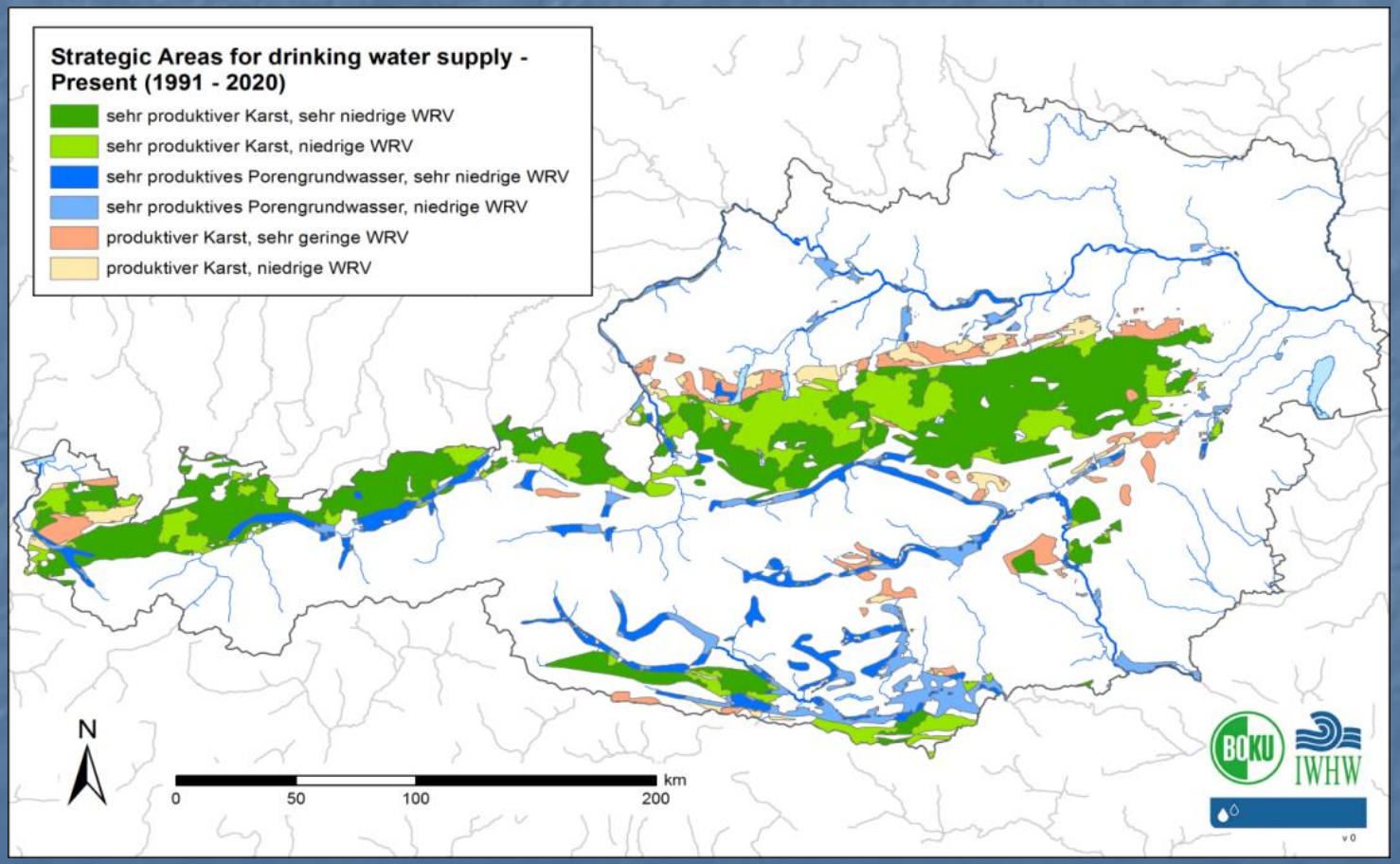


2035



Strategic water resources



Summary and conclusions

- Both climate change and land use impacts on water resources have been analysed (in detail for Austria and at a broader scale for SEE)
- With respect to CC Austria is in a transition zone. In the South East there will be an increasing stress on water resources
- The compound indicator „overall water resources vulnerability“considers physical, ecological and socio-economic indicators
- Climate change impacts are more pronounced in South East Europe
- Impacts of land use are decreasing in general
- ESS could compensate for lower income countries
- Uncertainty with respect to drivers can be considered by analysing the range of outputs (3 climate models, 5 land use scenarios)

Acknowledgements:

- **ERDF Project CC-Ware (2015):** Mitigating Vulnerability of Water Resources under Climate Change in SEE.

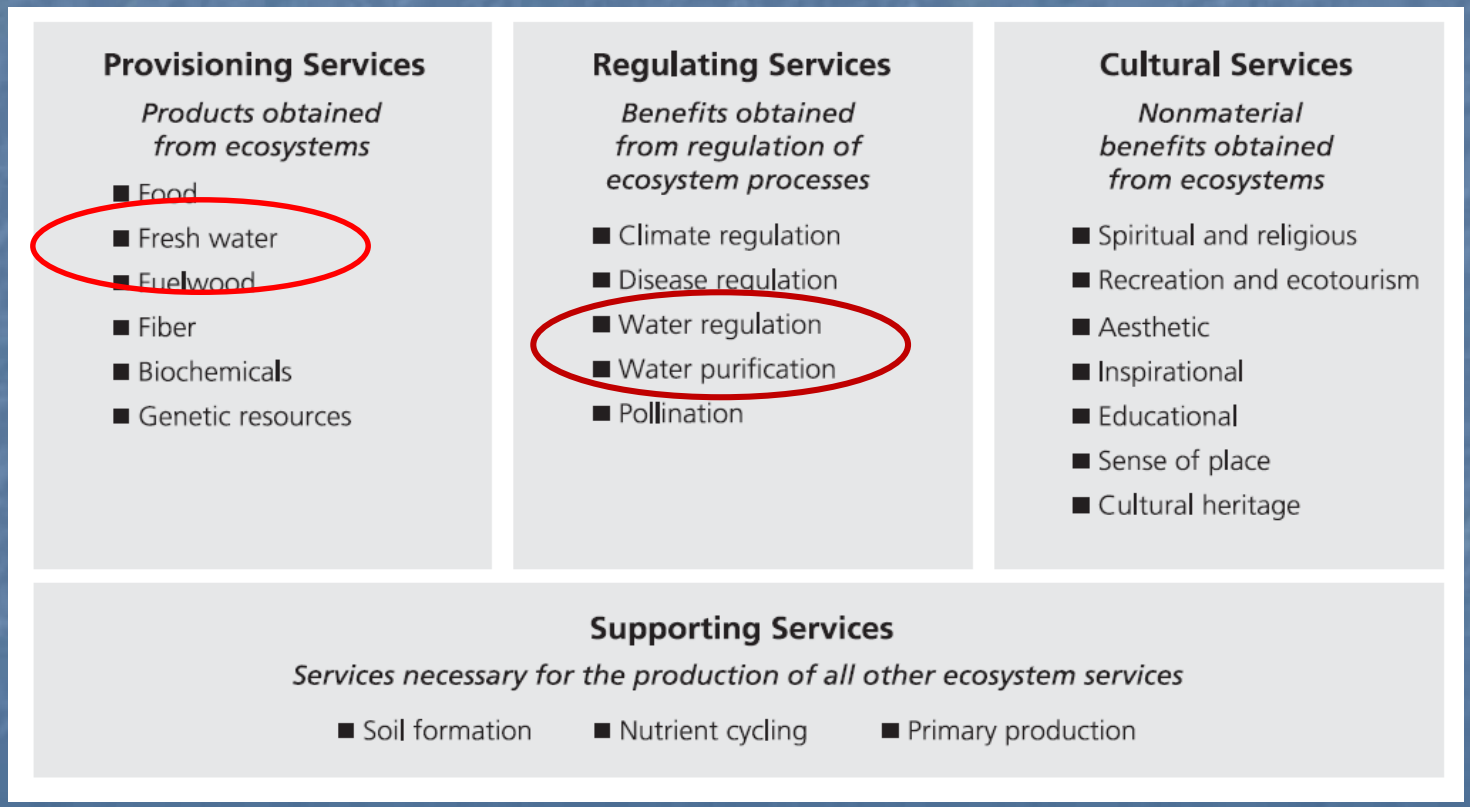
  http://www.ccware.eu/

- **Austrian Climate Research Program APCC (2014):** *Österreichischer Sachstandsbericht Klimawandel 2014 (AAR14)*.

  http://www.ccca.ac.at/de/apcc/

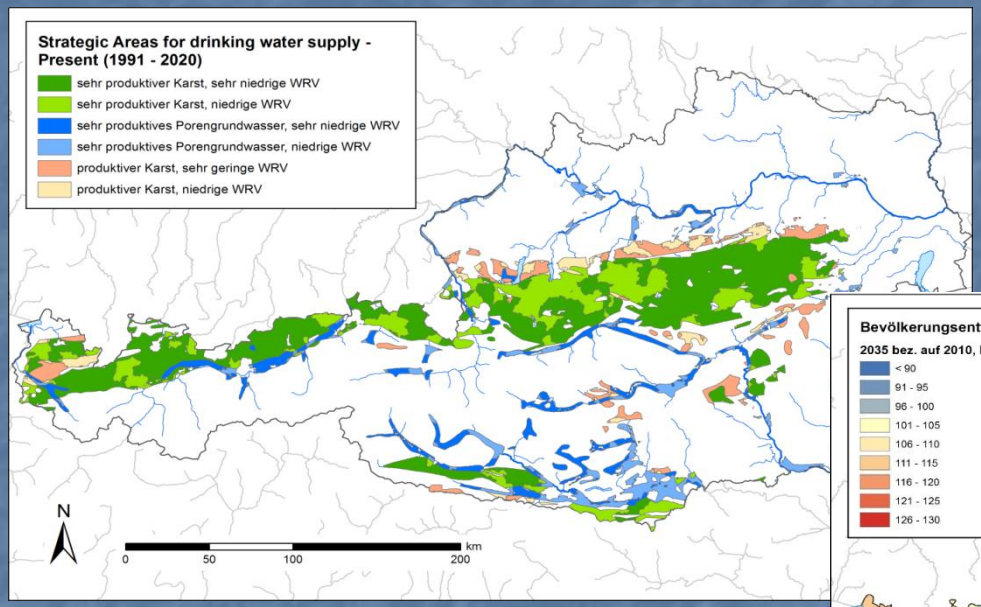
Thank you for your attention

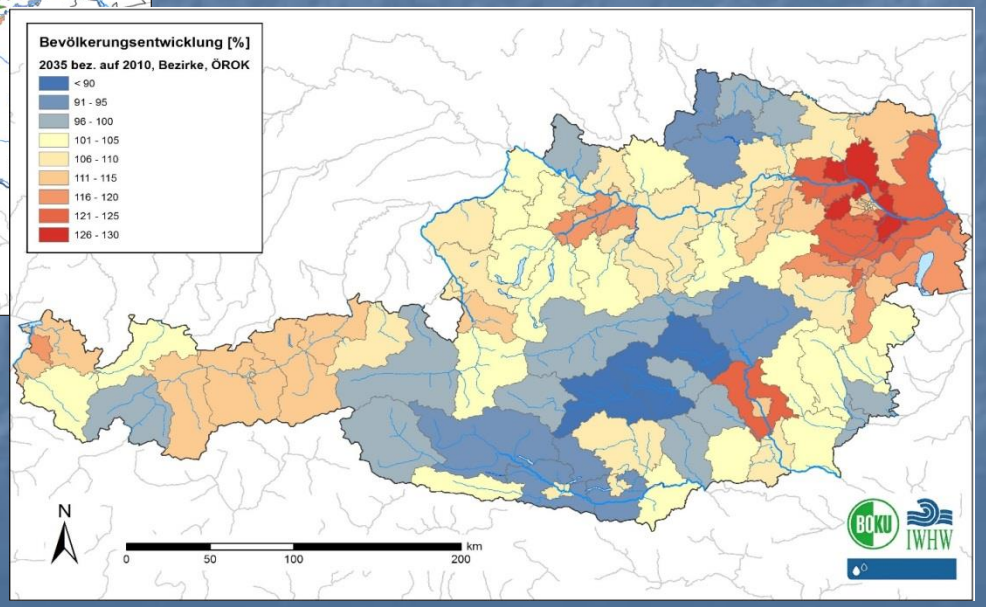
Classification scheme of ecosystem services MEA (2003)



Strategic water bodies (high yield and low pollution level)

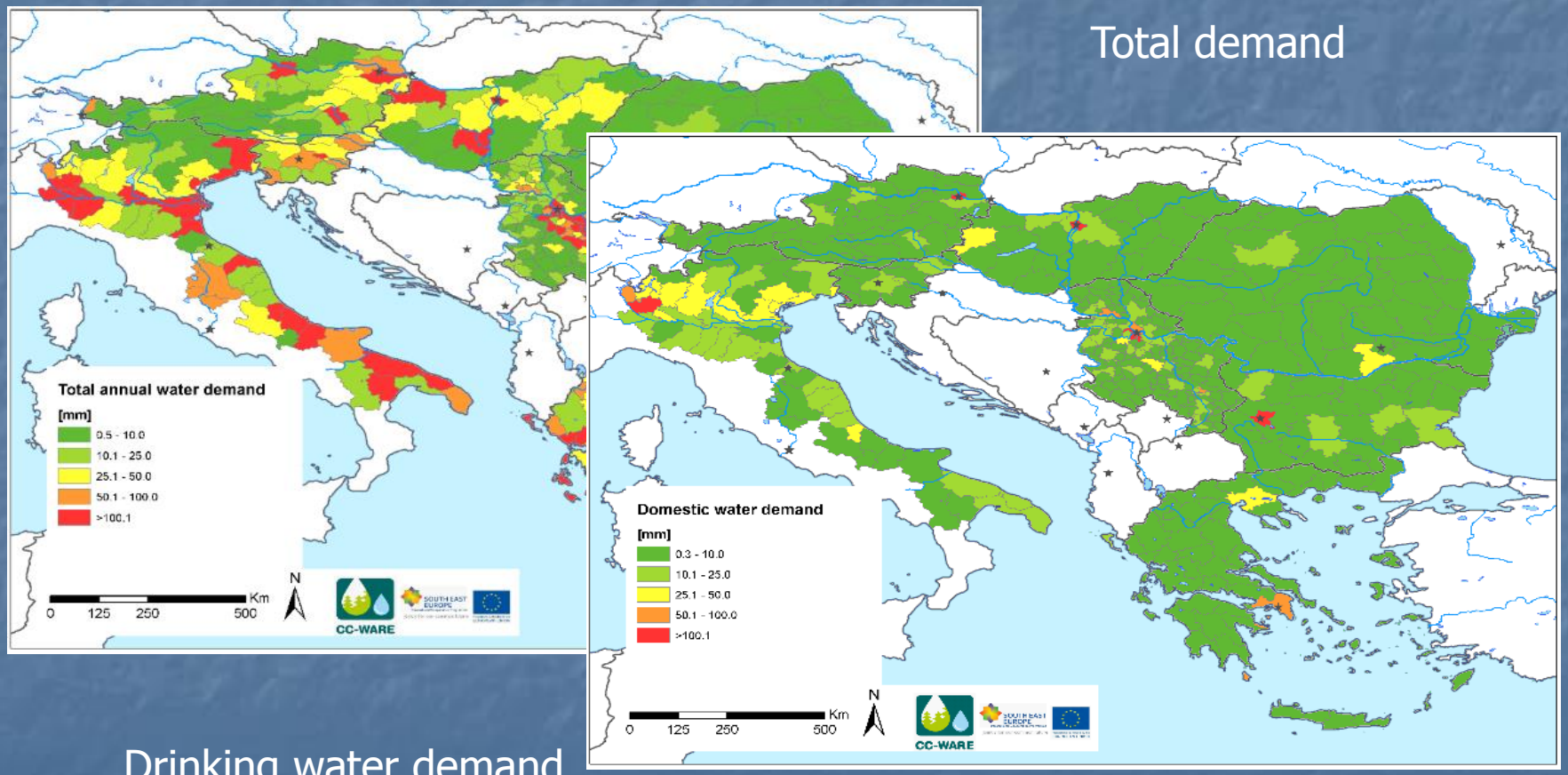
Expected change in population





2035

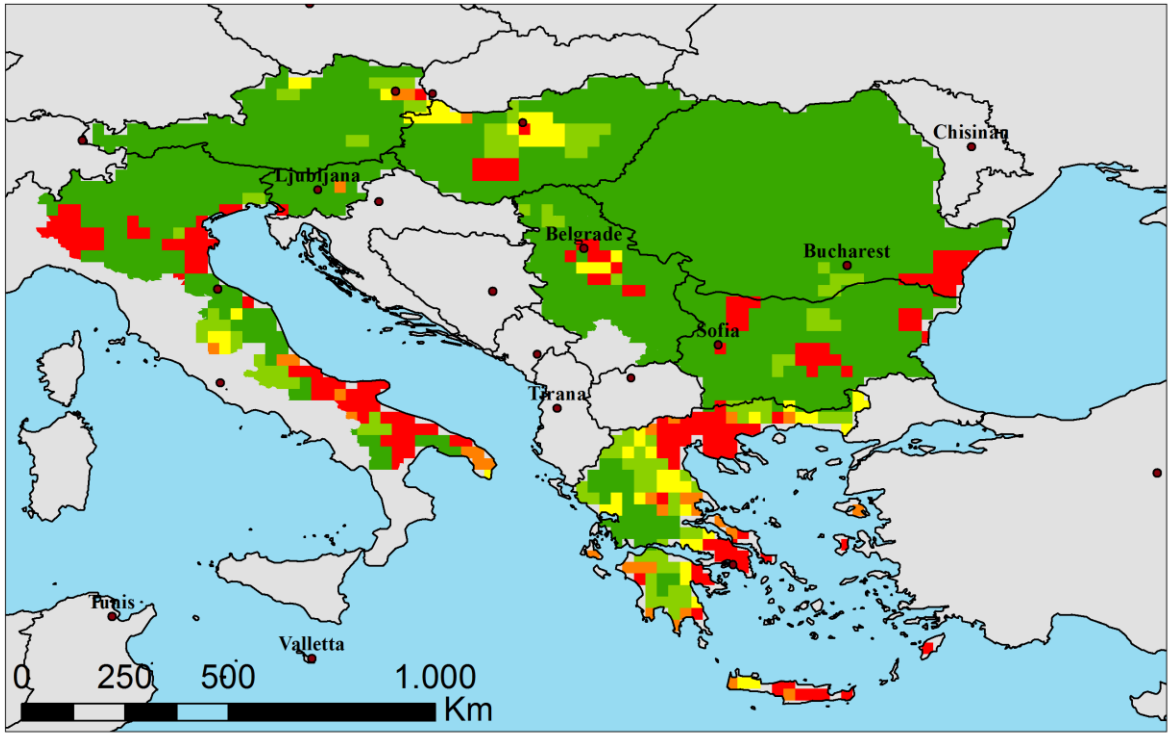
SEE region: Water demand today



Total demand

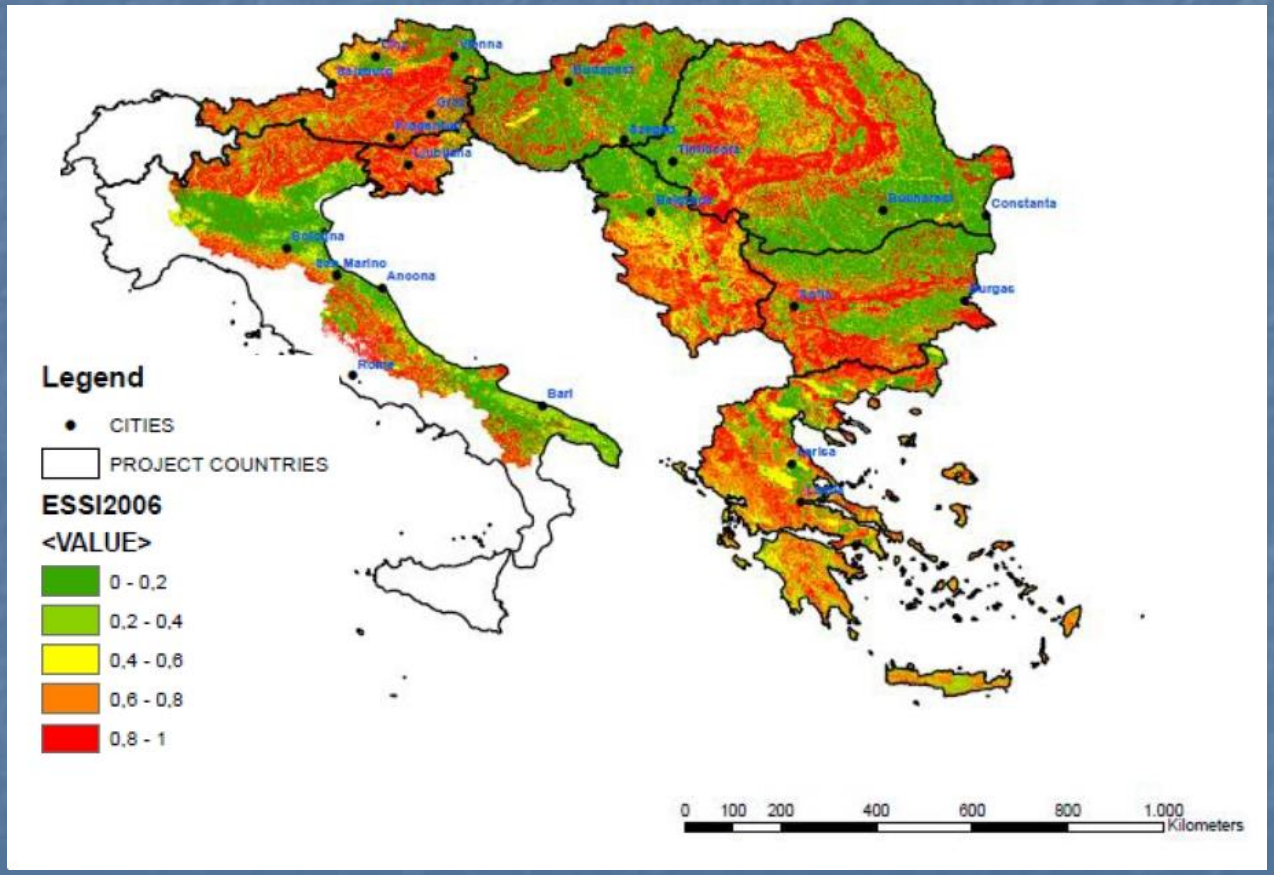
Drinking water demand

Local water exploitation index



Remarks:
Total runoff is calculated on a 25 km grid scale by the Budyko approach without considering inflow and outlow.
Water demand data are downscaled from the available level of informaion to the grid scale.

ESS (today)


Legend
CITIES
PROJECT COUNTRIES
ESSI2006
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0,4 - 0,6
0,6 - 0,8
0,8 - 1
Vienna
Budapest
Ljubljana
Bologna
San Marino
Ancona
Roma
Bari
Bucharest
Constanta
Burgas
Sofia
Serres
0 100 200 400 600 800 1.000
Kilometers

Motivation

- Within an South-East European Initiative (CC-Ware) we analysed together with water suppliers (e.g. MA31, Thessaloniki Water suppliers,….) and governmental institutions the possible impacts on water resources, especially with respect to drinking water resources
- http://www.ccware.eu/