BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES FOR EUROPE

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

SEVENTH FRAMEWORK PROGRAMME

BASE Training Workshop
Economic Evaluation of adaptation options

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BASE Report: „**Economic evaluation of adaptation options**"
http://base-adaptation.eu/sites/default/files/Deliverable_5_2.pdf

Objective of this WS

Training for economic evaluation of adaptation options:

1. Experience and results from BASE

2. Learn from each other

Agenda

14:15 – 15:30 **First part:**

Introduction into economic evaluation of adaptation options, experience and results from BASE

15:30 – 16:15 break

16:15 – 18:15 **Second part:**

Working groups

Agenda

14:15 – 15:30 **First part:**

Introduction into economic evaluation of adaptation options, experience and results from BASE

Questions & Discussion

Objective of economic evaluation of adaptation options

- Climate change impacts: need to adapt,
  but high uncertainties
- Scarce public budgets

➢ Decision support:

  ➢ Which adaptation options are (most likely) the best?
  ➢ Considering not only their positive effects (social, economic, environmental **benefits)**, but also their **costs**
  (seeking not only for ***effectiveness***, but also for ***efficiency***,
  i.e. an improve in societal welfare, wellbeing)

➢ Guidelines for selecting adaptation options, strategies

Diversity of guidelines for climate adaptation

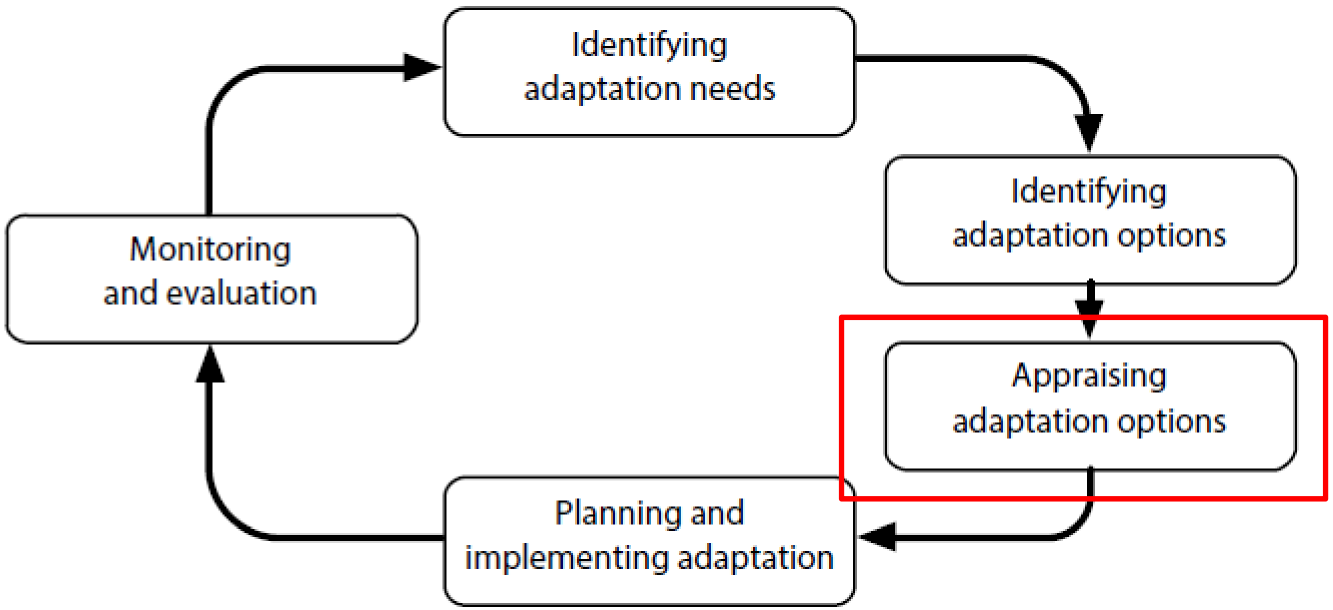


FIGURE 1.3.1 **The adaptation learning cycle.**

E.g. PROVIA http://www.unep.org/provia/Portals/24128/PROVIA_guidance_report.pdf

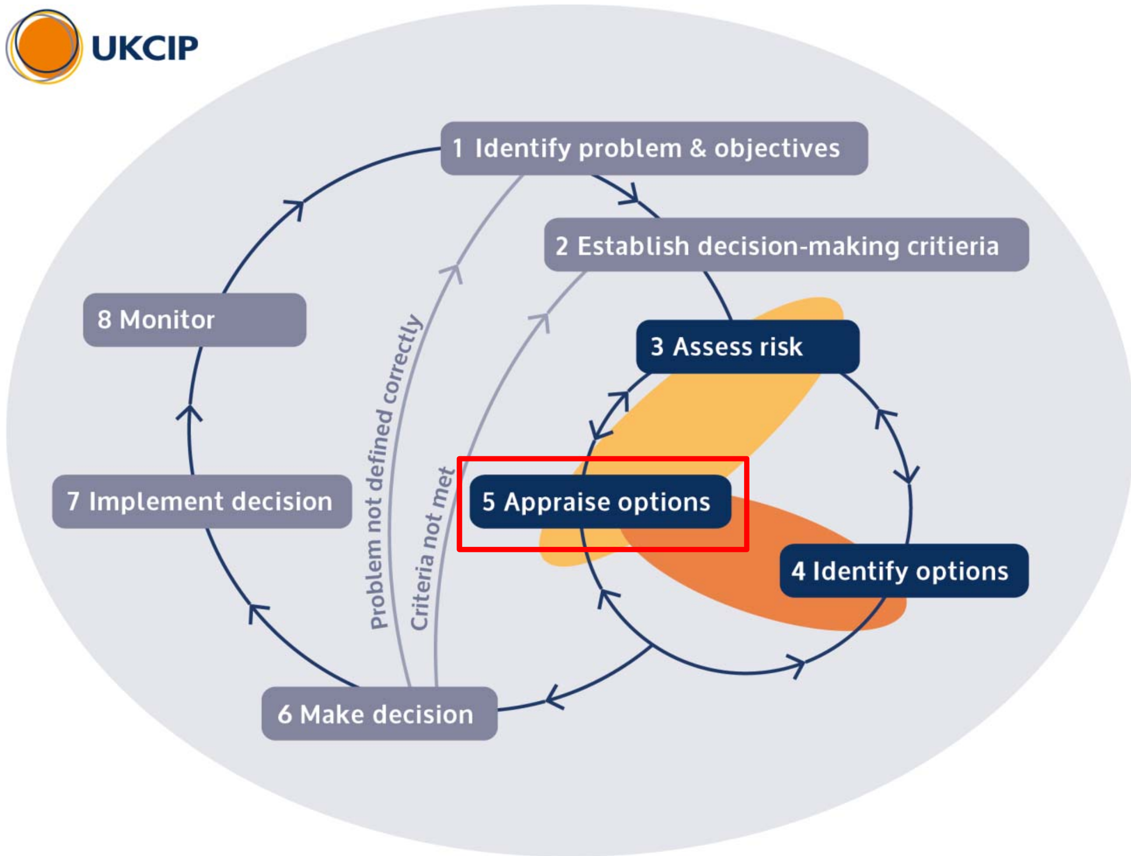
MEDIATION pathfinder http://www.mediation-project.eu/platform/apf_entry/entry_point.html

Diversity of guidelines for climate adaptation

E.g. Climate-Adapt, Adaptation support tool

http://climate-adapt.eea.europa.eu/adaptation-support-tool

Diversity of guidelines for climate adaptation



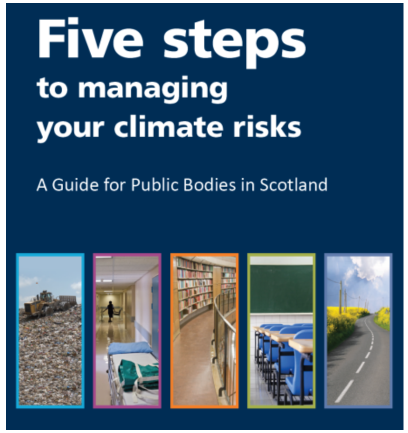
E.g. UKCIP, Adaptation Wizard

http://www.ukcip.org.uk/wizard/#.ViS09CtXyG4

Diversity of guidelines for climate adaptation

- Germany: Klimalotse (https://www.umweltbundesamt.de/node/8674)
- Denmark: Dansk Climate change adaptation platform
  (http://en.klimatilpasning.dk/tools.aspx)
- Scotland: Adaptation Scotland
  (http://www.adaptationscotland.org.uk/5/170/0/Five-steps-to-managing-your-climate-risks.aspx)
- …

ClimateChangeAdaptation



Guidelines: Common steps…

1. Problem identification (impact-, vulnerability- or risk assessment)
2. Selection of potential adaptation options
3. Evaluation of options
4. Implementation
5. Monitoring and ex-post evaluation

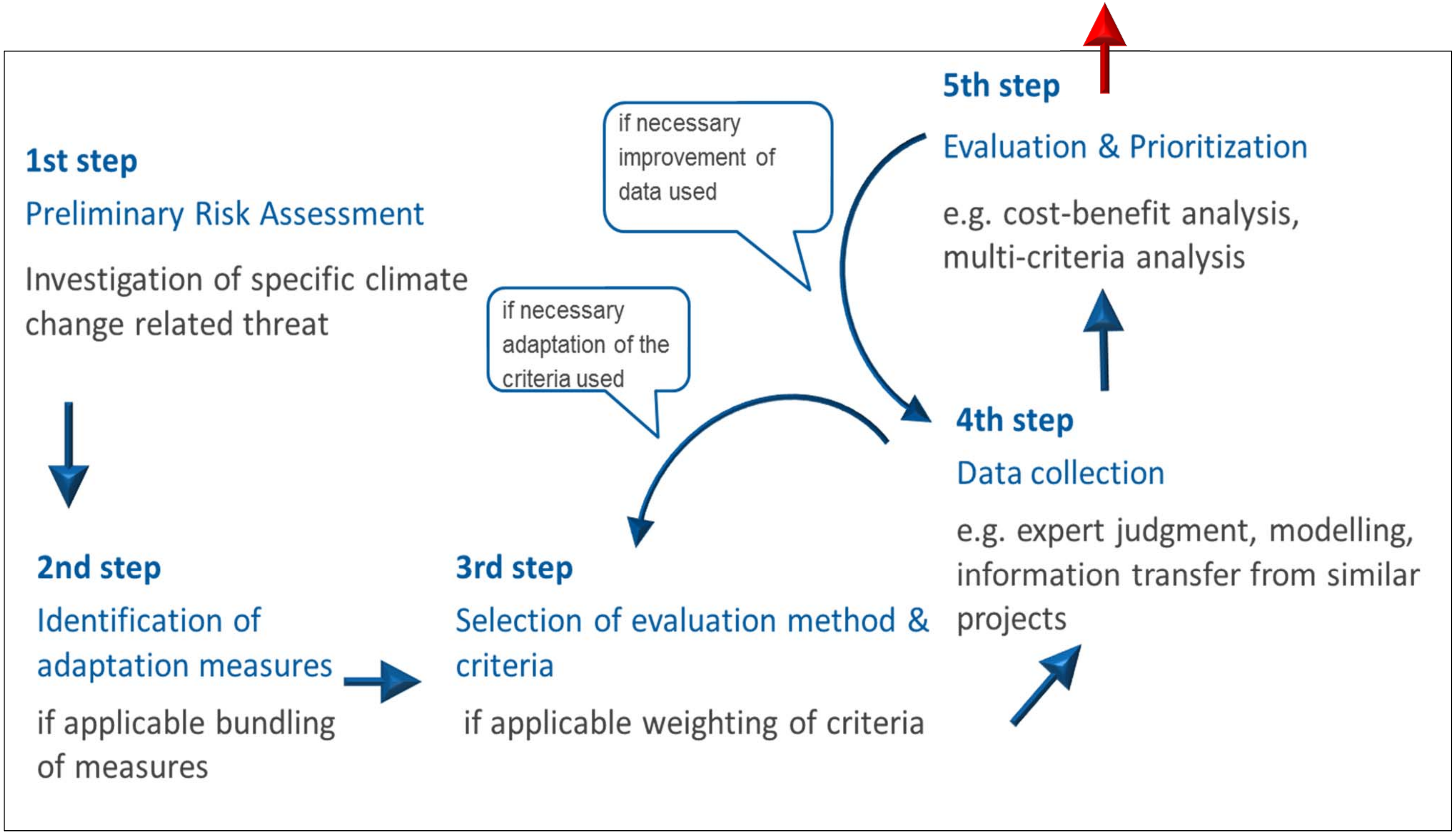
BASE-guideline:

- Focus on economic evaluation
- Focus on the local level

BASE stepwise approach

7th step: Monitoring

6th step: Implementation

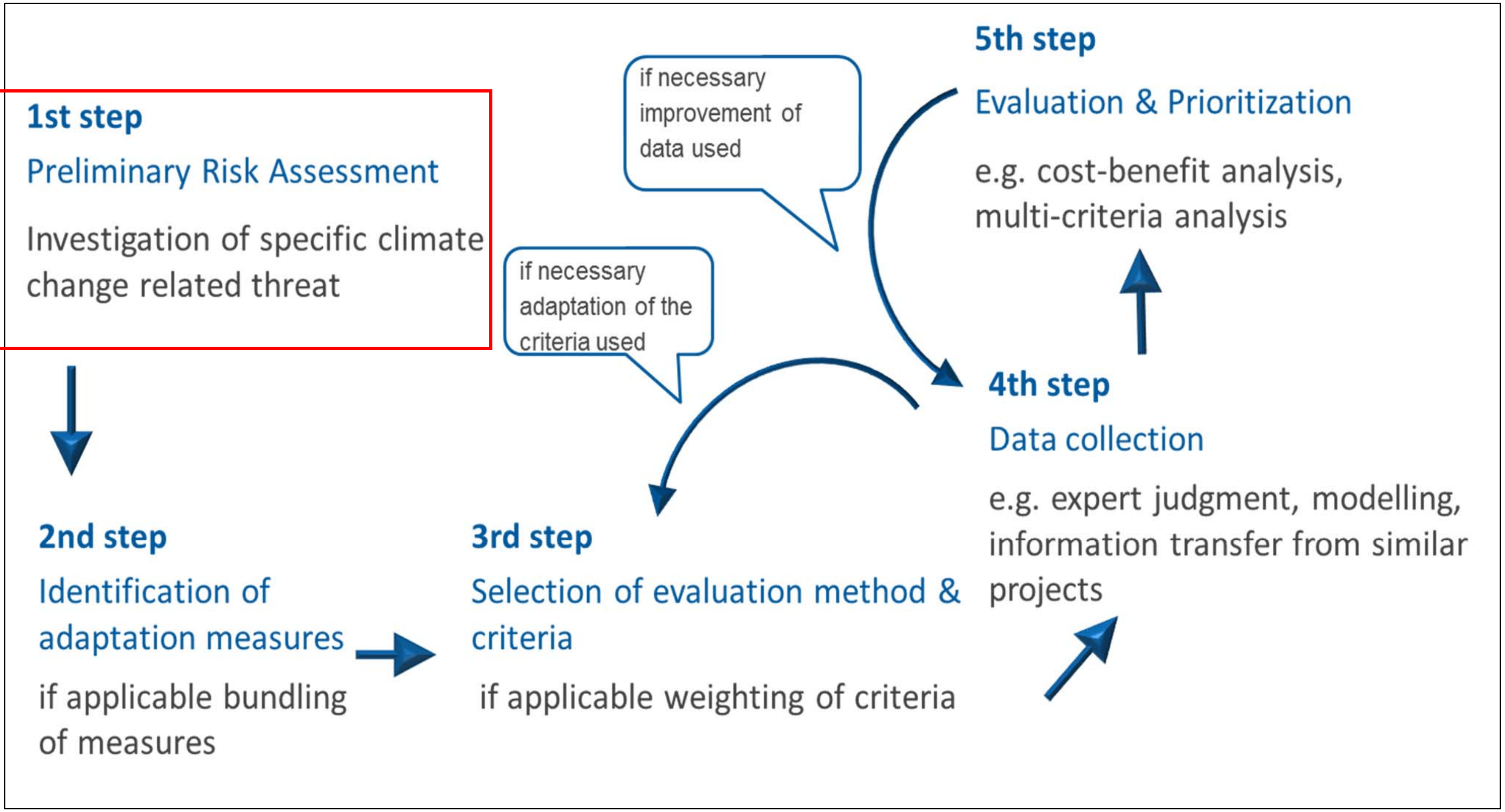


Gebhardt et al. 2013, Meyer et al. 2015

In BASE….

- Testing this stepwise approach in >20 case studies
  (different regions, different risks addressed,…)
- Final Report: „**Economic evaluation of adaptation options**"
  http://base-adaptation.eu/sites/default/files/Deliverable_5_2.pdf
  - Detailed reports from each case study (Annex, >350p)
  - Summary for each of the 5 steps
  - Overall results and conclusions (only 20p)
  - Guidance document on how to conduct economic evaluations (Annex, 20 p)

BASE stepwise approach



Gebhardt et al. 2013, Meyer et al. 2015

Step 1 Preliminary Risk Assessment

Which problems already exist, what is are the current risks?

- Analysis of past events
- Refer to existing risk or vulnerability assessments
- Which adaptation or protection measures are already in place?

How do these risks presumably change due to climate and socio-economic change?

- Use of downscaled climatic data,
  existing studies on climate change impacts,
  own modelling
- Which climate scenarios are used?
  In BASE: RCP 4.5 and 8.5

Identify adaptation objectives

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Step 1: risk assessment

Primary risks	Case studies
Floods (coastal, fluvial, pluvial)	Timmendorfer Strand (Coastal) Venice (Coastal) Kalundborg (Coastal) Aveiro Coast (Coastal) Copenhagen (Coastal, Pluvial) Cascais (Pluvial) South Devon Coast (Coastal, Fluvial), Rotterdam (Coastal, Fluvial) Prague (Fluvial) Holstebro (Fluvial) Kalajoki river basin (Fluvial) Leeds (Fluvial)
Heat stress	Jena Madrid Prague UK Health Cornwall
Ecosystem degradation	Czech “Green roof”
Water quality	Kalajoki river basin
Water scarcity	Alentejo Doñana
Health	UK Health Cornwall

Example:

City of Jena,

heat stress reduction

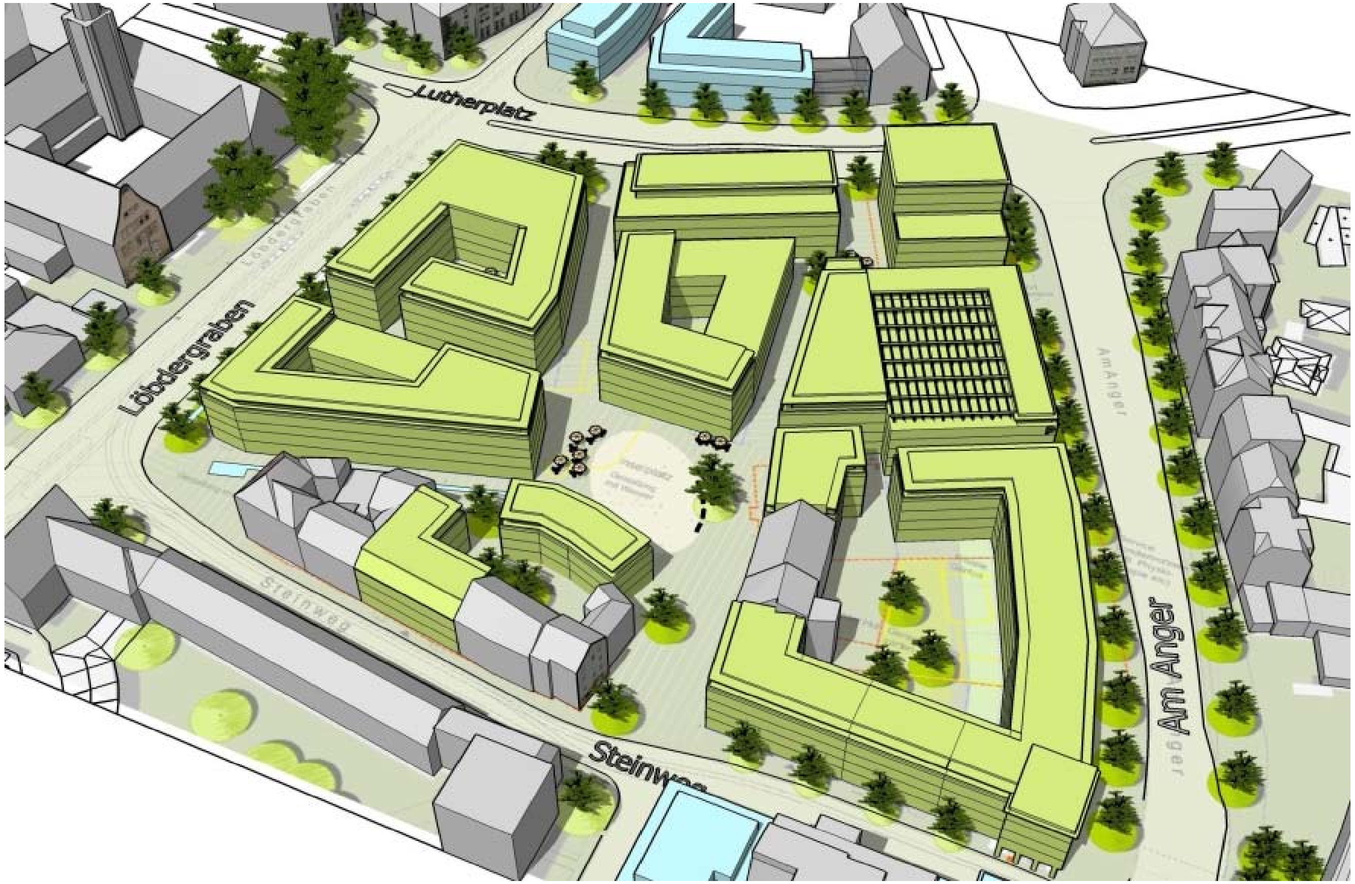
Step 1: risk assessment

- Climate adaptation pilot city in Central Germany (100.000 inh.)
- Exposition to various climate change related risks incl. **heat stress** and river flooding
- 2013: Approval of **urban adaptation strategy** by City Council as informal planning principle
- Economic assessment of 3 major (re)construction projects differing in size and the stage of development
- **Multi-criteria analysis** of climate adapted variations of preliminary drafts of **land development** resp. **construction plans**
- **(Cost-benefit analysis** for adaptation measure “green roof”)

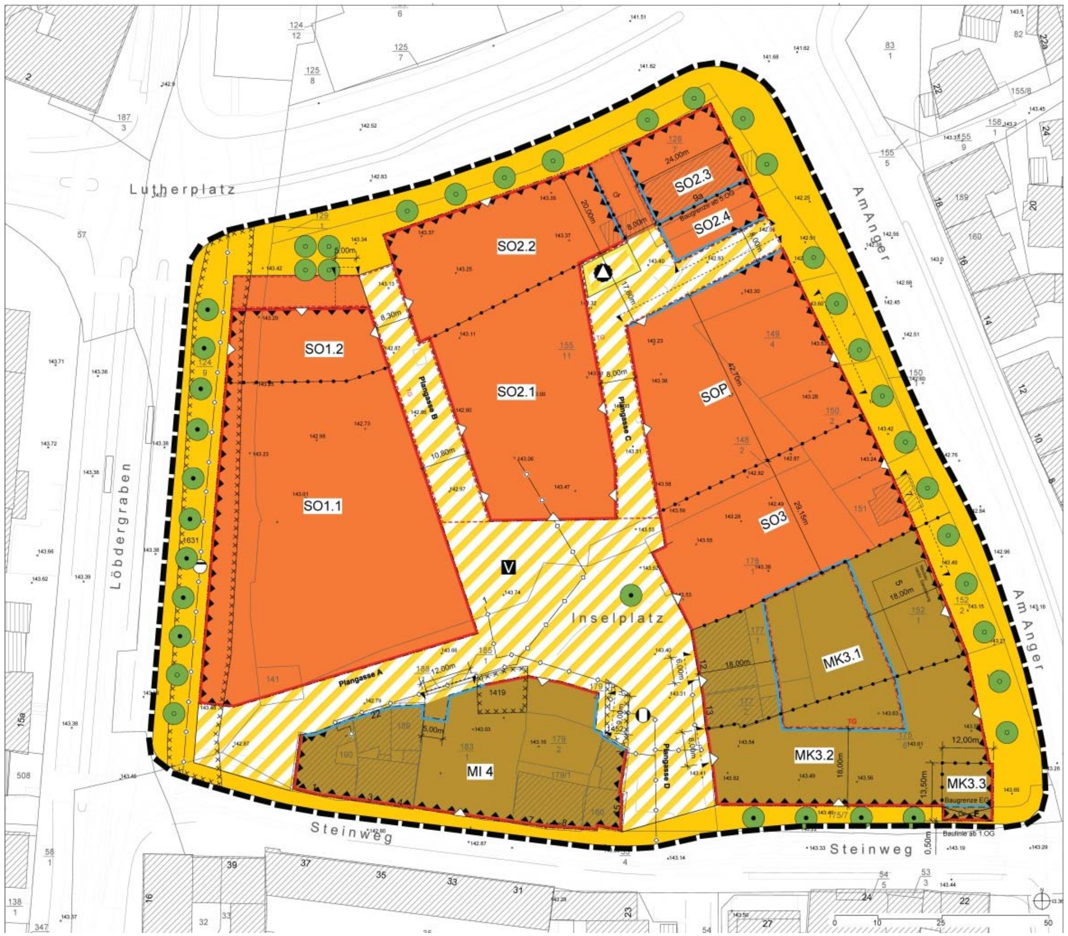
JENA

Inselplatz: Current situation

Inselplatz: Future university campus



Inselplatz: Current draft of the land development plan



Step 1: risk assessment

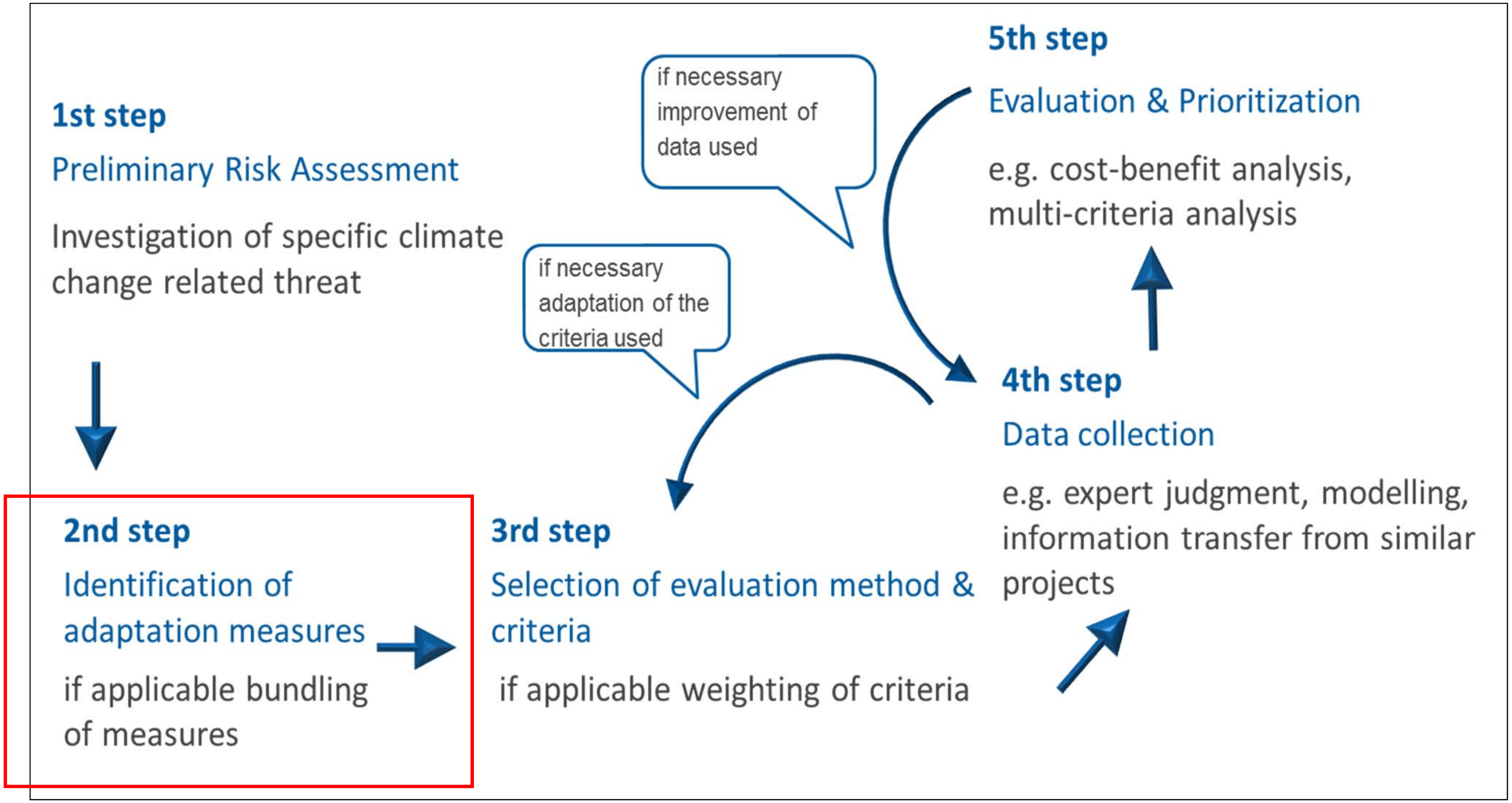
Development of selected climate parameters for Jena

	1981-2010	2071-2100 WETTREG A1B	2071-2100 CMIP5 RCP4.5	2071-2100 CMIP5 RCP8.5
T_{max} in summer quarter (°C)	24	28	27.2	30.2
Number of hot days (T_{max} ≥ 30°C)	11	39	35	49
Precipitation in summer quarter (mm)	160	175	*	135
Number of sultry days (vapour pressure > 18,8 hPa)	2.4	17.8	-	-

- **+3 - +6 Kelvin**
- **+200% - +350%**

Objective: reduce heat stress

BASE stepwise approach



Gebhardt et al. 2013, Meyer et al. 2015

Step 2 Identification of adaptation measures

What are the objectives of adaptation?

What are potential options to meet these objectives?

- Selection of potential measures which:
  - fulfil the objective(s),
  - (provide co-benefits)

Define baseline option

- Determine baseline upon which all costs and benefits are compared to
- In BASE: business as usual option

Bundling of measures?

- Identify complementary measures to attain the objective(s).

BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES FOR EUROPE

Step 2: adapation options in BASE

Primary risks	Type of measure	Examples for specific measures
Floods (Coastal, Fluvial, Pluvial)	Structural protection measure	e.g. Dikes, sluices, seawall,…
	Retention & room for the river measures	Room for the River, Retention, Sustainable urban drainage,…
	Private protection measures	domestic flood gates, pumps, dry flood proofing of houses
	Reduction of exposure and vulnerability	Re-routing railway line
Heat stress, health	Structural	Green roof , Light-coloured pavements
	Reduction of exposure and vulnerability	Heat health watch warning system, health campaign
	Nature-based	Trees, Façade greening
Ecosystem degradation	Non-structural	Sustainable forest management, Peat land and water course restoration, enlargement of core protection zones
Water quality	Nature-based	Buffer zones, constructed wetlands, Winter time vegetation cover , Perennial grass, Controlled drainage, Optimal fertilization
Water scarcity	1. Technological 2. Organizational 3. Governance	1. Water recirculation, … 2. Reduction of cultivated surface, … 3. Increase coordination between institutions, …

Example:

City of Jena,

heat stress reduction

Alternative options to implement the land development plan

	Alternative 1 „traditional“	Alternative 2 „moderate green & blue“	Alternative 3 „max green & blue“
Number of trees	Existing trees: 14 New trees: 25	Existing trees: 14 New trees: 29	Existing trees: 14 New trees: 31
Species of newly planted trees	25 small-crowned trees	15 large-crowned trees 14 small-crowned trees	27 large-crowned trees 4 small-crowned trees
Colour schemes of pavements	Entire area: ordinary pavements	Inner area: light-coloured pavements Outer area: ordinary pavements	Entire area: light-coloured pavements
Roof greening of new flat roofs	69% tar-gravel-roof 31% extensive green roof	48% tar-gravel-roof 52% extensive green roof	30% tar-gravel-roof 70% extensive green roof
Artificial water course	None	40m^2	80m^2

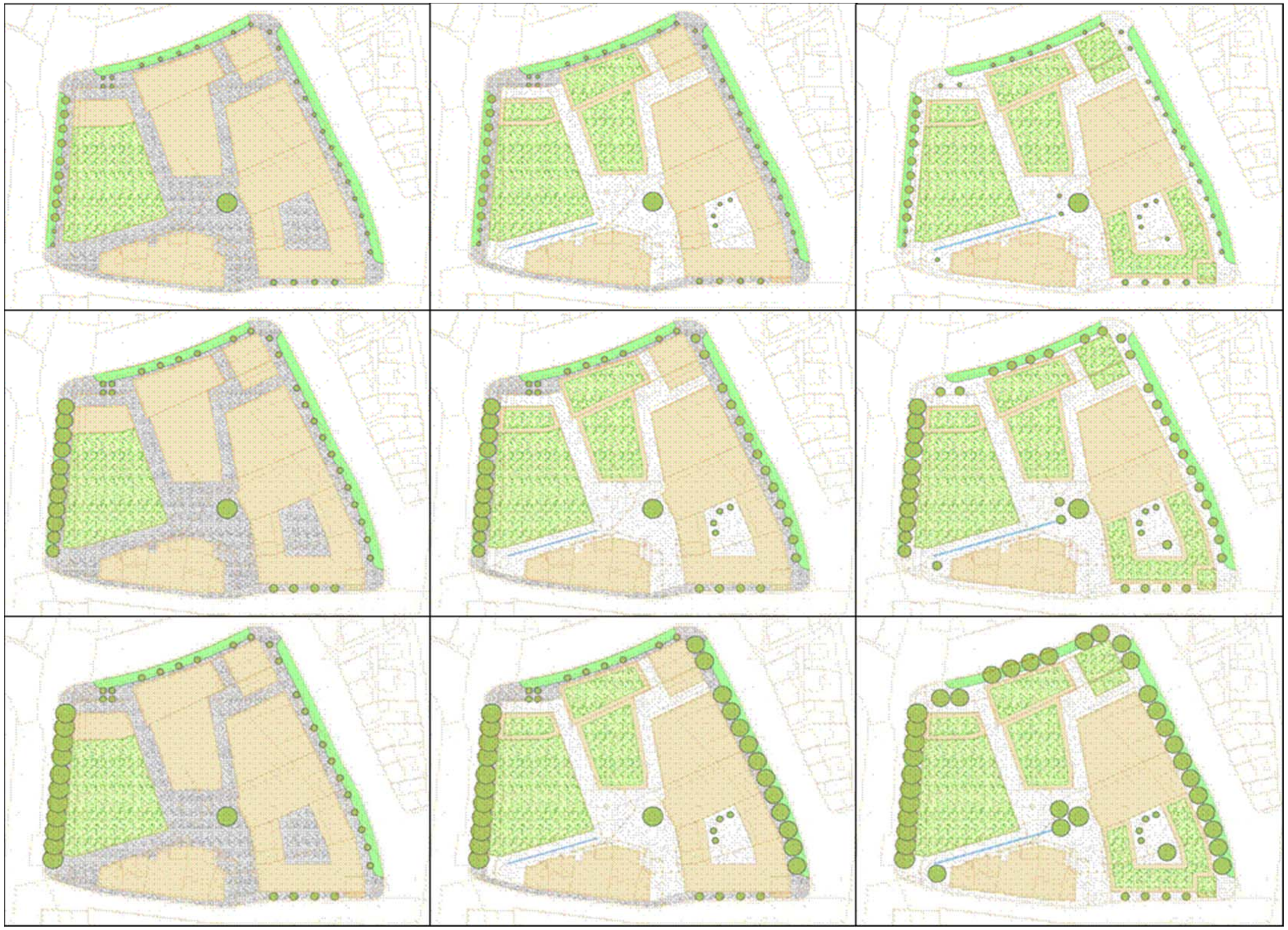
Step 2: adapation options

A1: „traditional“ | A2: „moderate“ | A3: „max green&blue“

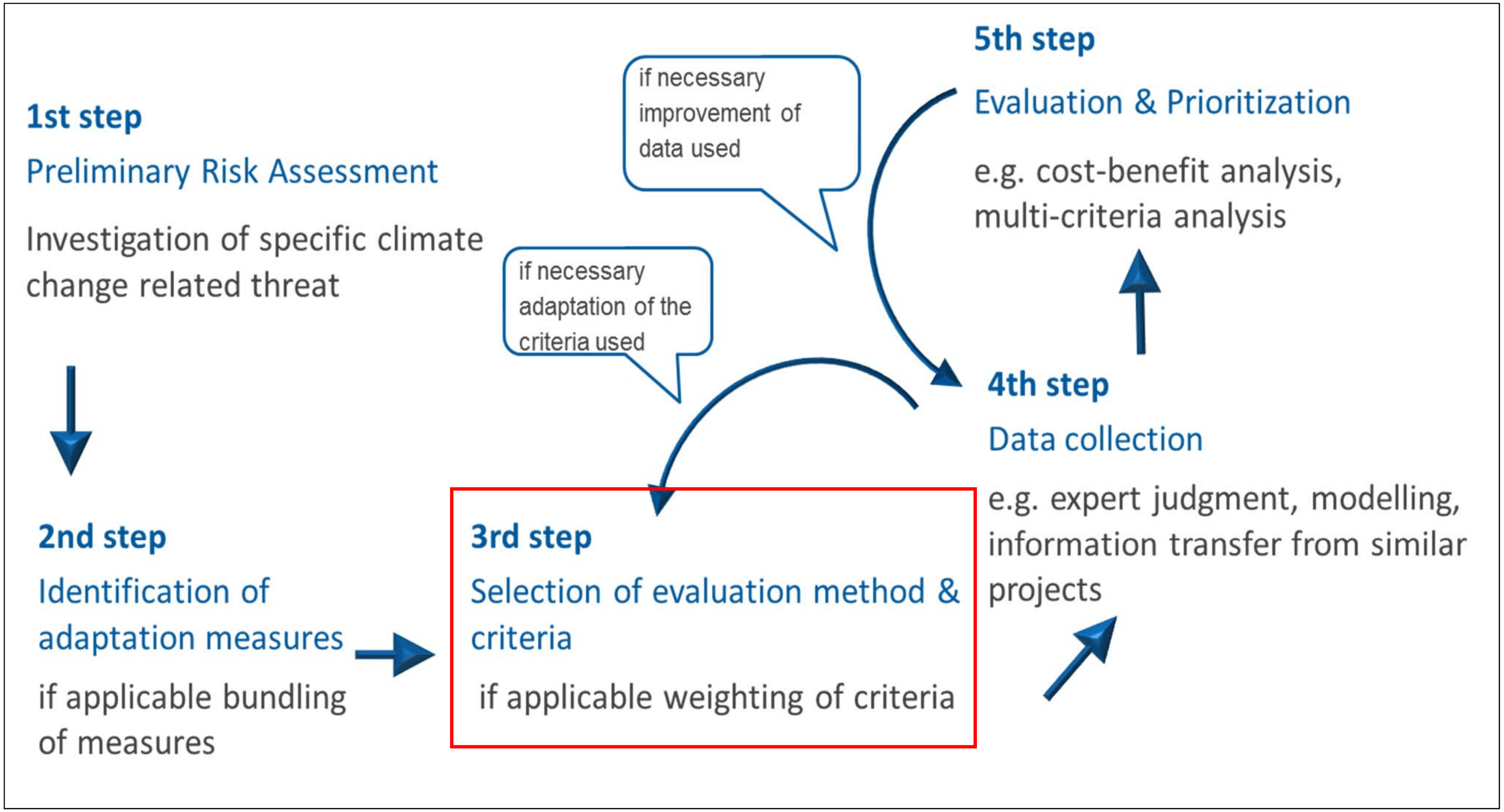
2021

2021-2050

2071-2100



BASE stepwise approach



Gebhardt et al. 2013, Meyer et al. 2015

Step 3a Selection of evaluation criteria

Identify appropriate evaluation criteria

- Determine evaluation criteria that reflect all relevant positive (benefits) and negative (costs) effects (not only market values!)

Potential cost-related criteria :

- Investment costs
- Re-investment costs
- Running costs, operation and maintenance costs
- Transaction costs
  (costs associated with the design and implementation of measures, e.g. participation, communication, negotiations, solving conflicts,…)
- Other negative side-effects,
  such as negative environmental and social effects of the measures.
  E.g. dikes could also have negative impacts on floodplain ecosystems.

Step 3a Selection of evaluation criteria

Potential benefit criteria

- **Damage avoided**
  - e.g. annual average flood damage avoided,
  - considering economic, social and environmental effects
  - change due to climate change
- **Other positive effects:**
  - Change of biodiversity and ecosystem services (e.g. due to a dike relocation)
  - Change of recreational value
  - …

Other criteria…

- Potential feasibility-related criteria:
  Technical complexity, Institutional complexity, Social acceptance,
  Financial viability

Define appropriate units to measure criteria

- Monetary, other quantitative units, qualitative units

Step 3b Selection of evaluation method(s)

Identification of appropriate method(s)

- Select appropriate method(s), based on type of criteria and data availability:
  - **Cost-benefit analysis (CBA)**
  - **Cost-effectiveness analysis (CEA)**
  - **Multicriteria analysis (MCA)**
  - **Participatory Benefit-Cost Analysis (PBCA)**
  - Others:
    - **Robust Decision Making** (e.g. Groves & Lempert 2006): Computing robust options, considering all uncertainties
    - **Real Options** (e.g. Woodward et al. 2014): optimising, considering costs of waiting for more certainty
    - **Dynamic Adaptation pathways** (Haasnoot et al. 2013): Identifying cost-effective adaptation pathways under global change
    - **Decision Heuristics** (Gigerenzer et al. 2009, 2011): simple decision rules

Step 3b Selection of evaluation method(s)

All relevant cost and benefit criteria can be assessed in **monetary terms**:

➢ **Cost-benefit analysis**

Steps (see e.g. Hanley & Spash 1993):

- Project definition:
  - Selection of alternative options (measures),
  - Determination of the evaluation timeframe
- Quantification and monetisation of all relevant project impacts
- Discounting
- Ranking of alternatives: Decision rules
- Sensitivity analysis

CBA: Project definition

- Selection of alternative options (measures)
  - Different measures aiming at improving the situation
    (e.g. dike heightening, flood retention, flood warning etc…)
  - 1 **baseline option** to which all others are compared to
    (usually the "**business as usual"-option,** e.g. maintaining current dike)
- Determination of the evaluation timeframe
  - Usually determined by the option with the longest lifetime
    (e.g. dike heightening 50 years, **retention 100 years**, flood warning system 20y)

CBA: Monetisation of all relevant project impacts

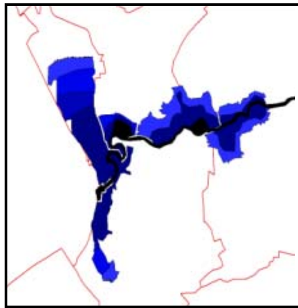
cost criteria

- Investment costs, re-investment costs, running costs (operation and maintenance costs), transaction costs, other negative side-effects

benefit criteria

- **Damage avoided,** e.g. flood damage avoided, health effects avoided, water scarcity losses avoided,…
- Other positive effects

Flood damage estimation: Basic components, necessary information:

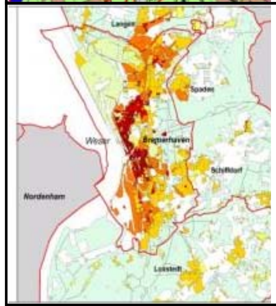


HAZARD

Inundation characteristics: Flood area and depth

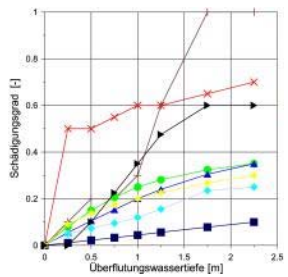
EXPOSURE

Land use data: type of elements at risk



Value of assets at risk

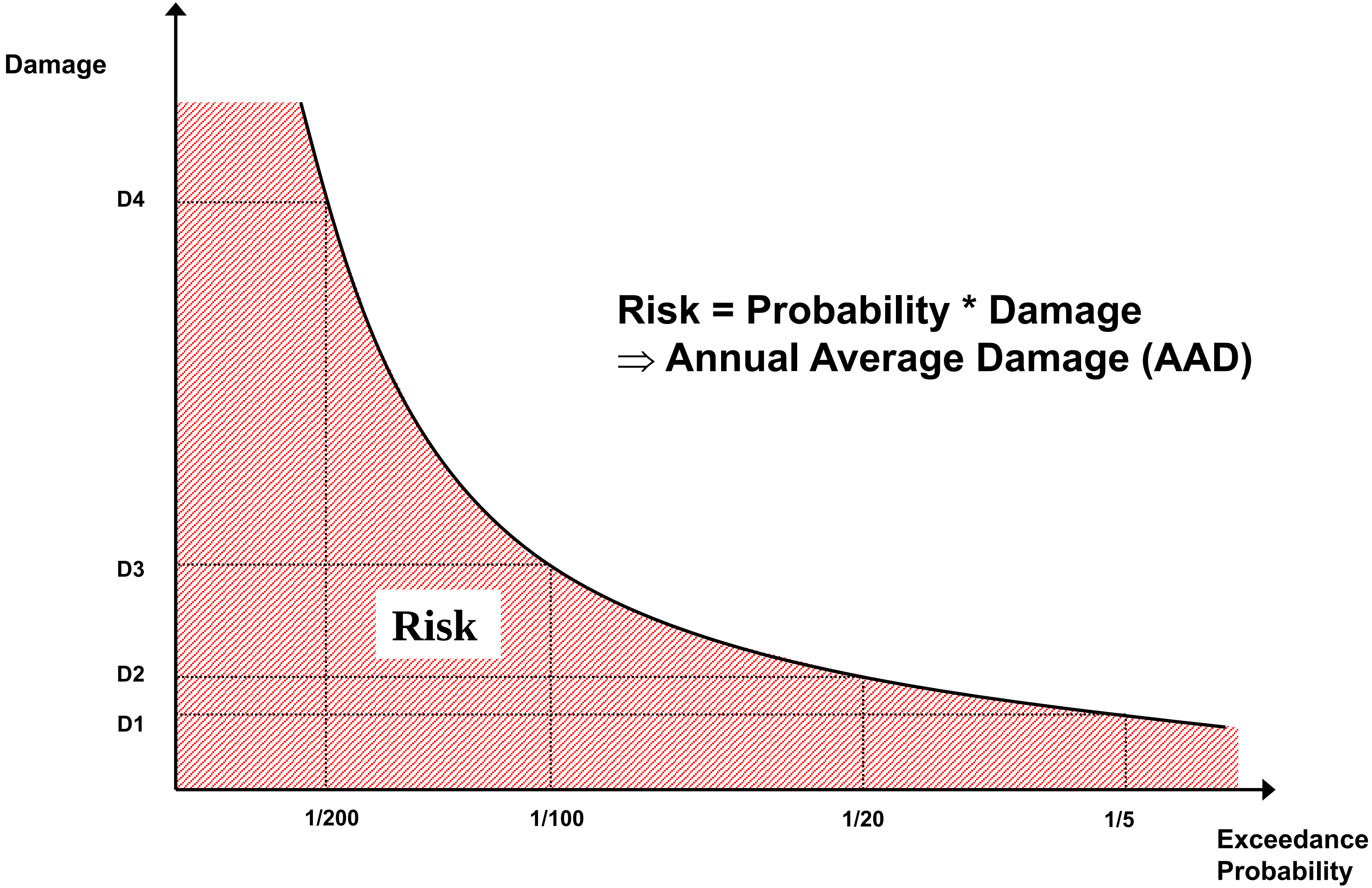
DAMAGE
(for a specific event with a given probability)



SUSCEPTIBILITY/ VULNERABILITY

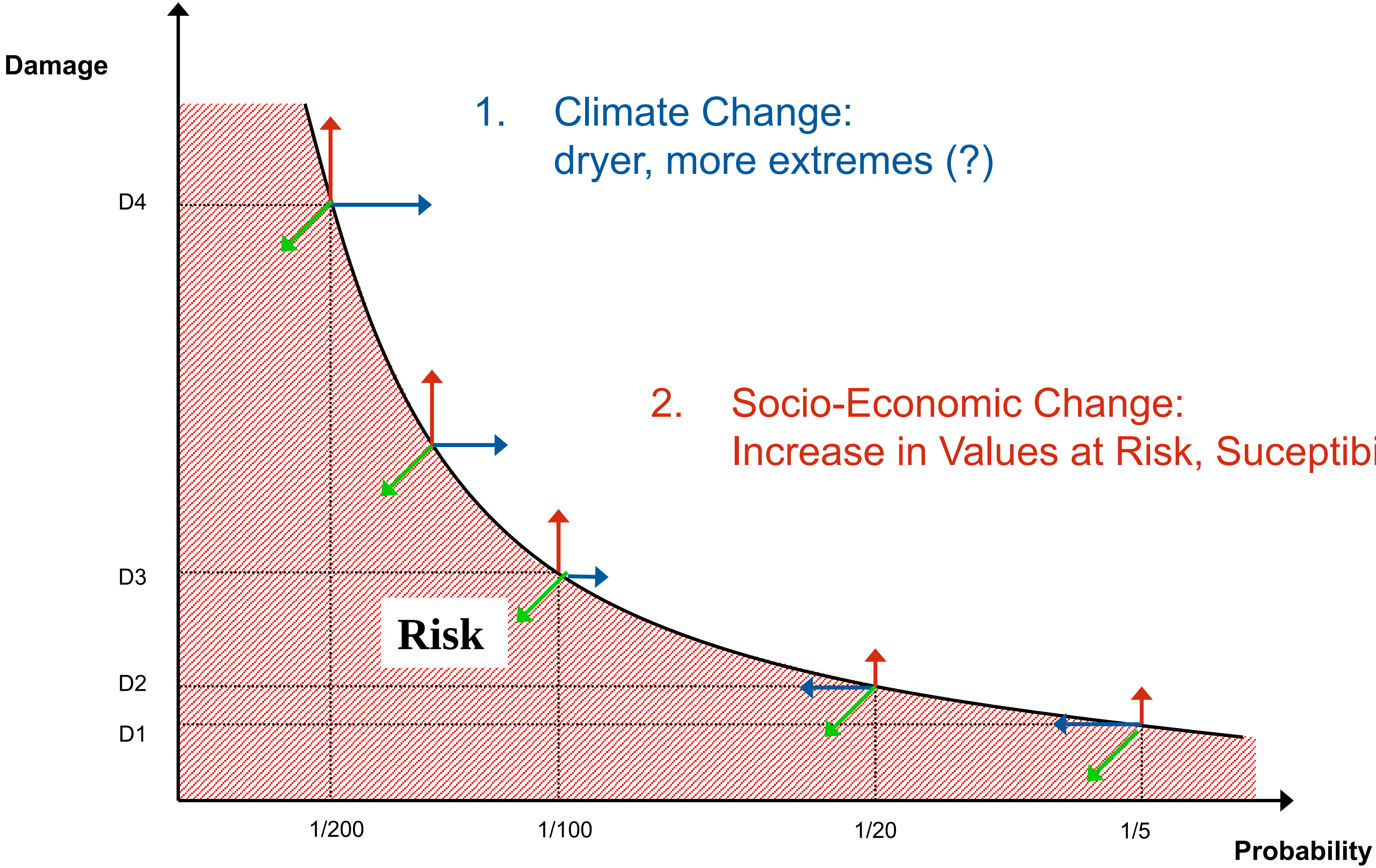
Depth/damage functions

Damage estimation ⇒ Risk assessment



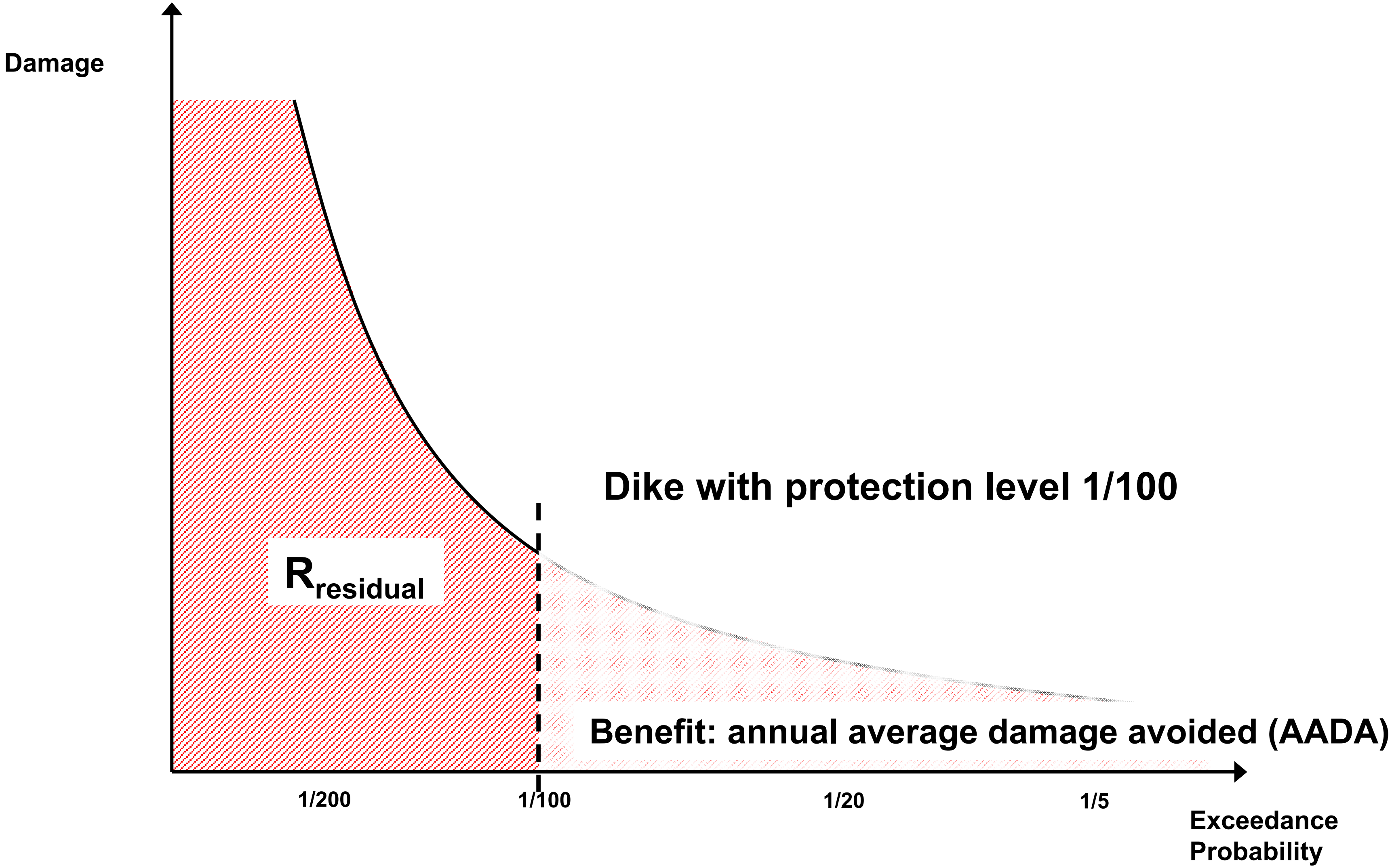
Risk = Probability * Damage
⇒ Annual Average Damage (AAD)

Challenge: global change
different drivers, different dynamics

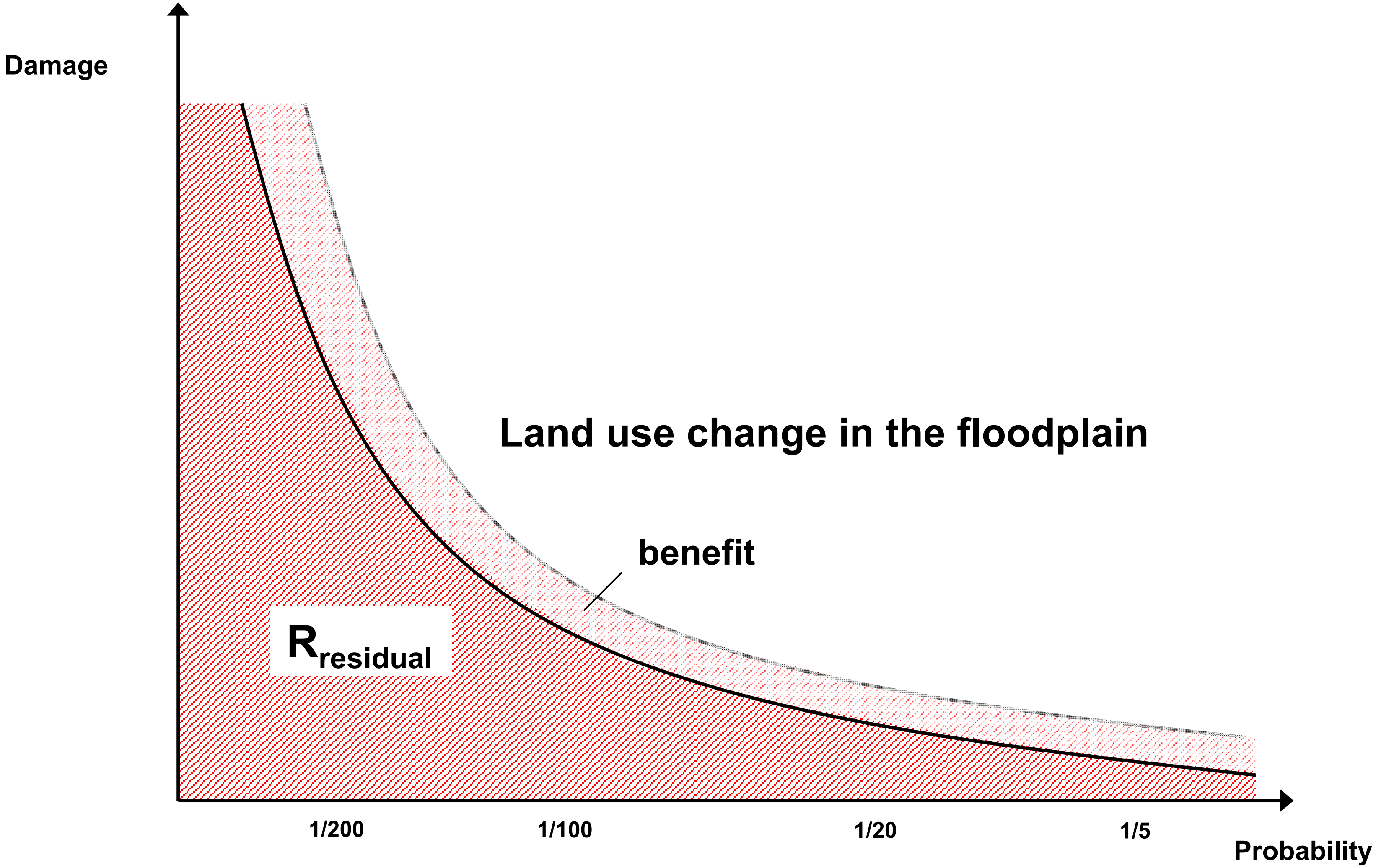


3. Adaptation, risk reduction measures

Risk reduction = Benefit



Risk reduction = Benefit

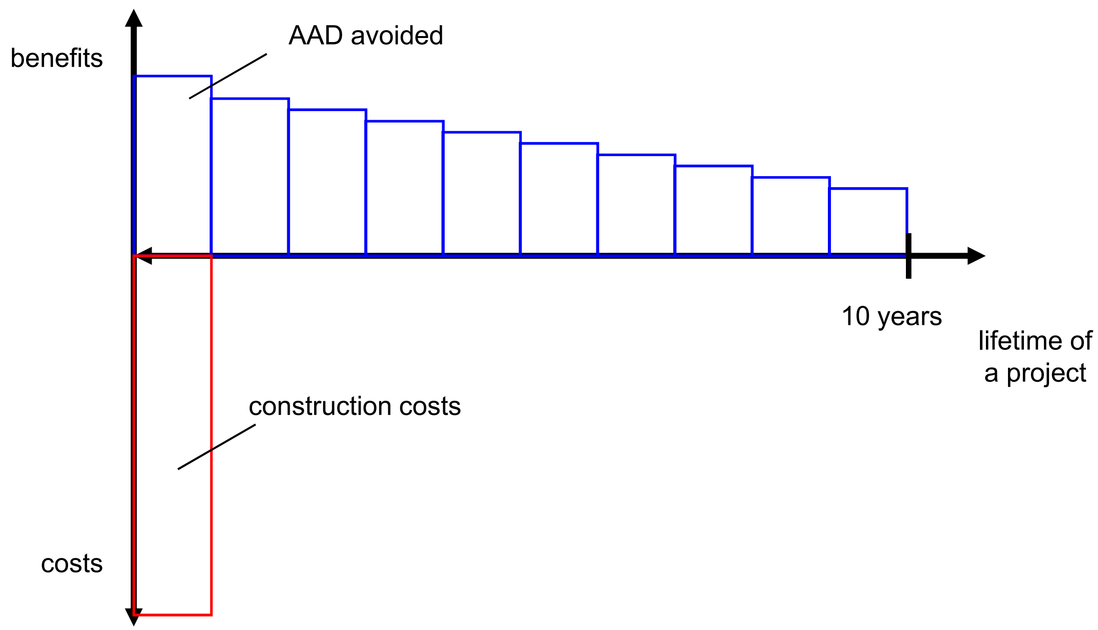


CBA: Discounting

- Future C & B need to be discounted to their *present value*
- Rationale:
  - Benefits & costs you have now count more than benefits & costs in the future
  - Money can be invested elsewhere in the meantime

$$PV(X_t) = X_t \left[(1+i)^{-t}\right]$$

With
$PV(X_t)$: present value of X_t
X_t: cost or benefit received in time t
i: discount rate



CBA: Discounting

- What is the right discount rate?
  - Low discount rate: high weight to future costs and benefits
  - High discount rate: low weight to future costs and benefits
- **In BASE**:
  - it is recommended to use the **discount rate prescribed by national guidelines** for climate change adaptation measures (or other public investments)
  - In addition, also a low and high discount rate should be tested to show **sensitivity** of results against different discount rates (**1% and 5%)**

CBA: Ranking, decision rules

1. **Net present value (NPV):** discounted benefits – discounted costs (>0 = efficient)

$$NPV = \sum_{t=0}^{n} B_t (1+i)^{-t} - \sum_{t=0}^{n} C_t (1+i)^{-t}$$

2. **Benefit cost ratio (BCR):** ratio of disc. benefits to disc. costs (>1 = efficient)

$$BCR = \frac{\sum_{t=0}^{n} B_t (1+i)^{-t}}{\sum_{t=0}^{n} C_t (1+i)^{-t}}$$

Ranking based on NPV or BCR? depends on the decision situation:

- **If only one option is funded**:
  choose the one with the **highest NPV**.
- **If capital budget is fixed & several projects should be carried out**:
  rank the projects **by their BCR**,
  and accept them in order of their ranking until the budget is exhausted

CBA: Sensitivity analysis

Test if ranking is robust with regard to changes…

1. …in the **input data**, e.g. when there are uncertainties in the input data
   - Test with high & low values of costs & benefits
   - Test with MonteCarlo simulation (e.g. 1000 runs of CBA with samples) probabilistic tools, e.g. PRIMATE, …
2. …in the **discount rate**:
   - Test with high (5%) and low (1%) discount rate

Cost-effectiveness analysis

The performance of the benefit criteria can be assessed by **a single non-monetary indicator**:

➢ Cost-effectiveness analysis

- Same steps as CBA, but…
- **Monetary costs** are related **to target achievement (‘effectiveness**’).
- The method can be used only for measures with the **same specific target** (e.g. reduction of thermal load by 1K, provide safety standard against 1/100 year flood) .
- **Decision rules**:
  - Costs to achieve the defined target
    e.g. measure which provides safety standard at lowest cost.
  - Effectiveness at a given cost level
    e.g. measure with the best performance for a given budget

Multicriteria analysis

Several objectives and/or criteria need to be used for assessment and **some of them cannot or cannot easily be expressed in monetary terms**?

➢ Multicriteria analysis

Steps (based on Munda 1995, Rauschmayer 2000; Malczewski 1999):

1. Problem Definition
2. Evaluation Criteria
3. Alternative options
4. **Criteria Evaluation / Decision Matrix**
5. **Criterion Weights**
6. **Decision Rules**
7. Sensitivity / Uncertainty
8. Ranking / Recommendation

MCA

Decision matrix: e.g. flood risk management options

Criteria / Alternative options	Benefits: Risk reduction to…					Costs
	people		environment		economy	
	people affected / year	loss of life/ year	Biotope area affected	pollution	Annual average damages	
Dike	100-110	0	10	High	30-50 Mio	**5 Mio**
Land use change	200	0.2	20	Low	40 Mio	**10 Mio**
Warning system	0	0.4	0	0	10 Mio	**3**

partial CBA

comprehensive CBA (requires monetisation of non-market values)

MCA (requires weighting of criteria)

MCA – Criteria weighting

Weight elicitation

- With stakeholders/decision makers…
  (subjective?)
- In case of the involvement of multiple stakeholder groups and/or decision makers a number of weighting sets can be obtained.

weighting methods…

- Swing-weight technique:
  start with the most important criteria (100 points)- how many points for the 2^{nd}, 3^{rd},…
- 100-point allocation method:
  allocate 100 points to the different criteria

MCA – Decision rules

Ranking of options based on different aggregation rules

e.g. Simple additive weighting:

1. Standardisation of criterion values (0-1)
2. Weighting of criteria (by decision makers)
3. Overall value =
   sum of weighted standardised criteria values
4. Ranking

options	Criteria			Total Score
	W: 0.5	W:0.1	W:0.4	
	people	environment	economy	
A1	100 (0.5)	5 (0.5)	50 Mio (1.0)	0.7
A2	200 (1.0)	10 (1)	30 Mio (0.6)	0.84
A3	0 (0)	0 (0)	10 Mio (0.2)	0.08

Outranking: e.g. PROMETHEE

1. pairwise comparison of alternatives & criteria
2. Weighting of criteria
3. counting of „votes“ for (outflux) or against (influx) an alternative
4. Overall „netflux“
5. Ranking

In the BASE case studies…

	CBA	CEA	MCA	PBCA
Flooding & Coastal erosion	Kalajoki Copenhagen Rotterdam Aveiro Coast South Devon Coast Leeds Timmendorfer Strand Prague	Cascais Holstebro	Kalajoki Copenhagen Rotterdam Aveiro Coast Cascais	Cascais
Heat stress & Health	Jena Madrid		Jena	
Water scarcity	Alentejo Doñana		Doñana	Alentejo
Water quality		Kalajoki		
Ecosystem degradation	Green roof			

Example:

City of Jena,

heat stress reduction

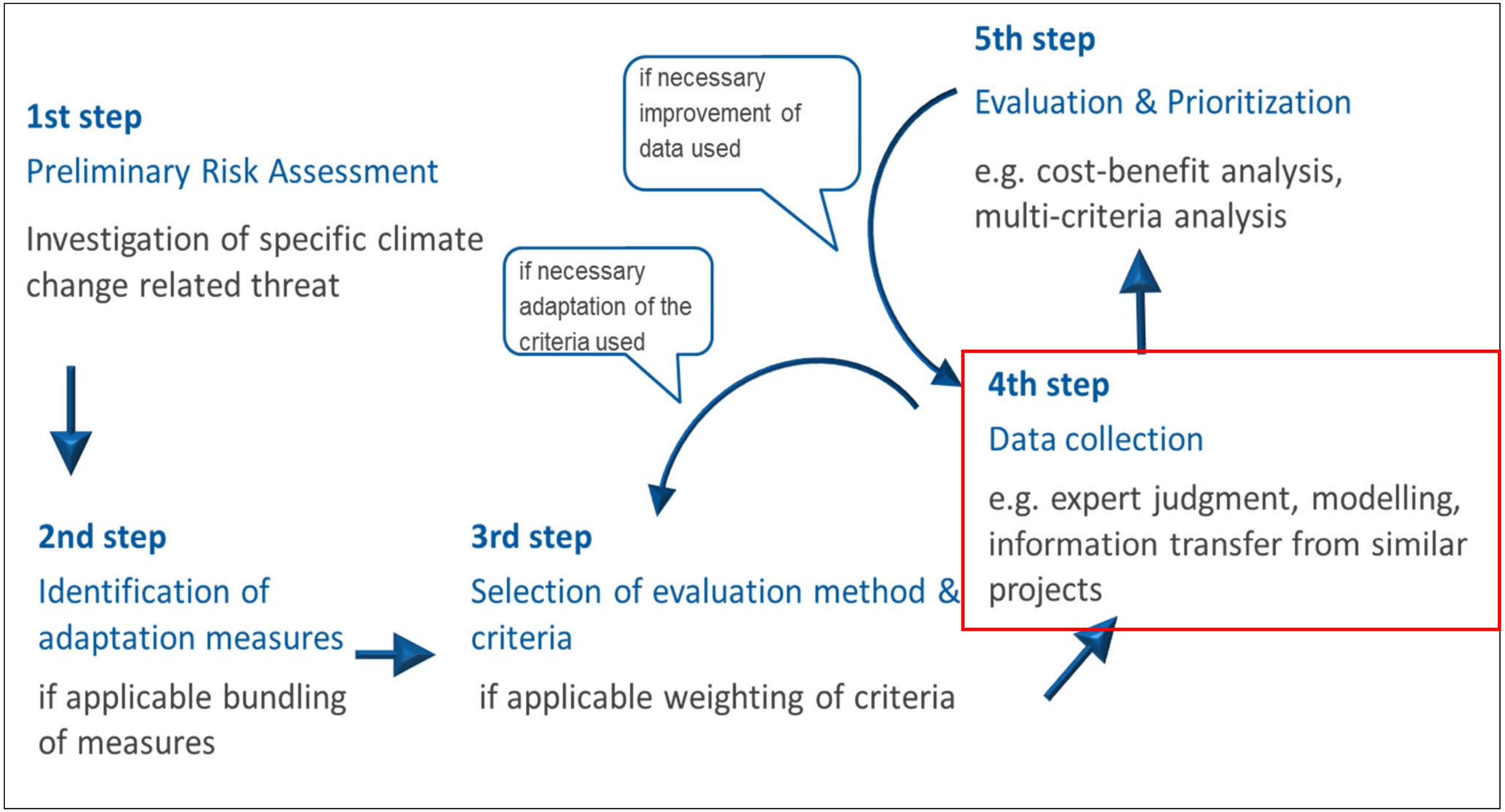
Evaluation criteria & method

- **Heat stress potential** (2021-2100, 10-point scale)
- **Net present costs** (2021-2100, EUR, discount rate 1.5%):
- **Amenity value** (2021-2100, 5-point Likert scale)
- **Architectural quality** (2021-2100, 5-point Likert scale)

} **MCA**

Criteria	**Weights in %**	
	Decision maker 1	Decision maker 2
Heat stress potential	35	20
Costs	20	40
Amenity value	20	20
Architectural quality	25	20

BASE stepwise approach



Gebhardt et al. 2013, Meyer et al. 2015

Step 4 Data collection

Data sources for data collection for each criteria selected

For avoided damages:

- damage & impact assessment methods, e.g.
  - Flood risk assessment models (PlanningKit DPRD, FLEMO, DamageScanner, MCM,…)
  - Heat stress assessment models (URBAHT, ENVI-MET, …)
  - Ecosystem service (InVEST,…)

For all cost & benefit criteria:

- Official plans
- Literature
- Consultancies
- Expert knowledge…

Discounting of costs and benefits

Step 4 Data collection

Treatment of data uncertainties

- Document uncertainty (lower/upper bounds, probability distrubition

- Refine criteria catalogue if no data is available at all

Example:

City of Jena,

heat stress reduction

Evaluation criteria & method

- **Heat stress potential** (2021-2100, 10-point scale)
- **Net present costs** (2021-2100, EUR, discount rate 1.5%):
- **Amenity value** (2021-2100, 5-point Likert scale)
- **Architectural quality** (2021-2100, 5-point Likert scale)

Urban heat tool - URBAHT

Structural parameters	Climate parameters
• Area type • Construction type • Share of sealed surface (without buildings) • Share of area covered with buildings • Average height of buildings • Average albedo value of surfaces • Share of water area(s) • Share of green structures (lawn, trees etc) • Irrigation of at least 50% of green areas in summer • Total population of the city • Population density of study area	• Global radiation • Average maximum temperature in summer quarter • Average precipitation in summer quarter • Influence of cold air flows for site-specific micro climate • Average wind speed

Urban heat tool - URBAHT

	Current climate conditions	**Future climate conditions**
Current spatial configuration	Current heat stress level	Heat stress level for future climate conditions
Changed spatial configuration	Heat stress level for changed spatial configuration	Heat stress level for changed spatial configuration and future climate conditions

URBAHT heat stress potential scores

Score	Heat stress level
0	Minimum
1	Very low
2	Low
3	Moderate
4	Medium
5	Slightly elevated
6	Moderately elevated
7	Strongly elevated
8	High
9	Very high
10	Maximum

Step 4: data collection

URBAHT scores

	Alternative 1 „traditional“			Alternative 2 „moderate“			Alternative 3 “max green & blue”		
Current climate	4.8			4.5			4.1		
	RCP 4.5 Min	**MV**	**RCP 8.5 Max**	**RCP 4.5 Min**	**MV**	**RCP 8.5 Max**	**RCP 4.5 Min**	**MV**	**RCP 8.5 Max**
Period 2021-2050	5.8	6	6.2	5.5	5.7	5.9	5	5.2	5.4
Period 2071-2100	6.6	7.5	8.4	6.3	7.2	8.1	5.8	6.7	7.6

Data matrix

Criteria	Alternative 1 „traditional“			Alternative 2 „moderate“			Alternative 3 “max green & blue”		
	Min	**MV**	Max	Min	**MV**	Max	Min	**MV**	Max
Heat stress potential (2021-2100) 1-10	6.20	**6.75**	7.30	5.90	**6.45**	7.00	5.40	**5.95**	6.50
present value costs (2021-2100) Mio EUR	4.0	**4.2**	4.3	4.0	**4.2**	4.4	4.0	**4.2**	4.4
Amenity value (2021-2100) 1-5	3.25	**3.4**	3.5	2.25	**2.5**	2.75	1.25	**1.5**	1.75
Architectural quality (2021-2100) 1-5	3.25	**3.6**	4	2.25	**2.6**	3	1.25	**1.6**	2

BASE stepwise approach

1st step

Preliminary Risk Assessment

Investigation of specific climate change related threat

2nd step

Identification of adaptation measures

if applicable bundling of measures

3rd step

Selection of evaluation method & criteria

if applicable weighting of criteria

4th step

Data collection

e.g. expert judgment, modelling, information transfer from similar projects

5th step

Evaluation & Prioritization

e.g. cost-benefit analysis, multi-criteria analysis

if necessary improvement of data used

if necessary adaptation of the criteria used

Gebhardt et al. 2013, Meyer et al. 2015

Step 5 Evaluation & Prioritisation

Apply the evaluation approach chosen for the ranking of options…

- CBA
- CEA
- MCA
- PBCA
- …

Evaluation software tools …

- CBA and/or MCA are supported by tools,
  e.g. Definite, D-Sight, SALDO, ADx, WEB-Hipre, PRIMATE …
- Analysis with the respective tool, presentation of the results and interpretation
- Documentation of uncertainties, sensitivity analysis

Example:

City of Jena,

heat stress reduction

Evaluation criteria & weighting

- **Heat stress potential** (2021-2050, 2021-2100)
- **Net present costs** (2021-2050, 2021-2100, discount rate 1.5%):
- **Amenity value** (2021-2050, 2021-2100, 5-point Likert scale)
- **Architectural quality** (2021-2050, 2021-2100, 5-point Likert scale)

Criteria	**Weights in %**	
	Urban Planner 1	Urban Planner 2
Heat stress potential	35	20
Costs	20	40
Amenity value	20	20
Architectural quality	25	20

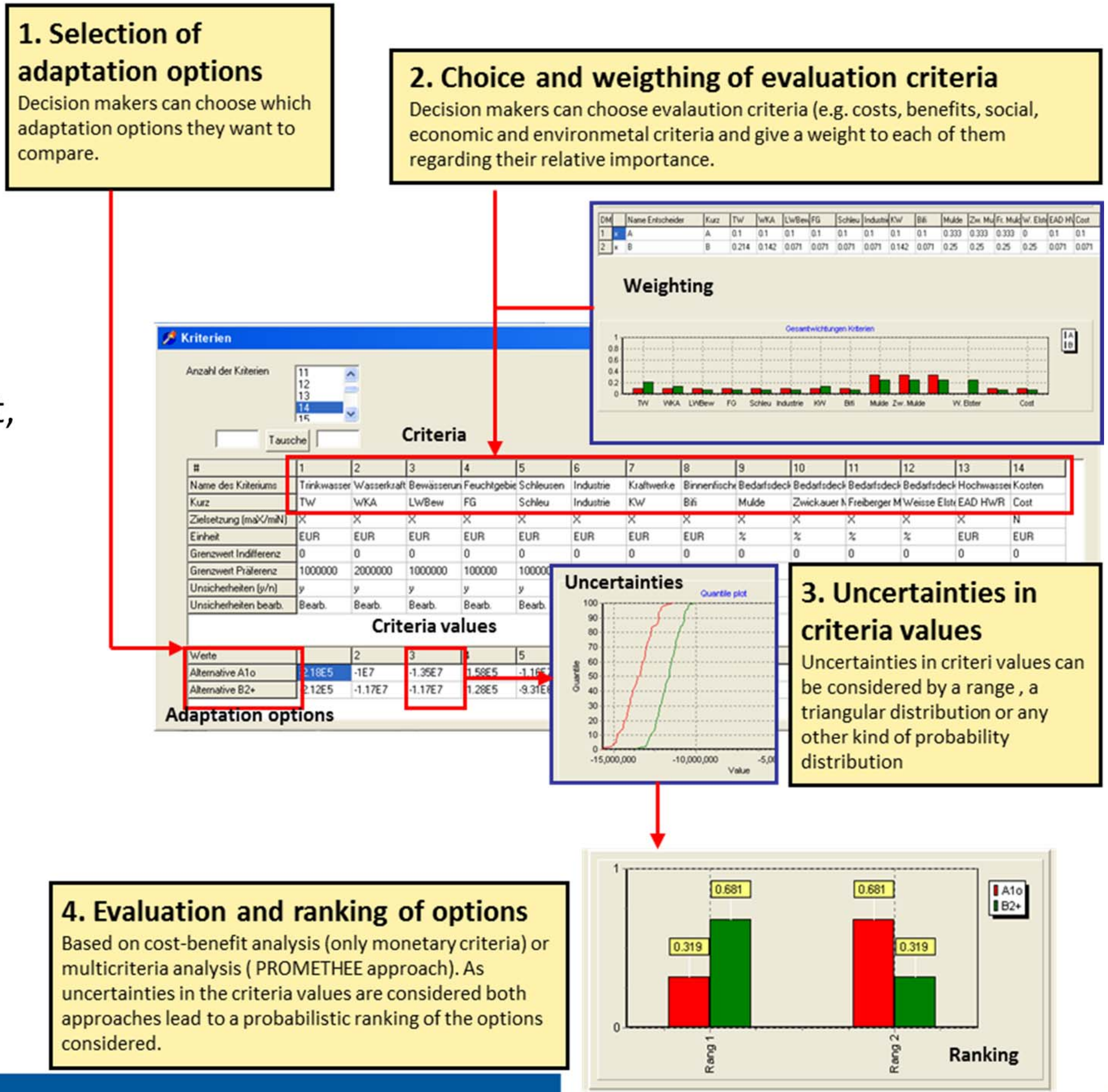
Data matrix

Criteria	Alternative 1 „traditional“			Alternative 2 „moderate“			Alternative 3 “max green & blue”		
	Min	**MV**	Max	Min	**MV**	Max	Min	**MV**	Max
Heat stress potential (2021-2100) 1-10	6.20	**6.75**	7.30	5.90	**6.45**	7.00	5.40	**5.95**	6.50
present value costs (2021-2100) Mio EUR	4.0	**4.2**	4.3	4.0	**4.2**	4.4	4.0	**4.2**	4.4
Amenity value (2021-2100) 1-5	3.25	**3.4**	3.5	2.25	**2.5**	2.75	1.25	**1.5**	1.75
Architectural quality (2021-2100) 1-5	3.25	**3.6**	4	2.25	**2.6**	3	1.25	**1.6**	2

PRIMATE tool

- **PRIMATE tool:**
  for cost-benefit analysis
  and multicriteria analysis
  under uncertainty

- Apllication e.g. for
  Water scarcity management,
  Heat stress,
  Climate change adaptation



Drechsler, Lange & Meyer 2009
Meyer et al. 2011
Gebhardt et al. 2013

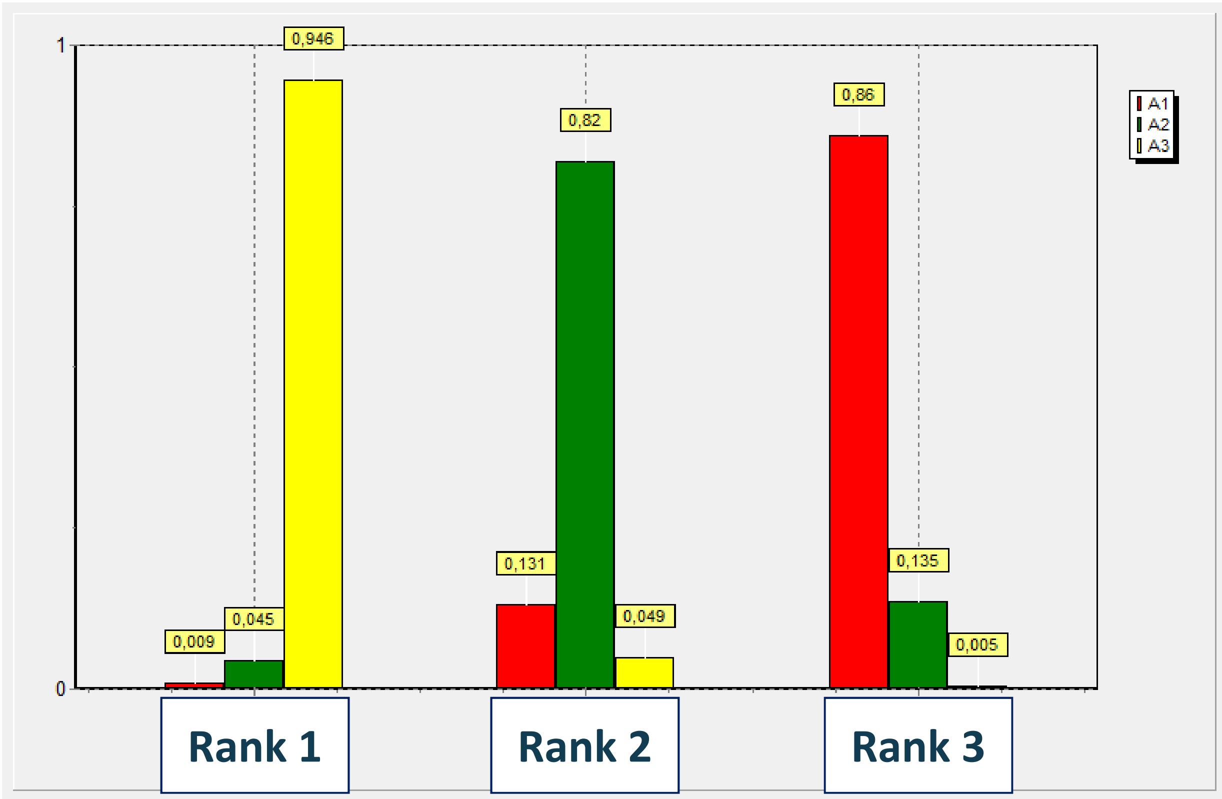


Fig: Overall ranking of the alternatives for the period 2021-2100

A1	**"Traditional"**
A2	**"Moderate"**
A3	**"Max Green & Blue"**

- In the long-term perspective the probabilities are 95% of **alternative 3 (max green & blue) ranking first**

Results MCA

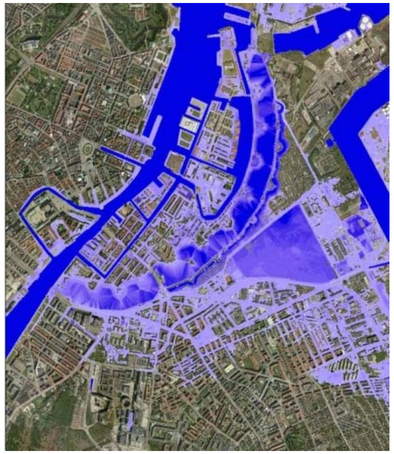
- **Light-coloured pavements, large-crowned trees:**
  - Very beneficial impacts on site-specific micro-climate
  - (Presumably) higher costs also pay-off with regard to rather aesthetic aspects
  - Costs (procurement, planting, replanting, care) of small-crowned trees higher than for large-crowned trees;
- **Artificial water courses:**
  - Limited impact on micro-climate, quite costly,
    overall value rather dependent on aesthetic preferences

BASE Results & Conclusions

Selected case studies´ evaluation results

Floods

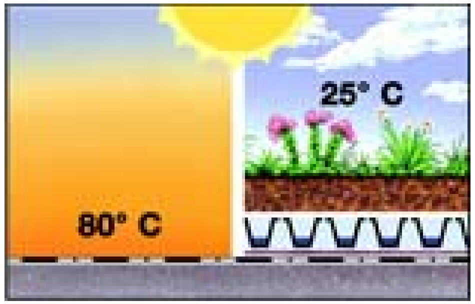
- In particular **in large cities** (but also in more rural areas),
  large structural flood risk mitigation measures seem to be highly efficient
  (Copenhagen, Leeds, Prague)
- But also **combinations of structural and non-structural measures** (room-for-the-river)
  turned out to be **cost-effective**
  (Rotterdam).
- **Including more intangible criteria**, (ecological, social criteria),
  results in **non-structural measures being ranked higher**
  (e.g. Kalajoki)
- **Private flood protection measures have proved**
  to be efficient in BASE case studies
  (South Devon, Venice).



Selected case studies´ evaluation results

Heat stress & Health

- **Land use-related measures have the potential to limit heat stress in cities** (Prague, Jena)
- **large trees** and **light-coloured pavements** for heat stress reduction prove to be very **beneficial** (Jena)
- **Heat & health warning system** is **efficient** and can be considered to be a **low regret measure** (Madrid)
- **Conflicting results** are derived **for green roofs** as an adaptation measure to reduce heat stress (positive in Jena, negative in Madrid)
- **Public health campaign** regarding UV exposure and related skin cancer risk turns out to be **highly efficient** (Cornwall)



Selected case studies´ evaluation results

Ecosystem Services

- In the Czech Green roof case study the "**Green strategy**", prioritising nature conservation, turns out to be **most efficient**

Water quality

- The Kalajoki water quality study showed that all **agro-environmental measures** analysed will become **more cost-effective in future climate** due to higher input load.
- But even the most cost-effective combination of measures would **struggle to achieve the target level of good ecological status in the future**.

Selected case studies´ evaluation results

Water Scarcity

- The participatory MCA in the Doñana case study elicited the **different values and preferences of different stakeholder groups**:
    - Farmers Association have preference for new water infrastructure and farming subsidies.
    - Environmentalists and administration actors supported the reduction of rice cultivated area

Selected case studies´ evaluation results

But…

- Although the process was **harmonized** as much as possible…
- …Case study results remain **to some degree incomparable**,
  due different site-specific context conditions
  (different risks addressed, different baseline protection, different project timeframes etc.).
- **simple transfer of results is not scientifically sound**,
  unless not only methods applied, but also all of the case-specific conditions are comparable.

Conclusions & key recommendations regarding evaluation process & applicability of evaluation methods

- When starting an economic evaluation of adaptation options **follow one of the various existing guidance documents**.
  - International: PROVIA, Europe: Climate Adapt, National Guidelines: UKCIP, Klimalotse, …
  - BASE-guidance focuses particularly on economic evaluation on the local level
- There are **already many impact assessment tools…**
  (particular for flood risk assessments, but also for heat stress, ecosystem services, water availability and water quality)
- It is **often better to rely on existing models** (and buy them in)
  than to try to generate own models and/or data.
  But: transferability of models is sometimes also limited.

Conclusions & key recommendations regarding evaluation process & applicability of evaluation methods

The **choice of an appropriate evaluation method** largely depends on several factors (see also PROVIA 2013):

Factor		
Objective	**Pre-feasibility study**	**Investment decision**
	Simple CEA, CBA or MCA	Comprehensive CBA, participatory MCA, RDM
Investment costs	**low**	**high**
	Simple CEA, CBA or MCA	Comprehensive CBA, participatory MCA, RDM
Uncertainties	**low**	**high**
	Simple CEA, CBA or MCA	CBA or MCA with Monte-Carlo simulation, RDM, ROA, DAP, Heuristics
Number of evaluation criteria	**low**	**high**
	CEA, partial CBA	Comprehensive CBA, MCA
Data availability	**low**	**high**
	MCA	CBA, RDM

Conclusions & key recommendations regarding evaluation process & applicability of evaluation methods

- No matter how sophisticated models are,
  there are always uncertainties inherent in the results
  due to: climate and socio-economic change,
  input data, models, or stakeholder preferences).
  - Uncertainties should be **considered in the evaluation process**
  - Uncertainties should be **made transparent** in the results.

- **use of participatory methods** is important when dealing with uncertainty, with complexity, with growing demand for transparency in public decision-making processes

BASE Report: „Economic evaluation of adaptation options”
http://base-adaptation.eu/sites/default/files/Deliverable_5_2.pdf

For an overview of damage assessment methods
for different natural hazards see:
www.conhaz.org

Second part:
Working groups

Working groups

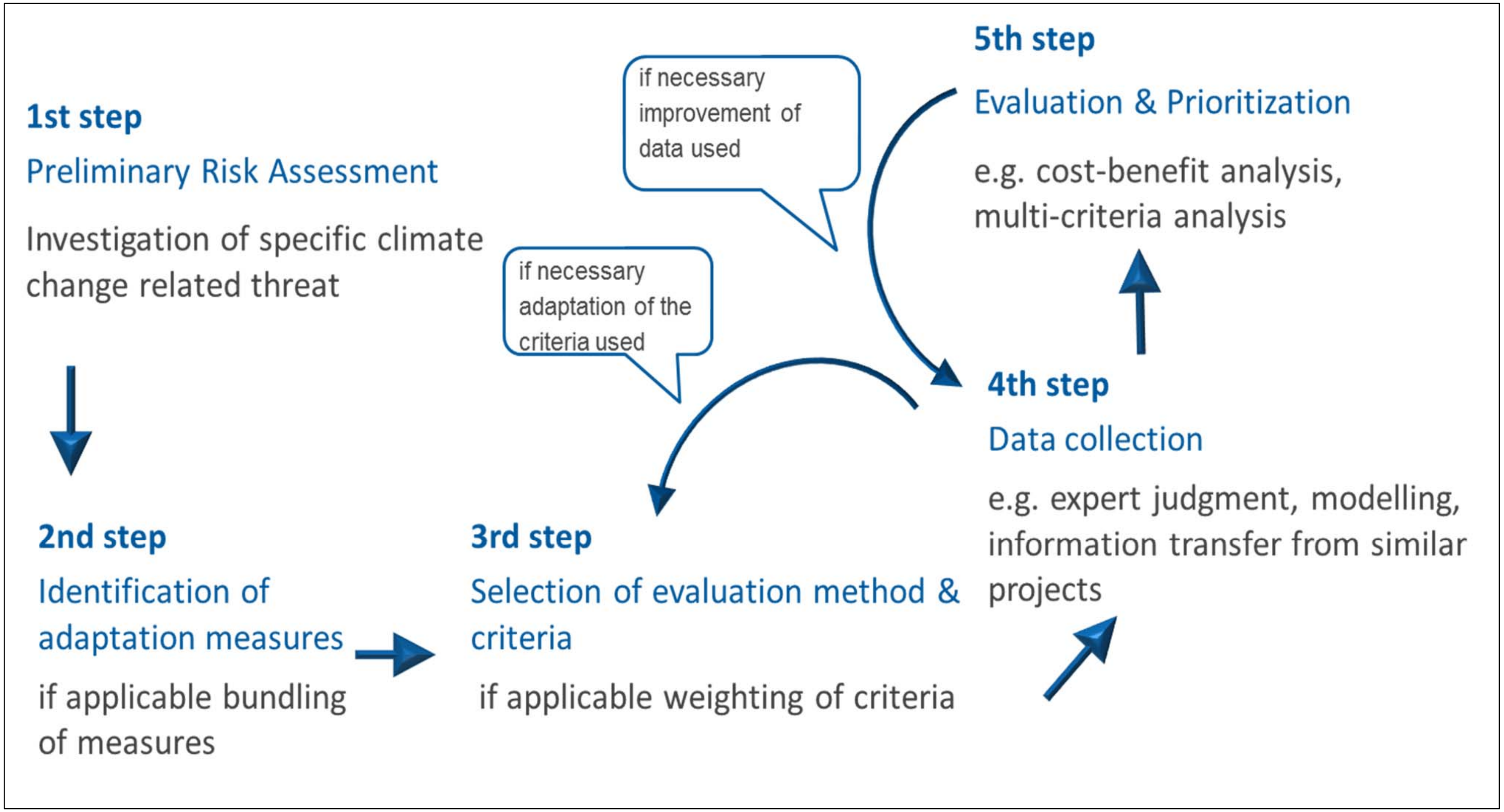
16:45 – 17:40 group work

- **Share experience**
  (participants with experience describe how it is done in their case study (or country): steps, methods, tools, data used…
- **Identify a real or hypothetical case study** from your group
  (ideally one where econ. evaluation would be needed,
  but only little experience on that so far)
- **Develop a concept how the economic evaluation should be performed for this case study** (go through the 5 steps of the BASE guideline (or any other sequence you prefer)
- **Illustrate your concept on a white board**
- Identify 1or 2 presenters

17:45 Presentation & discussion of the group work

- **presentation of the group work** (max 5 minutes + questions & feedback)
- overall questions, discussion & feedback

BASE stepwise approach



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BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES FOR EUROPE

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

SEVENTH FRAMEWORK PROGRAMME

2nd Example:

Czech „Green Roof" (Sumava National Park)

CBA of Management options

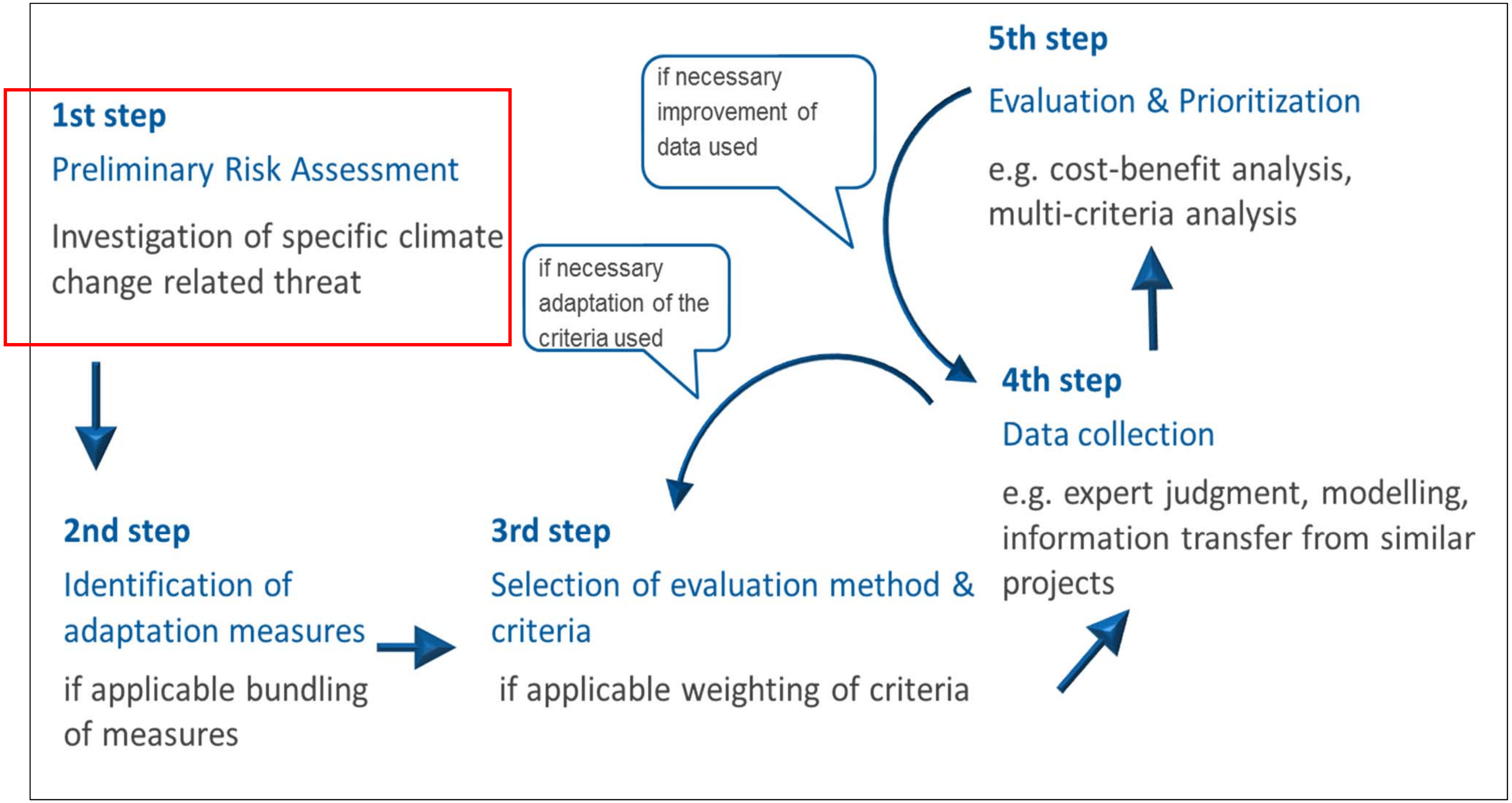
Case study performed by:

Zuzana Harmáčková, Eliška Lorencová, David Vačkář, Blanka Loučková

CzechGlobe

BASE stepwise approach: Czech "Green roof" (Sumava National Park)

Zuzana Harmáčková, Eliška Lorencová, David Vačkář, Blanka Loučková, CzechGlobe



Gebhardt et al. 2013, Meyer et al. 2015

Risk assessment

- Czech National park. Sumava
- Risk of ecosystem degradation due to higher temperatures, windstorms, beetle outbrakes, etc.
- RCP 4.5 and 8.5
- ALARM scenarios for land use change

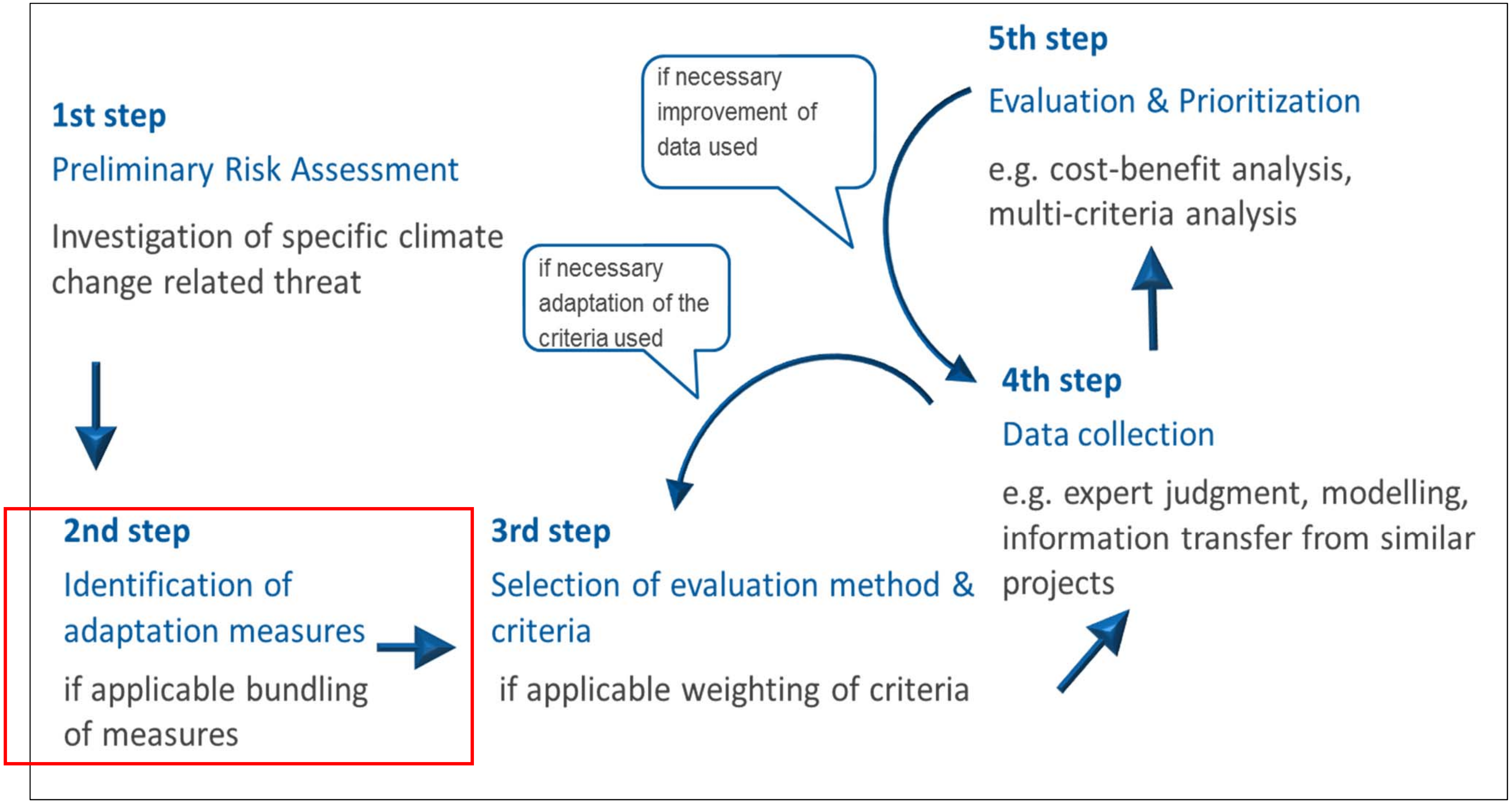
BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES FOR EUROPE

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

SEVENTH FRAMEWORK PROGRAMME

BASE stepwise approach: Czech "Green roof" (Sumava National Park)

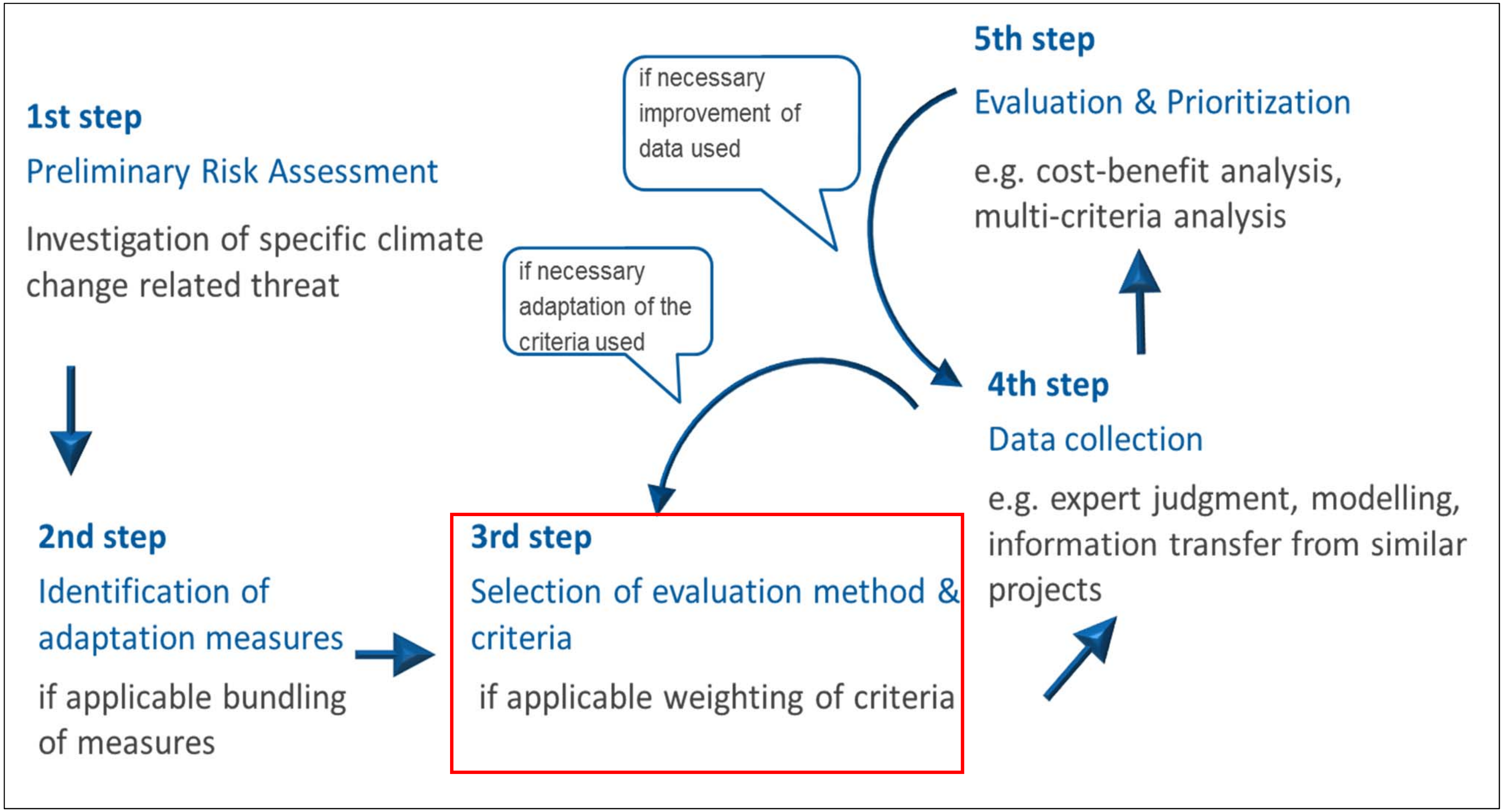
Zuzana Harmáčková, Eliška Lorencová, David Vačkář, Blanka Loučková, CzechGlobe



2. Adaptation options

- Mainly ecosystem-based adaptation measures:
  - Sustainable forest management
  - Peat land and water course restoration
  - Enhancement of ecosystem protection, i.e. an enlargement of nature conservation zones
- Bundling of adaptation measures for 3 strategies
  - Green scenario:
    Prioritising nature conservation
  - Red scenario:
    Prioritising economic development
  - Shared vision scenario:
    Sustainable economic development, Maintaining level of nature conservation, Focus on small-scale businesses and local production
  - Baseline: Business-as-usual

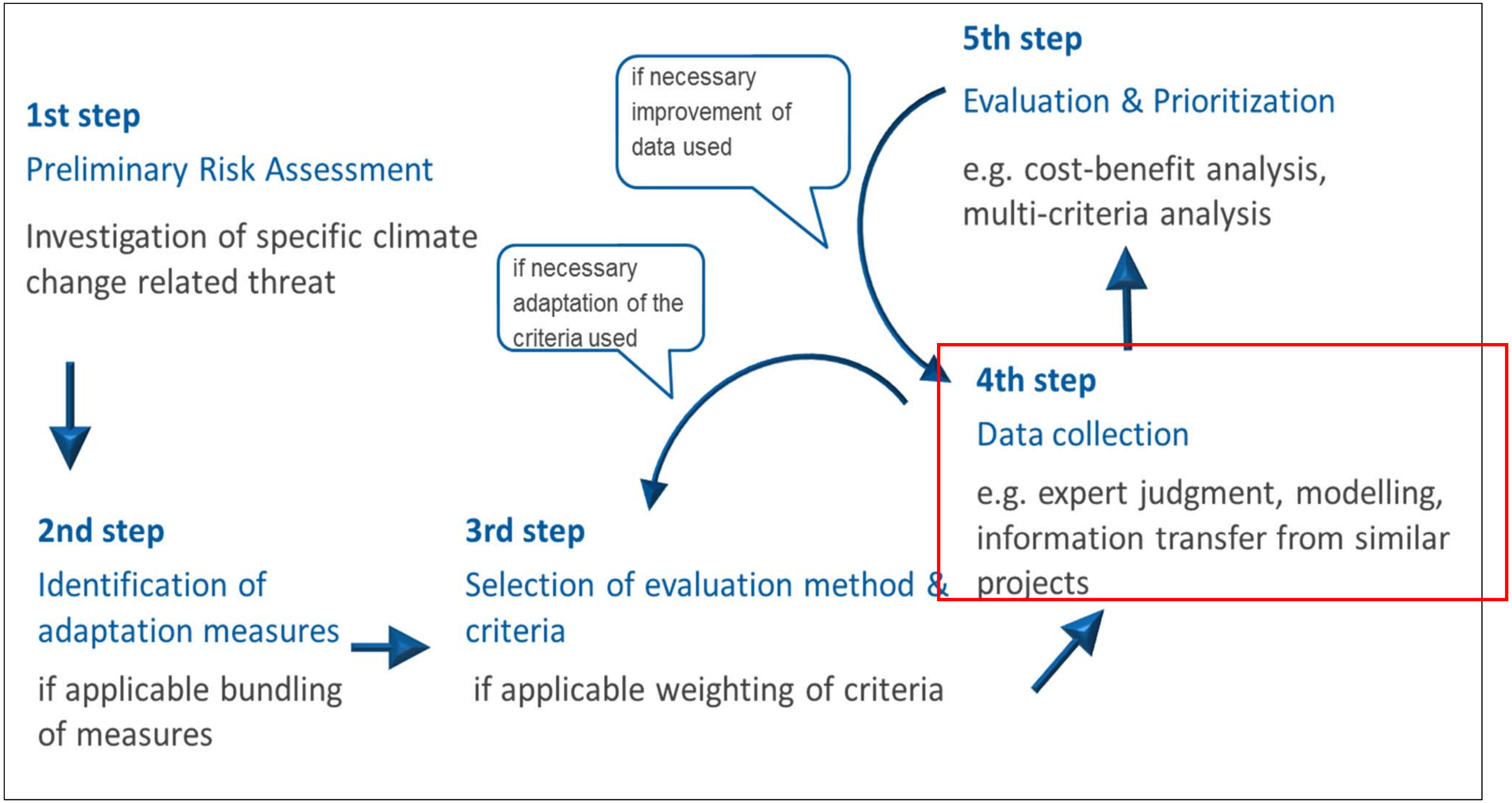
BASE stepwise approach: Czech “Green roof”



3. Evaluation criteria & method

- Costs:
  - Investment costs (peat-land restoration)
  - Maintenance and operation costs (sustainable forest management)
  - Investment cost of infrastructure (paths for tourists and foresters, tourist information facilities, etc.)
  - Costs influenced by the provision of ecosystem services (sediment dredging, nitrogen removal)
- Benefits:
  - Resulting from the provision of ecosystem services, i.e. carbon sequestration, hydropower production
  - Resulting from the implementation of adaptation measures, i.e. timber sales, sales of services related to hunting
- Method: CBA

BASE stepwise approach: Czech “Green roof”



4. Data collection

- Land use and land cover change:

  European ALARM scenarios & locally-specific trends defined by stakeholders

- Bundles of land use-based adaptation measures:

  Participatory development by stakeholders for each scenario

- Climate data (levels of precipitation, evapotranspiration):

  CORDEX simulations, RCP4.5, RCP8.5

4. Data collection

Costs related to ecosystem services:

Artificial water purification by Sediment retention - Data sources:

- Ecosystem-service modelling with InVEST tools
- Economic value based on costs of nitrogen removal from water run-off, calculated in a Central European study by Rybanič et al. (1999)
- Economic value based on sediment dredging costs, derived from the database of public procurements administered by the Ministry of Regional Development of the Czech Republic

Nitrogen retention - Data sources:

- Ecosystem-service modelling with InVEST tools
- Economic value based on costs of nitrogen removal from water run-off, calculated in a Central European study by Rybanič et al. (1999)

Costs of the implementation of ecosystem-based adaptation measures

Inland marshes and peat bogs restoration

Forest management, operation costs

Maintenance of touristic paths

4. Data collection

Benefits related to ecosystem services:

Hydropower production

- Data sources: Ecosystem-service modelling with InVEST tools, defined as the amount of hydropower generated owing to a water yield provided by adjacent ecosystems.
- Economic value based on the average subsidy for hydropower production specified by the Energy Regulatory Office of the Czech Republic.

Carbon sequestration

- Data sources: Ecosystem-service modelling with InVEST tools. Economic value based on social value of carbon, calculated for the Czech Republic in a study by Hönigová et al. (2012)

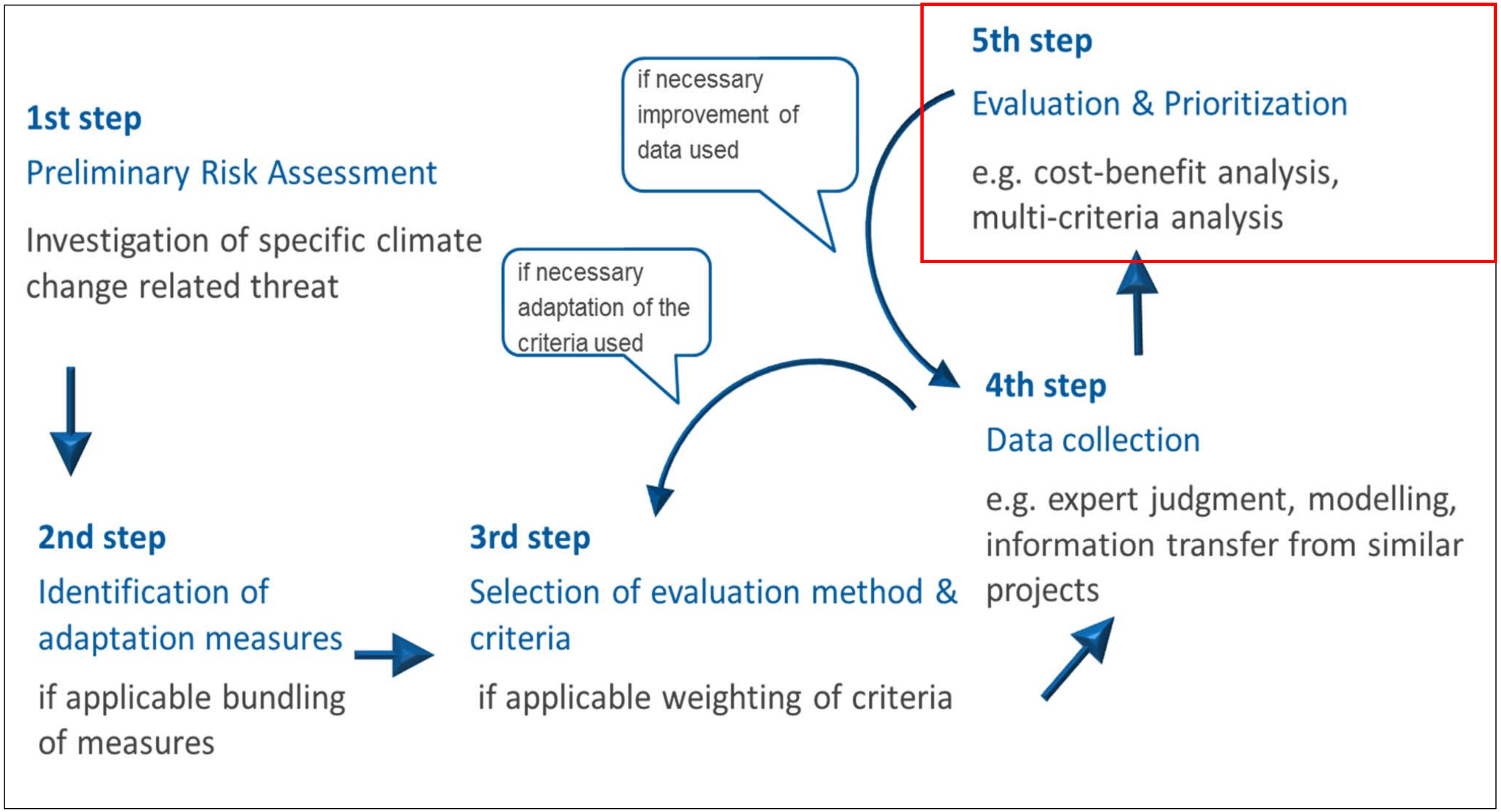
Benefits of the implementation of ecosystem-based adaptation measures

Timber sales

Sales of services related to hunting

BASE stepwise approach: Czech “Green roof”

Zuzana Harmáčková, Eliška Lorencová, David Vačkář, Blanka Loučková, CzechGlobe



Gebhardt et al. 2013, Meyer et al. 2015

				Scenario							
				RCP4.5				RCP8.5			
				BaU	Green scenario	Shared Vision	Red scenario	BaU	Green scenario	Shared vision	Red scenario
Costs	Costs related to ecosystem services	Sediment dredging	mean	2,929,467	2,198,942	2,950,440	3,017,797	2,929,467	2,198,942	2,950,440	3,017,797
			min	1,611,024	1,209,280	1,622,558	1,659,599	1,611,024	1,209,280	1,622,558	1,659,599
			max	6,045,174	4,537,680	6,088,454	6,227,449	6,045,174	4,537,680	6,088,454	6,227,449
		Nitrogen retention		908,170	808,004	922,164	973,388	908,170	808,098	922,339	973,610
	Annual management costs	Inland marshes and peat bogs restoration	mean	83,428	121,125	83,428	0	83,428	121,125	83,428	0
			min	36,757	53,366	36,757	0	36,757	53,366	36,757	0
			max	338,224	491,056	338,224	0	338,224	491,056	338,224	0
		Forest management , operation costs	mean	21,623,473	11,312,768	19,779,485	24,765,350	21,623,473	11,312,768	19,779,485	24,765,350
			min	11,514,931	6,024,275	10,532,971	13,188,044	11,514,931	6,024,275	10,532,971	13,188,044
			max	33,687,688	17,624,413	30,814,899	38,582,489	33,687,688	17,624,413	30,814,899	38,582,489
		Infrastructure	mean	14,831,696	7,759,510	13,566,892	16,986,733	14,831,696	7,759,510	13,566,892	16,986,733
			min	6,115,169	3,199,277	5,593,685	7,003,699	6,115,169	3,199,277	5,593,685	7,003,699
			max	23,334,180	12,207,760	21,344,308	26,724,622	23,334,180	12,207,760	21,344,308	26,724,622
	Sum		mean	40,376,234	22,200,349	37,302,409	45,743,269	40,376,234	22,200,443	37,302,584	45,743,490
			min	20,186,051	11,294,203	18,708,135	22,824,731	20,186,051	11,294,297	18,708,309	22,824,952
			max	64,313,437	35,668,913	59,508,049	72,507,948	64,313,437	35,669,007	59,508,224	72,508,170
	Sum of costs compared to baseline (BaU)		mean	0	-18,175,885	-3,073,825	5,367,034	0	-18,175,791	-3,073,650	5,367,256
			min	0	-8,891,848	-1,477,916	2,638,680	0	-8,891,754	-1,477,742	2,638,901
			max	0	-28,644,524	-4,805,387	8,194,512	0	-28,644,430	-4,805,213	8,194,733
Benefits	Benefits related to ecosystem services	Hydropower production	mean	222,694,639	240,161,096	240,614,386	241,806,653	222,694,639	235,866,462	236,348,595	237,635,915
			min	164,958,992	177,897,108	178,232,878	179,116,039	164,958,992	174,715,898	175,073,034	176,026,604
			max	274,931,653	296,495,180	297,054,797	298,526,732	274,931,653	291,193,163	291,788,389	293,377,673
		Carbon sequestration		0	66,758,122	2,484,392	-57,227,934	0	66,758,122	2,484,392	-57,227,934
	Annual market benefits	Timber sales	mean	81,740,906	42,764,450	74,770,277	93,617,811	81,740,906	42,764,450	74,770,277	93,617,811
			min	71,843,595	37,586,466	65,716,979	82,282,426	71,843,595	37,586,466	65,716,979	82,282,426
			max	91,330,452	47,781,420	83,542,054	104,600,712	91,330,452	47,781,420	83,542,054	104,600,712
		Sales of services related to hunting	mean	671,032	351,064	613,808	768,532	671,032	351,064	613,808	768,532
			min	580,961	303,942	531,418	665,374	580,961	303,942	531,418	665,374
			max	735,439	384,760	672,723	842,298	735,439	384,760	672,723	842,298
	Sum		mean	305,106,576	350,034,731	318,482,862	278,965,062	305,106,576	345,740,098	314,217,072	274,794,324
			min	237,383,547	282,545,638	246,965,667	204,835,905	237,383,547	279,364,427	243,805,823	201,746,469
			max	366,997,544	411,419,482	383,753,965	346,741,808	366,997,544	406,117,465	378,487,557	341,592,748
	Sum of benefits compared to baseline (BaU)		mean	0	44,928,155	13,376,286	-26,141,515	0	40,633,522	9,110,495	-30,312,253
			min	0	45,162,091	9,582,121	-32,547,642	0	41,980,881	6,422,276	-35,637,078
			max	0	44,421,938	16,756,422	-20,255,736	0	39,119,921	11,490,014	-25,404,795
Benefits - Costs			mean	264,730,342	327,834,382	281,180,453	233,221,793	264,730,342	323,539,655	276,914,488	229,050,834
			min	217,197,496	271,251,434	228,257,533	182,011,174	217,197,496	268,070,130	225,097,514	178,921,517
			max	302,684,107	375,750,569	324,245,916	274,233,859	302,684,107	370,448,458	318,979,334	269,084,579
NPV (Difference to BaU), i.e. $NPV_{scenario} - NPV_{BaU}$			mean	0	63,104,040	16,450,110	-31,508,549	0	58,809,313	12,184,146	-35,679,508
			min	0	54,053,938	11,060,037	-35,186,322	0	50,872,634	7,900,018	-38,275,979
			max	0	73,066,462	21,561,809	-28,450,247	0	67,764,351	16,295,227	-33,599,528

Results in brief

5% discount rate		Scenario					
		RCP4.5			RCP8.5		
		Green scenario	Shared Vision	Red scenario	Green scenario	Shared vision	Red scenario
NPV (Difference to BaU), i.e. $NPV_{scenario} - NPV_{BaU}$	mean	63,104,040	16,450,110	-31,508,549	58,809,313	12,184,146	-35,679,508

- Green scenario most efficient
- Sensitivity:
  - Ranking the same for different RCPs,
  - Min-Max input data
  - 1% and 5% discount rate