REKLIM Helmholtz-Verbund Regionale Klimaänderungen

Helmholtz Climate Initiative

Regional Climate Change

HELMHOLTZ GEMEINSCHAFT

Klimawandel im Elbegebiet und Anpassung in Wirtschaft und Gesellschaft

Bernd Hansjürgens

Helmholtz Centre for Environmental Research – UFZ

Fachkonferenz "Klimawandel in Regionen"

29. September 2010 in Karlsruhe

AWI Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft

HelmholtzZentrum münchen Deutsches Forschungszentrum für Gesundheit und Umwelt

JÜLICH FORSCHUNGSZENTRUM

GKSS FORSCHUNGSZENTRUM in der HELMHOLTZ GEMEINSCHAFT

KIT Karlsruhe Institute of Technology

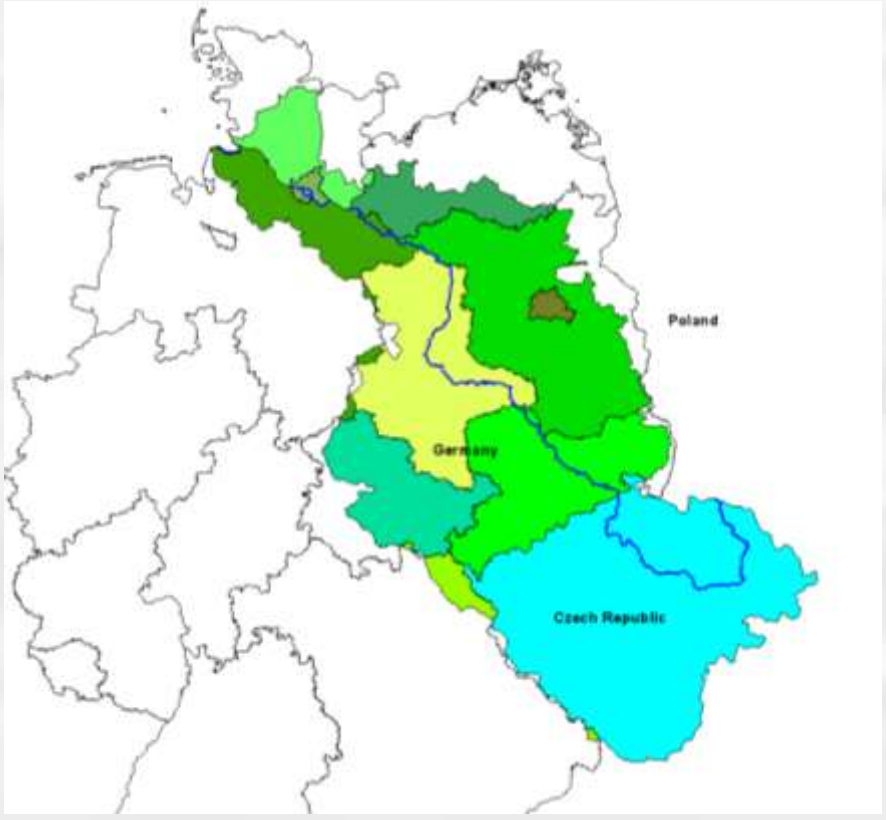
GFZ Helmholtz Centre POTSDAM

HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

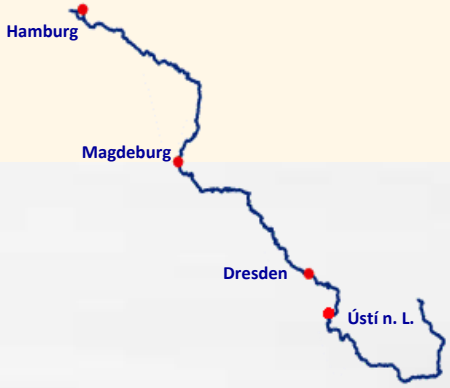
DLR

The project GLOWA Elbe

1. Show the impacts of climate and socio-demographic change on water demand and water availability (~2050)
2. Identify conflicts
3. Design and assess adaptation strategies



Approach



1. Scenario-based approach:

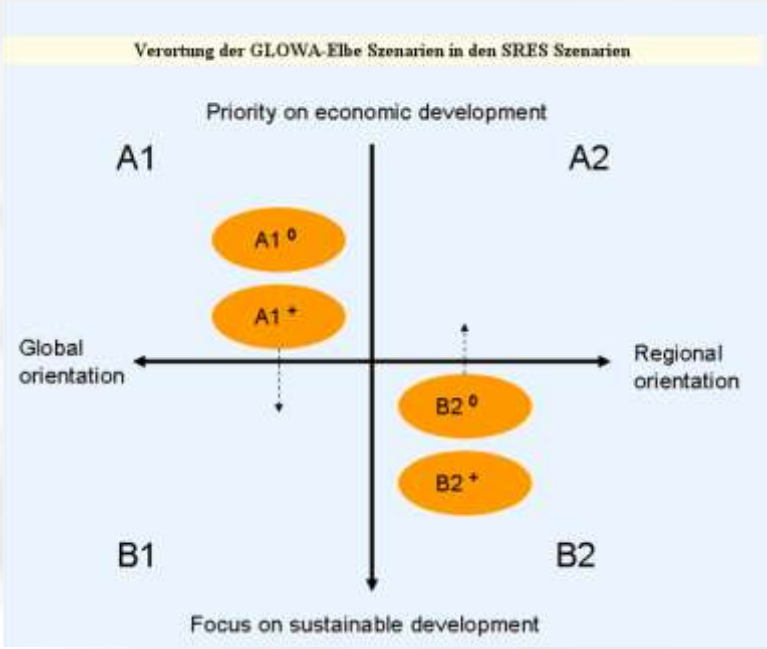
Two scenarios (IPCC) are considered:

$A1^0$: Globalisation:

- Increasing *global convergence*,
- *low* priority for environmental policy goals

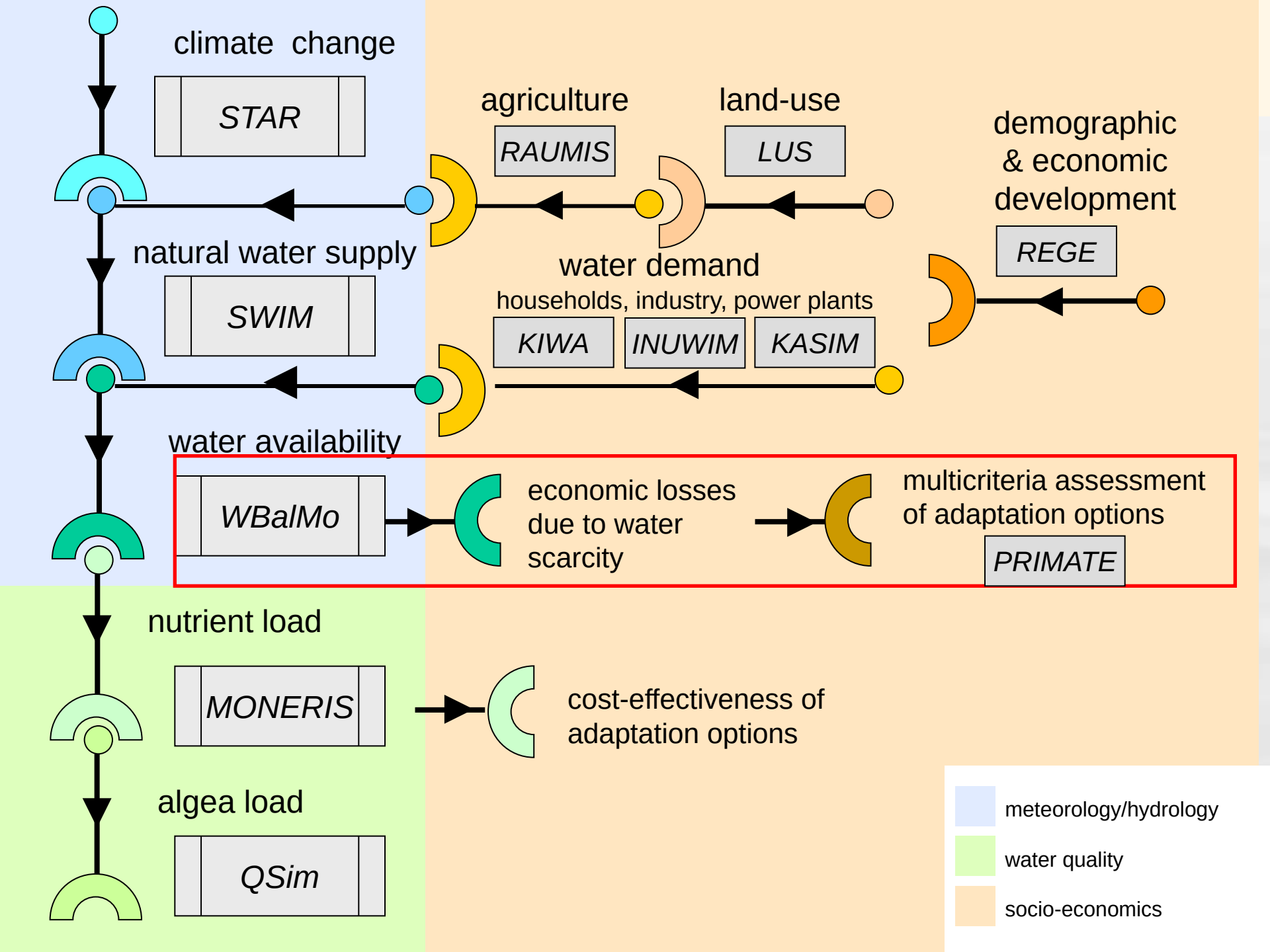
$B2^+$: Regionalisation:

- Persistance of *regional differentiation*,
- *high* priority for enviromental policy goals

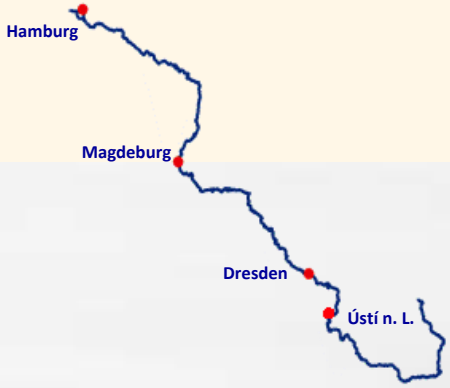


2. Interdisciplinary, model-based approach

- 12 Research Institutes involved
  (PIK, UFZ, TU Berlin, DHI Wasy, IGB, …)
- models from different disciplines…
  (meteorology, hydrology, ecology, …, economics!)


climate change
STAR
agriculture
RAUMIS
land-use
LUS
demographic & economic development
REGE
natural water supply
SWIM
water demand
households, industry, power plants
KIWA
INUWIM
KASIM
water availability
WBalMo
economic losses due to water scarcity
multicriteria assessment of adaptation options
PRIMATE
nutrient load
MONERIS
cost-effectiveness of adaptation options
algea load
QSim
meteorology/hydrology
water quality
socio-economics

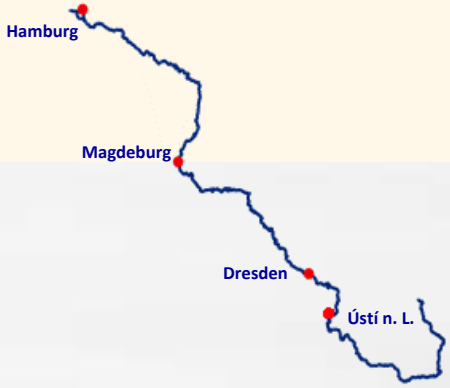
Gliederung



1) Klimawandel im Elbegebiet

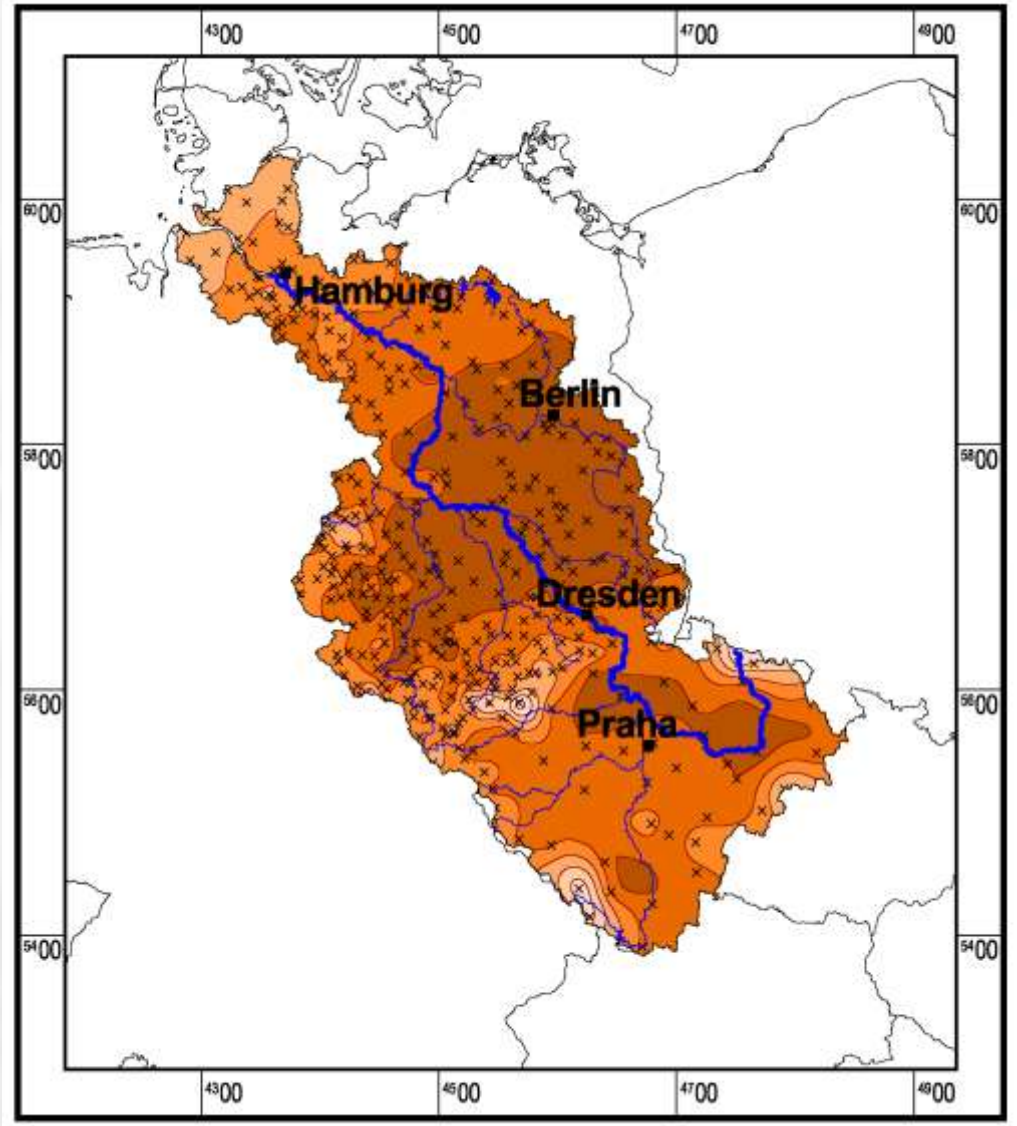
2) Ökonomische Verluste aufgrund von Wasserknappheit
   - Bewertungsansatz
   - Ergebnisse

3) Auswahl und Bewertung von Anpassungsmaßnahmen



1) Klimawandel im Elbegebiet

Temperaturextreme (I)



Magdeburg

Dresden

stí n. L.

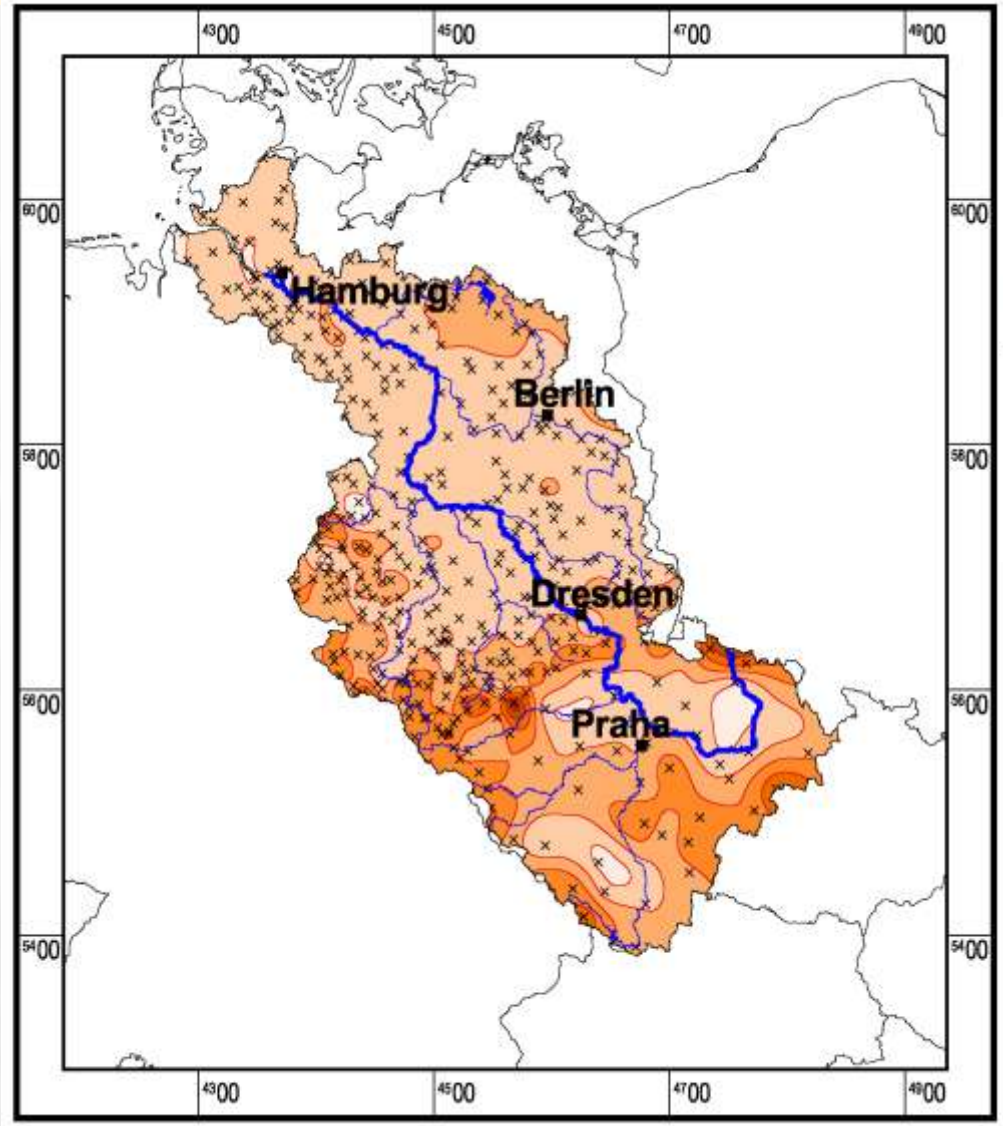
Change in number of summer days
2046/2055 - 1951/2003

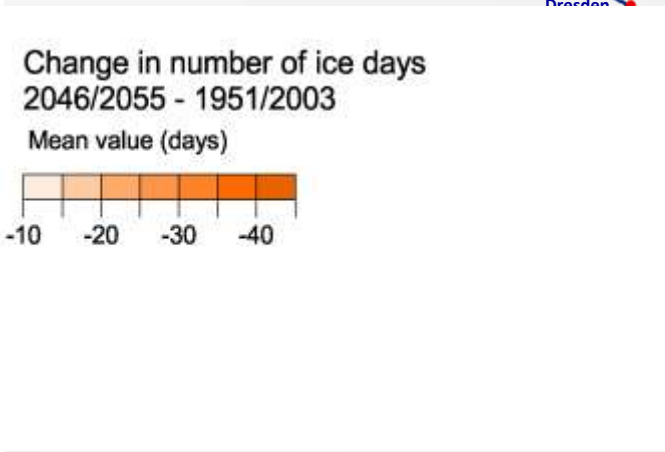
Mean value (days)

0 10 20 30 40

× *Meteorological station*

Temperaturextreme (II)



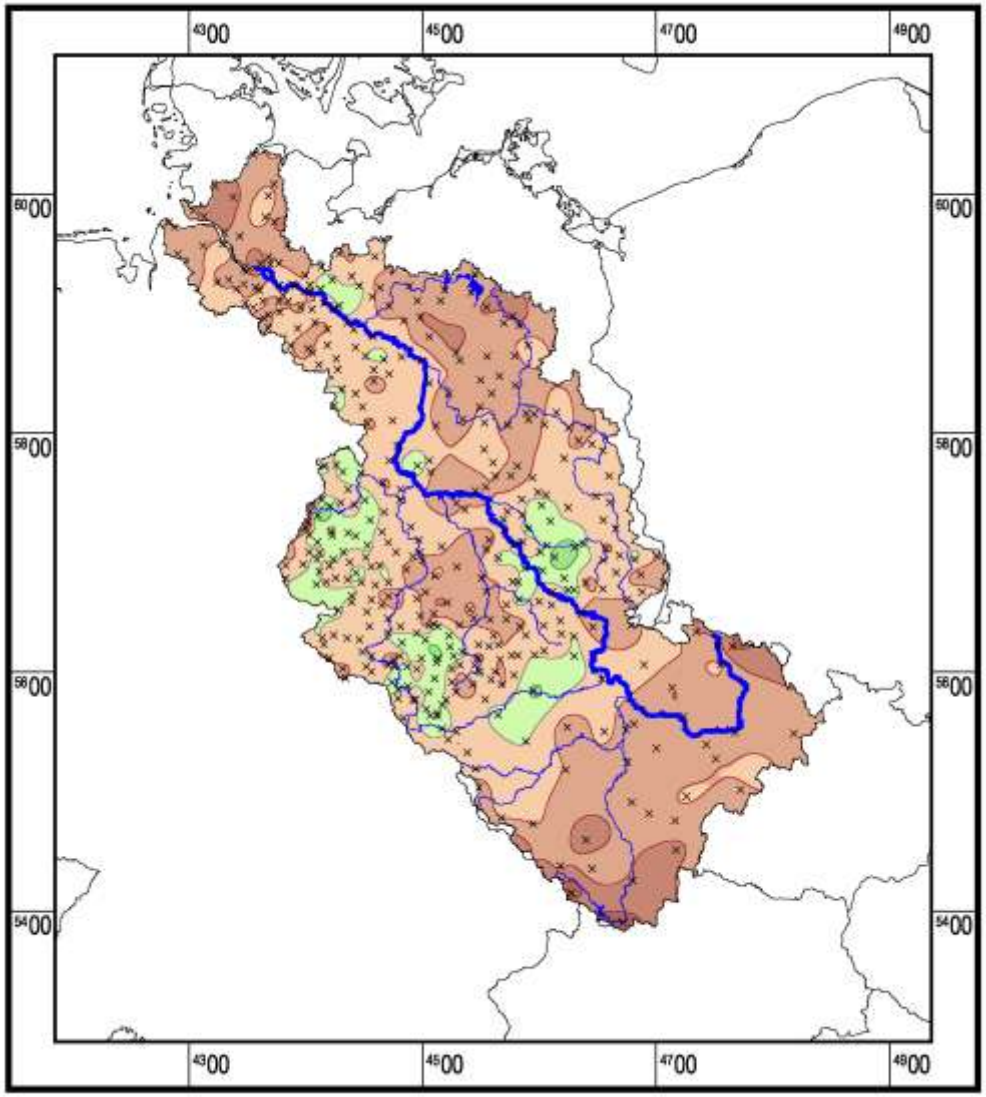


× *Meteorological station*

Zusammenfassung zu den Temperaturänderungen im Elbegebiet

- Verdoppelung der Sommertage
- Reduzierung der Eistage bis zu 50%
- Zunahmen der heißen Tage und der Sommertage im zentralen Elbegebiet
- Signifikante Abnahme der Eistage im Bereich des Oberlaufes der Elbe

Veränderungen der Niederschläge (I)



Magdeburg

Dresden

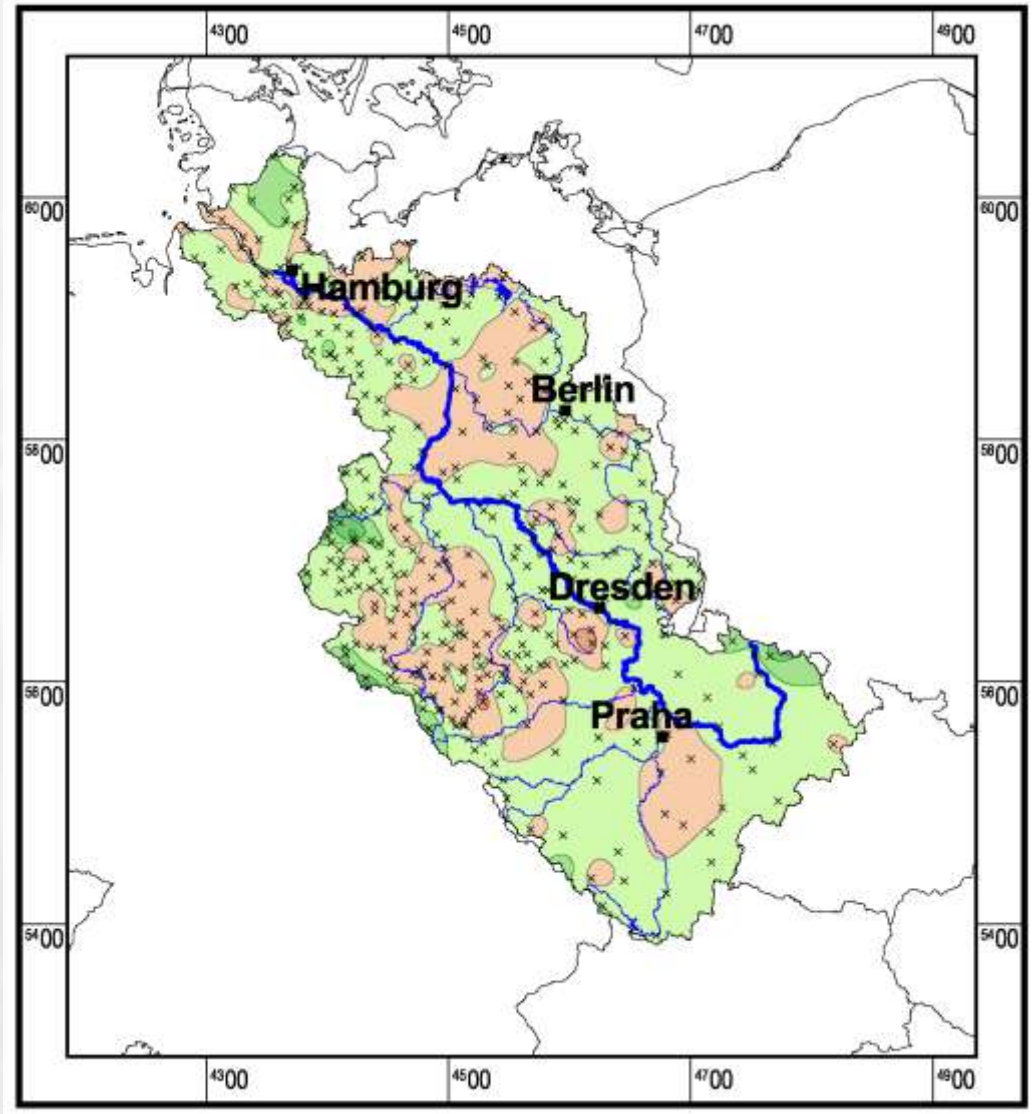
Change in days with precipitation > 10 mm
2046/2055 - 1951/2003, summer

Difference (days)

-4 -2 0 2

× *Meteorological station*

Veränderungen der Niederschläge (II)



Magdeburg

Dresden

Change in days with precipitation > 10 mm
2046/2055 - 1951/2003, winter

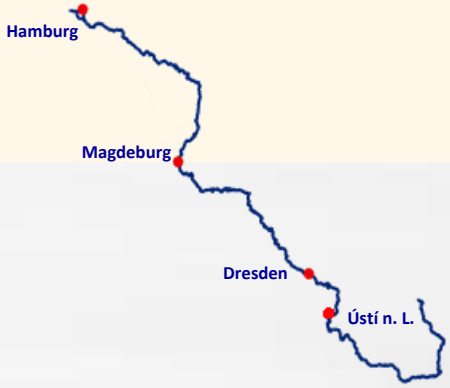
Difference (days)

-2 0 2 4

× *Meteorological station*

Zusammenfassung zu den Niederschlägen im Elbegebiet

- Zunahme der Tage ohne und mit starkem Niederschlag
- Zunahme trockener Tage im Sommer
- Keine signifikanten Trends starker Niederschlagsereignisse im Sommer
- Nördliche Teile – Reduktion, südliche Teile Zunahme der trockenen Tage im Winter
- Im Winter dominiert die Zunahme der Tage mit starken Niederschlägen



2) Ökonomische Verluste aufgrund von Wasserknappheit

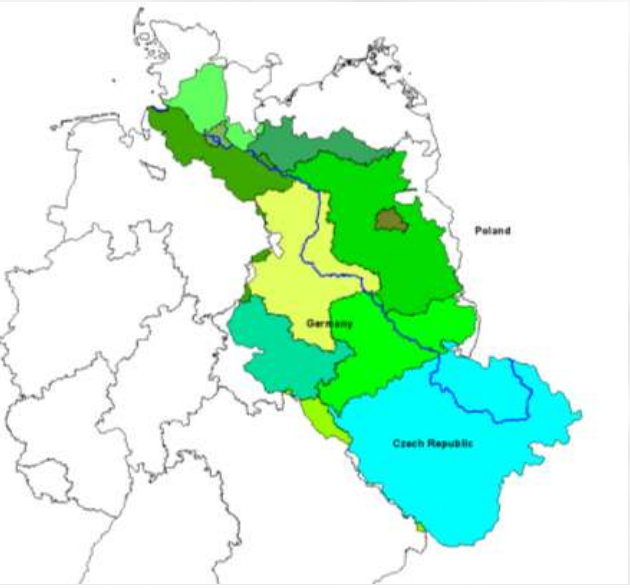
- Bewertungsansatz
- Ergebnisse

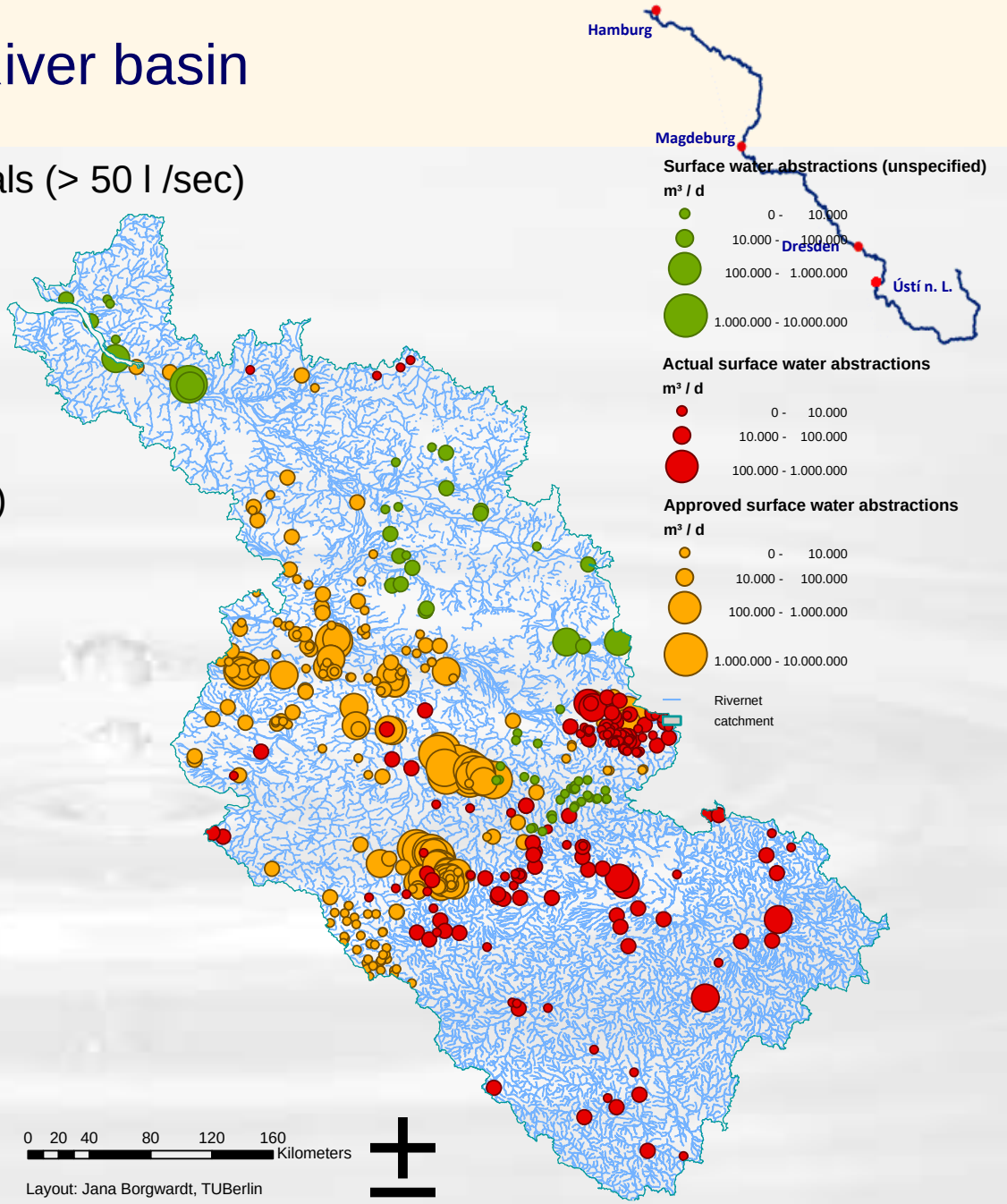
Water users in the Elbe River basin

477 significant surface water withdrawals (> 50 l /sec)

Water users under investigation:

- Power plants
- Hydropower plants
- Agricultural irrigation
- Recreation (boating and mining lakes)
- Wetlands
- Industry
- Drinking water supply
- Pond fisheries





The evaluation approach

Vulnerability is measured with a probabilistic concept of expected annual loss:

$$EL_t = \sum_i P_i L_i$$

Expected loss in period t

Realisation with occurrence probability and loss

realisation period loss/a

P	NPER	Wert_pa
70	2	-5112204
71	2	-5428555
72	2	-5835776
73	2	-6086835
74	2	-6183078
75	2	-6327937
76	2	-6519064
77	2	-6707476
78	2	-7002354
79	2	-7148366
80	2	-7548116
81	2	-8002958
82	2	-8114627
83	2	-8320206
84	2	-8541725
85	2	-9052224
86	2	-9288400
87	2	-9881320
88	2	-10104185
89	2	-10958681
90	2	-11098509
91	2	-11892784
92	2	-12426286
93	2	-12799316
94	2	-13532562
95	2	-14077406
96	2	-15254731
97	2	-16136484
98	2	-16564652
99	2	-20967202

Economic loss is analysed with respect to:

- Water user groups
- Time (2008-2052)

loss functions integrated in WBalMo

Energy production (large power plants)

Agricultural irrigation

Hydropower plants

Wetlands (CO2, habitat, agriculture)

Recreation at mining lakes

Inland waterway transportation

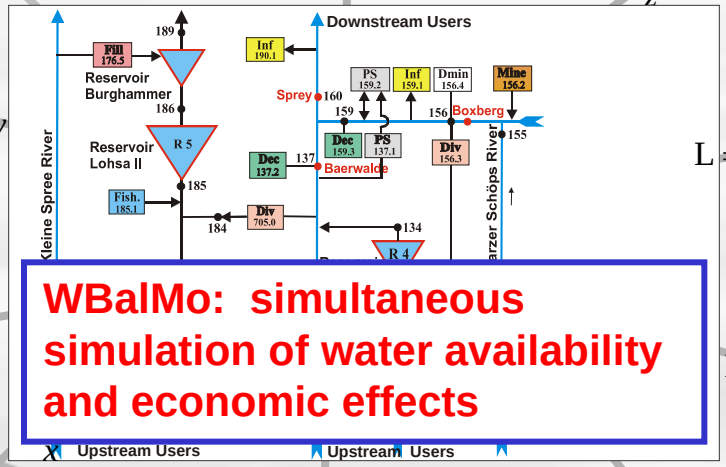
Industry

Water supply companies

Recreation- boating (wetlands and rivers)

Pond fisheries

$$L = \frac{x}{z} \cdot y$$



WBalMo: simultaneous simulation of water availability and economic effects

User groups with loss functions integrated in WBalMo

Energy production (large power plants)

Agricultural irrigation

Hydropower plants

Wetlands (CO2, habitat, agriculture)

Recreation at mining lakes

Inland waterway transportation

Industry

Water supply companies

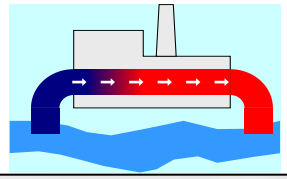
Recreation- boating (wetlands and rivers)

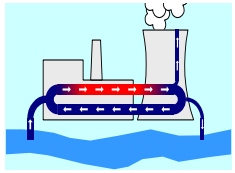
Pond fisheries

$$L = \frac{x}{z} \cdot y$$

- **Reduced water availability/higher water temperature**
- **Reduced production capacity**
- **Reduced profit**

$$V_KW_{(ds,t)} = \sum_{m} (nKW_{(ds)} - KW_{(ds,m,t)}) * h * (P_{(t)} - Cv_{(ds)})$$





User groups with loss functions integrated in WBalMo

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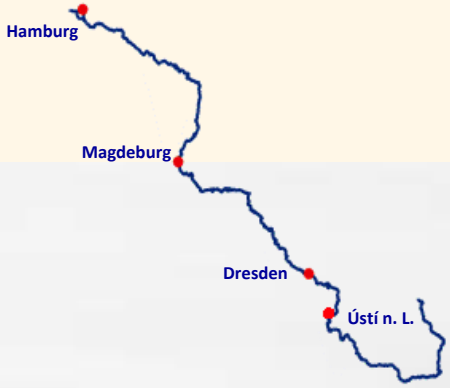
Recreation- boating (wetlands and rivers)

Pond fisheries

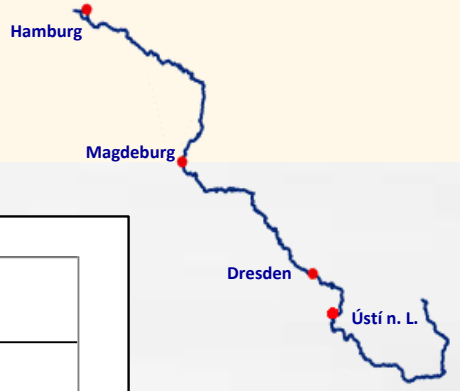
- **water scarcity**
- **reduced crop yield compared to optimal irrigation**
- **loss in net income**

$$V_LW_{ds,t} = \sum_{crp}((Ya_{crp,irr=io,t} - Ya_{crp,irr=i,t}) * A_{crp} * P_{crp,t}) - ((E_{ds} - AE_{ds}) * C\,\mathrm{var})$$

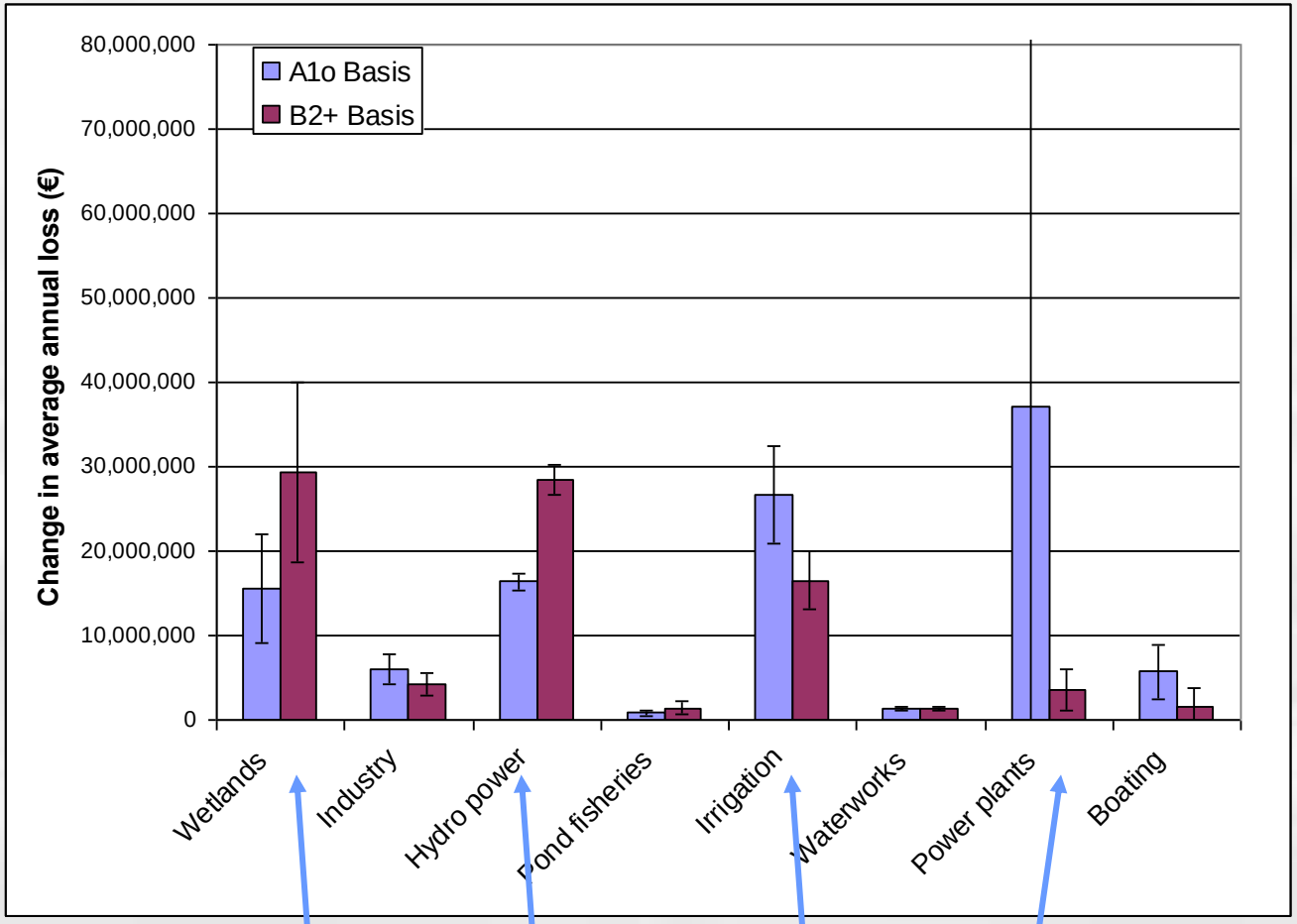


Ergebnisse

Expected annual loss among water users



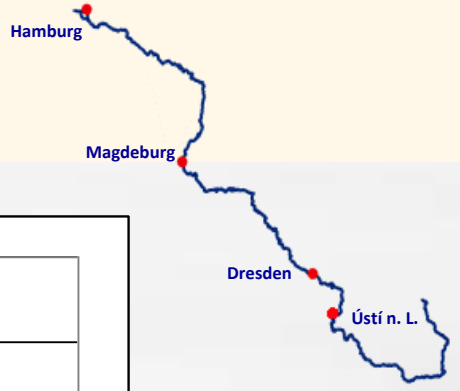
Change in loss between period 2008-2012 and period 2048-2052



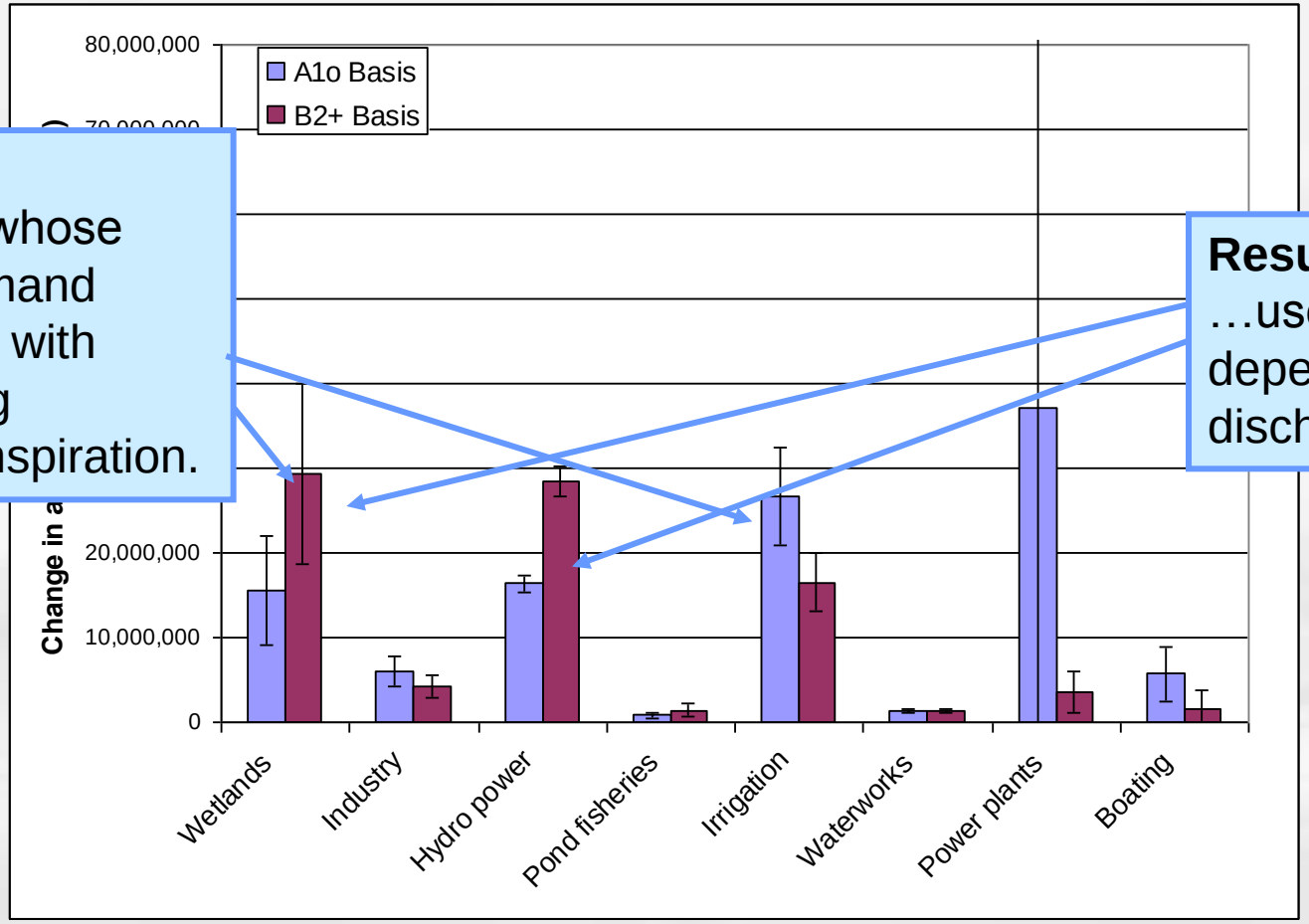
Source: Grossmann et al. 2009

Result 1: Wetlands, hydro power, agricultural irrigation and power plants are most strongly affected by water scarcity.

Expected annual loss among water users



Change in loss between period 2008-2012 and period 2048-2052



Result 2:
…users, whose water demand increases with increasing evapotranspiration.

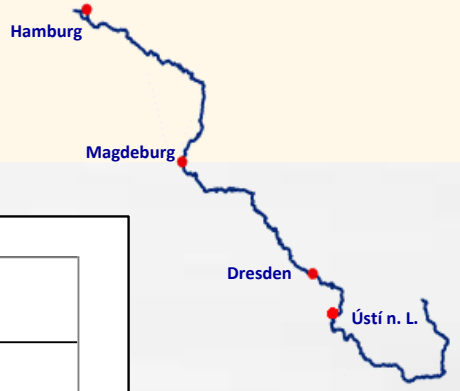
Result 3:
…users that depend on discharge.

Source: Grossmann et al. 2009

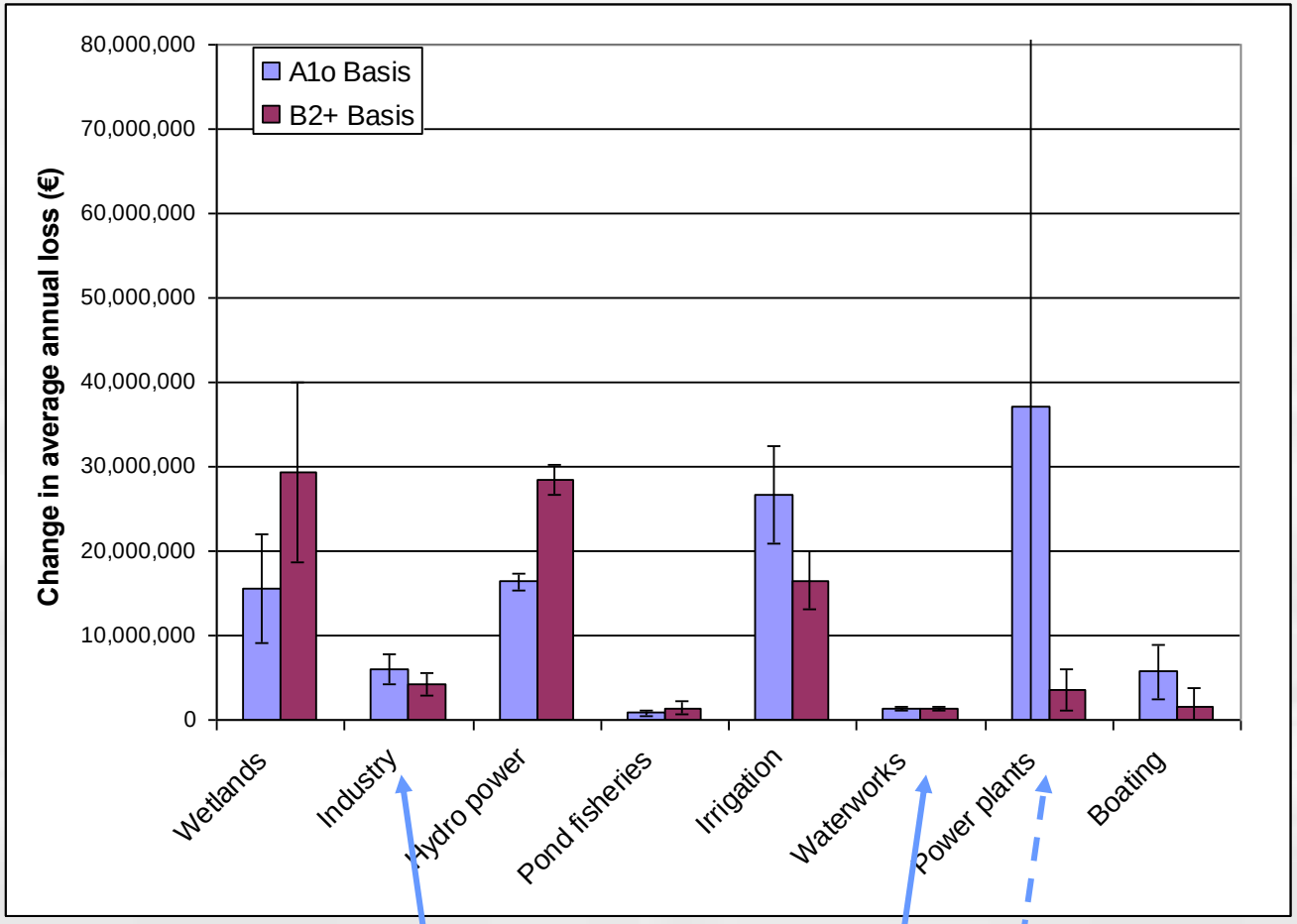
Basis: STAR A1B, S2

These water users have hardly any adaptation capacity.

Expected annual loss among water users



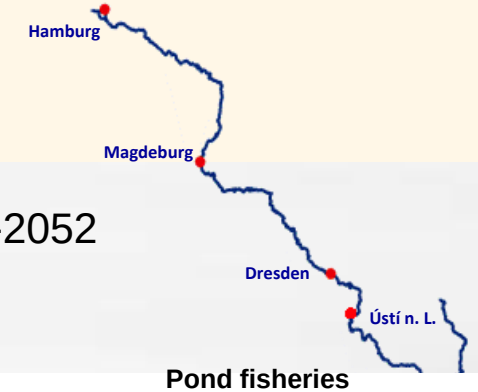
Change in loss between period 2008-2012 and period 2048-2052



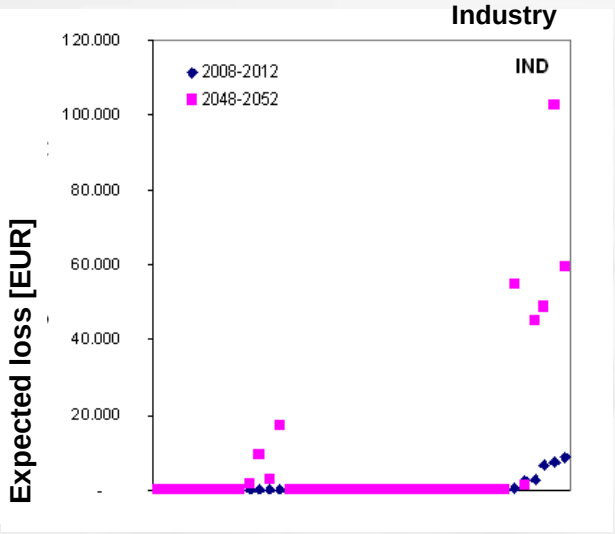
Source: Grossmann et al. 2009

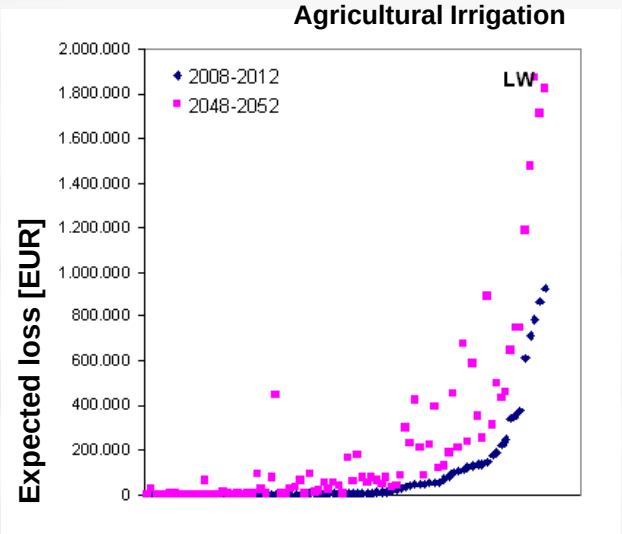
Result 4: Users demanding large quantities of water are less affected – if they use technological adaptation options…

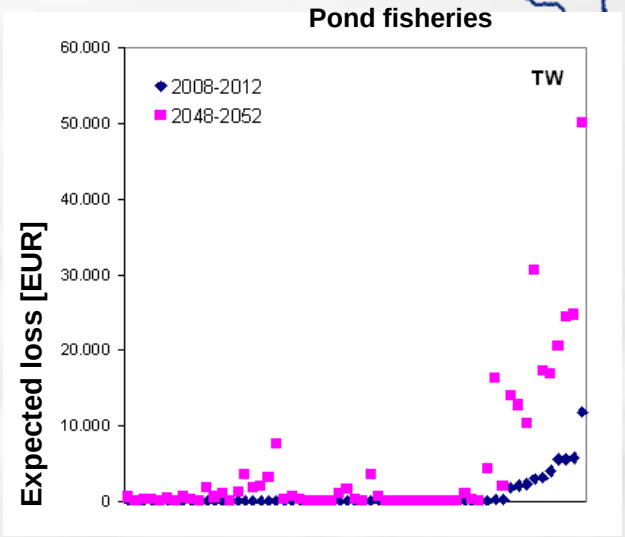
Expected loss per individual water user



Expected loss for each individual user in period 2008-2012 and 2048-2052



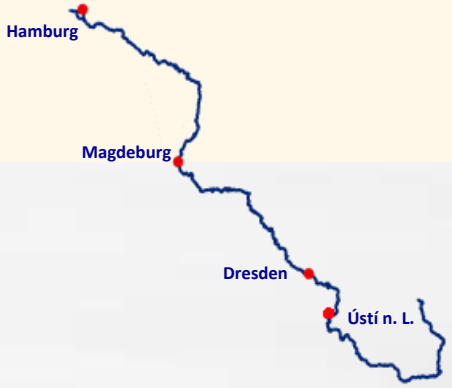




Result 5:

- More than 50% of users face no loss.
- Less than 20% of users represent most of the overall loss.
- Exception: Among hydro power plants and wetlands all users will face loss.

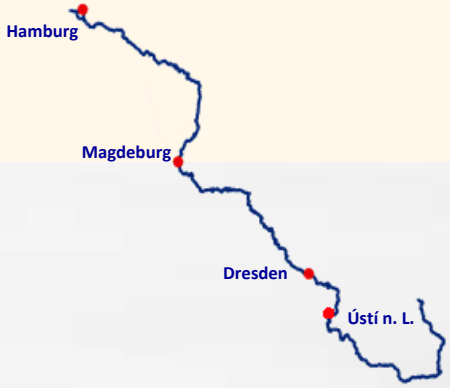
Conclusion regarding vulnerability



- We do not expect basin-wide water scarcity problems
- But: some user groups or individual users will be strongly affected
- In particular water users that are already affected today will face an increase in loss in future

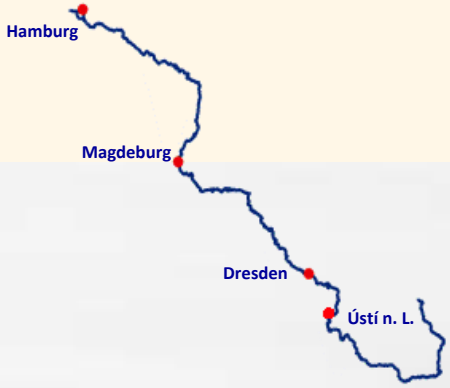
What does this mean for the management of water resources?

- Focus on current problems
- *Adaptation options?*



3. Auswahl und Bewertung von Anpassungsmaßnahmen

Adaptation strategies



Objective:

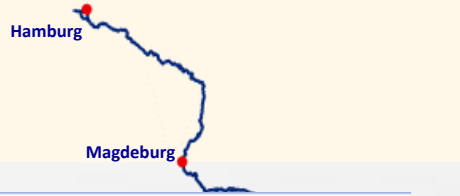
- Identify adaptation options
- Assessment and comparison (under uncertainty)

➢ **(Further) development of an assessment tool:**

  ➢ **PRIMATE** (***Martin Drechsler***, *Martin Lange, Volker Meyer*)

  ➢ supporting stakeholders in the choice and assessment process

Stakeholder involvement in PRIMATE



choice of adaptation strategies

choice and weighting of evaluation criteria

Kriterien

15

Tausche

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name des Kriteriums	Trinkwasser	Wasserkraft	Bewässerun	Feuchtgebie	Schleusen	Industrie	Kraftwerke	Binnenfische	Bedarfsdeck	Bedarfsdeck	Bedarfsdeck	Bedarfsdeck	Hochwasser	Kosten
Kurz	TW	WKA	LWBew	FG	Schleu	Industrie	KW	Bifi	Mulde	Zwickauer M	Freiberger M	Weisse Elste	EAD HWR	Cost
Zielsetzung (maX/miN)	X	X	X	X	X	X	X	X	X	X	X	X	X	N
Einheit	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	%	%	%	%	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grenzwert Präferenz	1000000	2000000	1000000	100000	1000000	100000	1000000	1000000	1	1	1	1	0	0
Unsicherheiten (y/n)	y	y	y	y	y	y	y	y	y	y	y	y	n	n
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

Werte	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Alternative A1o	-2.18E5	-1E7	-1.35E7	-1.58E5	-1.16E7	-6.72E5	-9.19E5	-1.36E5	80.40	82.50	100.00	85.40	0.00	0.00
Alternative B2+	-2.12E5	-1.17E7	-1.17E7	-1.28E5	-9.31E6	-5.91E5	-1.22E6	-1.64E5	81.40	81.70	100.00	85.50	0.00	0.00

Stakeholder involvement in PRIMATE

choice of adaptation strategies

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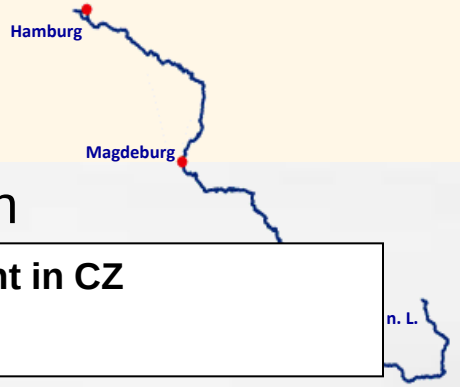
Kurz	TW	WKA	LWBew	FG	Schleu	Industrie	KW	Bifi	Mulde	Zwickauer M	Freiberger M	Weisse Elste	EAD HWR	Cost
Zielsetzung (maX/miN)	X	X	X	X	X	X	X	X	X	X	X	X	X	N
Einheit	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	%	%	%	%	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grenzwert Präferenz	1000000	2000000	1000000	100000	1000000	100000	1000000	1000000	1	1	1	1	0	0
Unsicherheiten (y/n)	y	y	y	y	y	y	y	y	y	y	y	y	n	n
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

Werte	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Alternative A1o	-2.18E5	-1E7	-1.35E7	-1.58E5	-1.16E7	-6.72E5	-9.19E5	-1.36E5	80.40	82.50	100.00	85.40	0.00	0.00
Alternative B2+	-2.12E5	-1.17E7	-1.17E7	-1.28E5	-9.31E6	-5.91E5	-1.22E6	-1.64E5	81.40	81.70	100.00	85.50	0.00	0.00

Choice of adaptation strategies



based on stakeholder workshop, bilateral communication

fields of adaptation:

- reservoir management
- water transition
- wetland management
- demand management

- **reservoir management in CZ**
- **Polder in Germany**

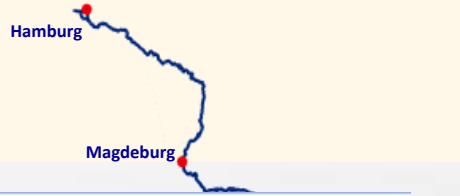
- **Elbe → Spree, Schwarze Elster**
- **Oder → Spree**
- **Oder → Oder-Spree-Channel**
- **Mittellandkanal**
- **Oder-Havel-Channel**

- **Extensivation:** cropland to greenland
- **Intensivation:** greenland to cropland
- **water logging in peatlands**

public water supply, industry, power plants, agriculture:

- **price**
- **technological options**
- **legal instruments**

Stakeholder involvement in PRIMATE



choice of adaptation strategies

choice and weighting of evaluation criteria

Kriterien

Tausche

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name des Kriteriums	Trinkwasser	Wasserkraft	Bewässerun	Feuchtgebie	Schleusen	Industrie	Kraftwerke	Binnenfische	Bedarfsdeck	Bedarfsdeck	Bedarfsdeck	Bedarfsdeck	Hochwasser	Kosten
Kurz	TW	WKA	LWBew	FG	Schleu	Industrie	KW	Bifi	Mulde	Zwickauer M	Freiberger M	Weisse Elste	EAD HWR	Cost
Zielsetzung (maX/miN)	X	X	X	X	X	X	X	X	X	X	X	X	X	N
Einheit	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	%	%	%	%	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grenzwert Präferenz	1000000	2000000	1000000	100000	1000000	100000	1000000	1000000	1	1	1	1	0	0
Unsicherheiten (y/n)	y	y	y	y	y	y	y	y	y	y	y	y	n	n
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

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Evaluation criteria

1. Selection of evaluation criteria

2. Weighting of criteria

… for different decisions makers/ interest groups

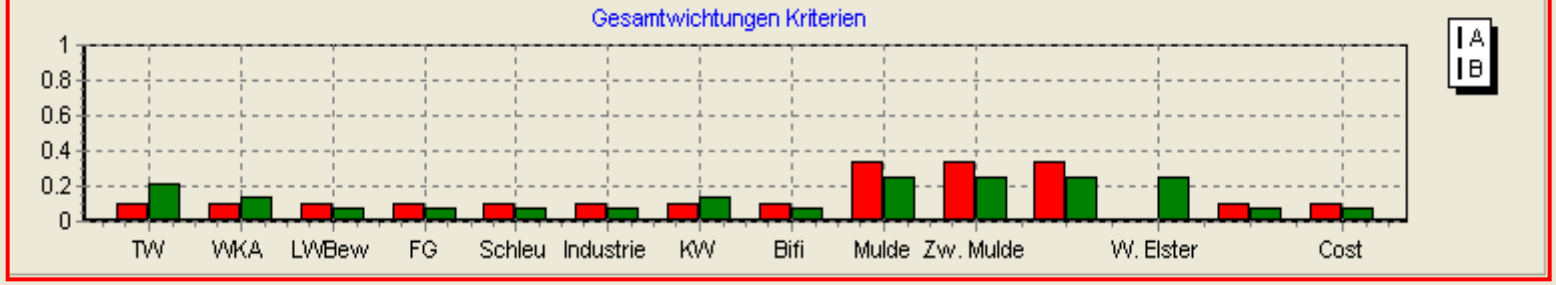
criteria:

- **monetary losses of different user groups**
  - **agriculture**
  - **industry**
  - **power plants**
  - **…**
- **relative fulfilment of demand of ecological discharge**
  - **single gauges (-300) or subbasins**
- **flood risk: annual average damage (from VERIS-Elbe project)**

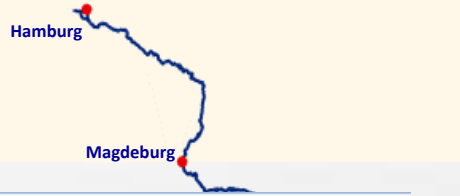
1-n decision makers

criteria weights

DM		Name Entscheider	Kurz	TW	WKA	LWBew	FG	Schleu	Industrie	KW	Bifi	Mulde	Zw. Mu	Fr. Mulc	W. Elste	EAD HV	Cost
1	x	A	A	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.333	0.333	0.333	0	0.1	0.1
2	x	B	B	0.214	0.142	0.071	0.071	0.071	0.071	0.142	0.071	0.25	0.25	0.25	0.25	0.071	0.071



Uncertainties



choice of adaptation strategies

choice and weighting of evaluation criteria

Uncertainties in criteria values

Kriterien

Tausche

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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Kurz	TW	WKA	LWBew	FG	Schleu	Industrie	KW	Bifi	Mulde	Zwickauer M	Freiberger M	Weisse Elste	EAD HWR	Cost
Zielsetzung (maX/miN)	X	X	X	X	X	X	X	X	X	X	X	X	X	N
Einheit	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	%	%	%	%	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grenzwert Präferenz	1000000	2000000	1000000	100000	1000000	100000	1000000	1000000	1	1	1	1	0	0
Unsicherheiten (y/n)	y	y	y	y	y	y	y	y	y	y	y	y	n	n
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

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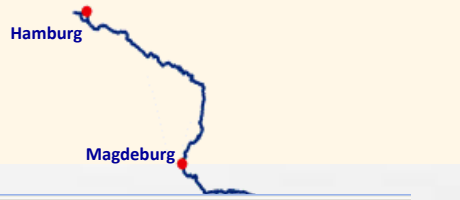
Uncertainties: distribution function



Kriterien

Anzahl der Kriterien: 11, 12, 13, 14, 15

Tausche

#	1	2	3	4	5
Name des Kriteriums	Trinkwasser	Wasserkraft	Bewässerun	Feuchtgebie	Schleus
Kurz	TW	WKA	LWBew	FG	Schleu
Zielsetzung (maX/miN)	X	X	X	X	X
Einheit	EUR	EUR	EUR	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0
Grenzwert Präferenz	1000000	2000000	1000000	100000	1000000
Unsicherheiten (y/n)	y	y	y	y	y
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

Werte	1	2	3	4	5
Alternative A1o	-2.18E5	-1E7	-1.35E7	-1.58E5	-1.16E7
Alternative B2+	-2.12E5	-1.17E7	-1.17E7	-1.28E5	-9.31E6

Kriterium LWBew

Werte / Differenzen

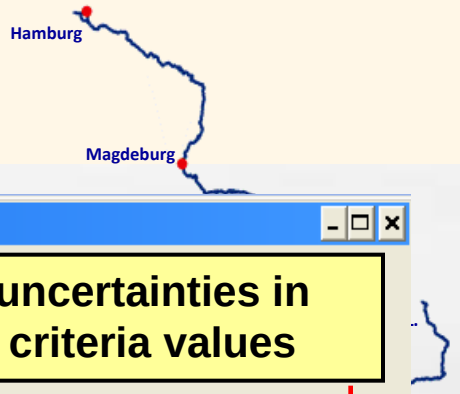
Stichproben (I

Datei laden

Grenzwert Indifferenz: 0

Grenzwert Präferenz: 1000000

Assessment



choice of adaptation strategies

choice and weighting of evaluation criteria

uncertainties in criteria values

Kriterien

Tausche

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
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Zielsetzung (maX/miN)	X	X	X	X	X	X	X	X	X	X	X	X	X	N
Einheit	EUR	EUR	EUR	EUR	EUR	EUR	EUR	EUR	%	%	%	%	EUR	EUR
Grenzwert Indifferenz	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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Unsicherheiten (y/n)	y	y	y	y	y	y	y	y	y	y	y	y	n	n
Unsicherheiten bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.	Bearb.

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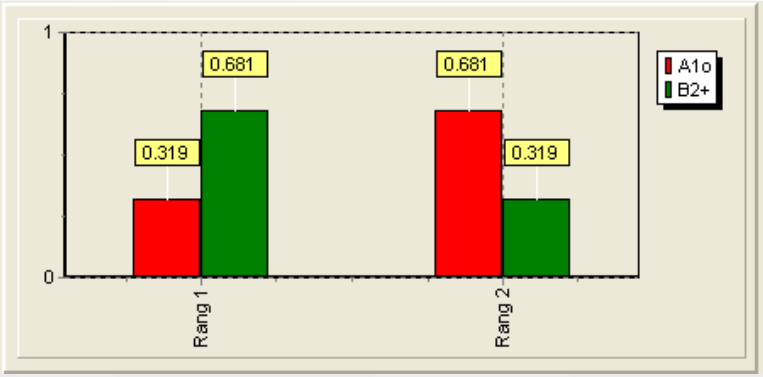
assessment and ranking of options



Two assessment approaches

Cost-benefit analysis

- only monetary criteria (costs, benefits)
- addition of discounted costs and benefits

⇒ **net benefits**

(compared to the baseline option)

Multicriteria analysis:

PROMETHEE (Outranking-approach)

- pairwise comparison of alternatives & criteria
- counting of „votes“ *for* (outflux) or *against* (influx) an alternative

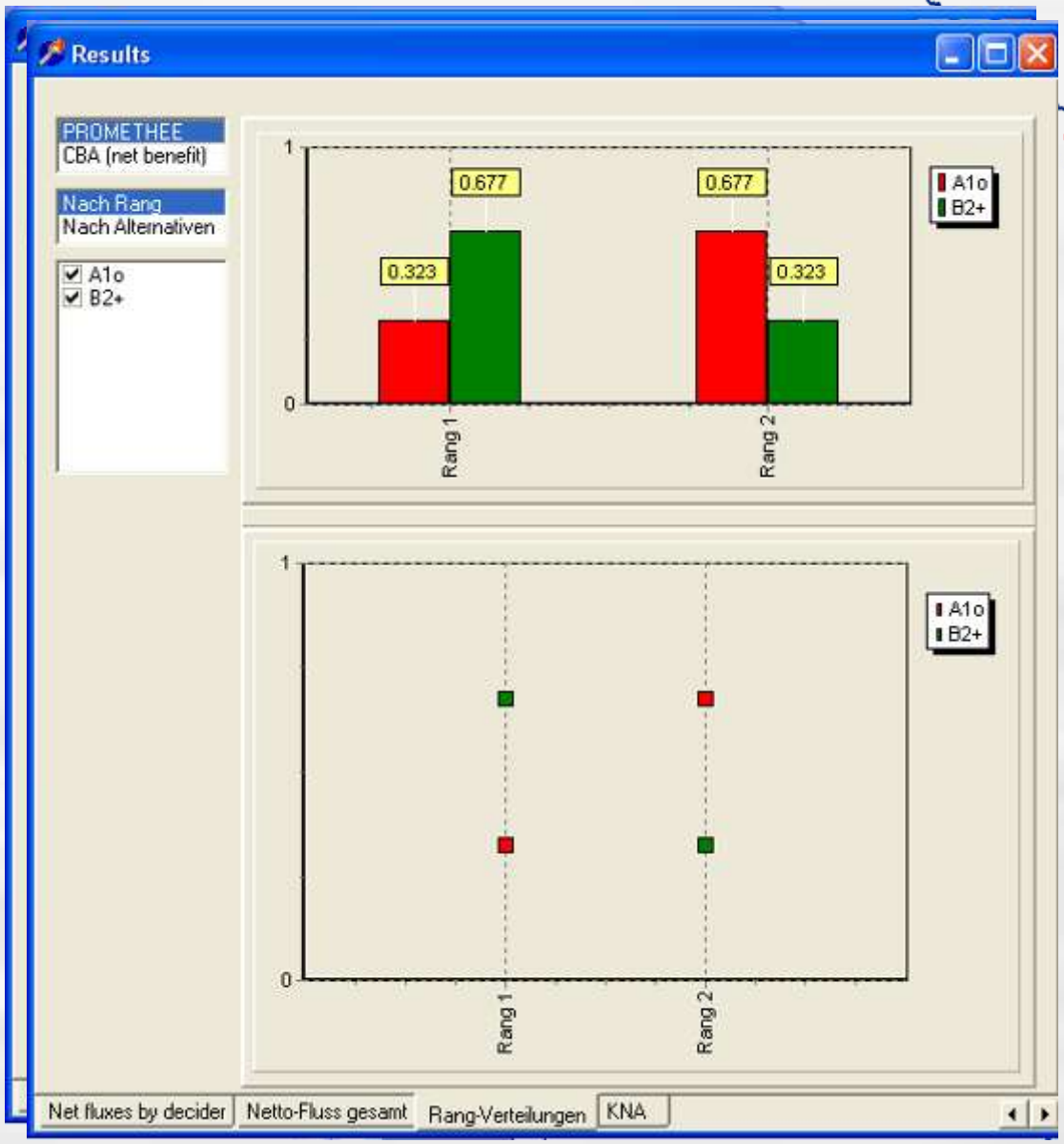
⇒ **„netflux “**

(also for different decision makers)

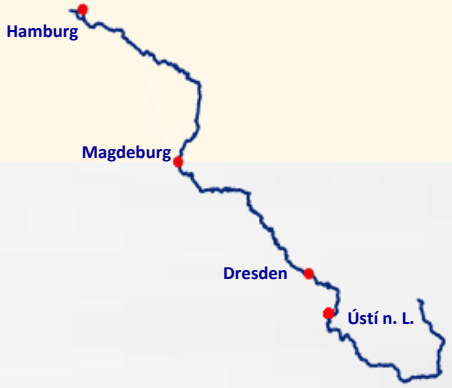
Ranking (probability)

for:

- **cost-benefit analysis**
- **multicriteria analysis**



Finally…



- Only a decision *support:*
  - which options perform best under which scenarios?
  - which options are robust?

- Tool is ready
- But results still to come…

REKLIM Helmholtz-Verbund Regionale Klimaänderungen

Helmholtz Climate Initiative

HELMHOLTZ GEMEINSCHAFT

Regional Climate Change

Vielen Dank für Ihre Aufmerksamkeit

Malte Grossmann, Nele Lienhoop, Volker Meyer, Martin Lange
Stefan Vögele, Konar Mutafoglu, Hagen Koch, Ottfried Dietrich,
Jacob Möhring, Michael Kaltofen, **Bernd Hansjürgens**, Martin Drechsler

Overall impact of water-related economic losses

Overall annual loss: **€ 30.4 - 30.6 million**

GVA Germany: about € 2 400 000 million

GVA New Länder: about € 362 000 million

In economic terms, loss caused by water scarcity in the Elbe Region only comprises 0.00001% of national GVA, and

0.0001% of East German GVA.

Global change on water users in the Elbe River Basin seems negligible.

But: focus here is merely on water scarcity and on one region

→ substitutes are available in other parts of Germany (e.g. agriculture)

Climate change likely to affect some water users nation-wide (e.g. wetlands)

Climate change itself not negligible.

Impact on the national economy: hydro power

Estimated equivalent average annual loss: **€ 9.3 - 10 million**

Revenue of renewable energy generation: € 25 000 million (2007)

Revenue of hydro power generation: € 1 230 million (2007)

- Share of hydro power in energy consumption: 0.8 %
- Hydro power has become less important in recent years.
- Wind power and biomass are favourised substitutes.
- Elbe River basin has a very small share in overall hydro power generation (South Germany has more potential).

From a national economy point of view, the expected economic loss is not of great concern.