CzechGlobe

Subgroup:

InVEST subgroup

Biodiversity and ecosystem services

Case-study: **Green Roof**

(CzechGlobe, Czech Republic)

02/12/2014

Case study developed by:

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Purpose of this document:

"The Case Studies Living Document (CSLD) will be the document that each case study leader will use to share the information that (i) characterize and give context to its case study, (ii) the goals within BASE, (iii) the methods used and mainly (iv) a synthesis of the results that that case study is providing to BASE project. This will allow the CS leader to understand how its own case is going (having a good overview), but also (v) will allow the sub-group to which the case study belong to know what is happening and what can be done (mainly on synergies and so on) as well as to (vi) WP4 & 5 coordinators to use that information to report (including each WP task leaders). These living document will also (vii) allow WP6 & 7 partner to know the information."

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1. General Case Study Description

a) Location

GPS: N 49°6′ N / 13°8′ E
Area: National Park Šumava 680.64 km^2,
Protected landscape area 996.24 km^2

b) Case Study Summary

Green roof case study is focusing on ecosystem services and biodiversity in a Central-European mountainous forested range Šumava (Black Forest, Bohemian Forest). The area is one of the most extensive forest landscapes in central Europe located in the southern part of the Czech Republic. Furthermore, it is one of the major European watersheds and is important with regard to nature conservation (National Park and Protected Landscape Area), forest and water management and pest management (bark beetle infestations). Peat mires and mountainous meadows are also protected in the Šumava region. The area of National Park Šumava is 68,064 ha; protected landscape area has 99,624 ha. Together with the neighbouring Bavarian Forest National Park in southeast Germany, the Šumava National Park covers one of the largest forest areas in central Europe, also called the Green Roof.

One of the main aims of the “Green Roof” case study is to propose several adaptation scenarios for Šumava National Park and evaluate their impact on local ecosystem service provision. Since potential ecosystem-based adaptation measures in the study area will encompass land-use/land-cover (LULC) changes, it is vital to assess the actual impact of these measures on the future levels of ecosystem services. To achieve this objective within the “Green Roof“ case study, the InVEST modelling tools (Integrated Valuation of Ecosystem Services and Tradeoffs) will be utilized.

c) Context

The Šumava National Park (NP) was established in 1991 owing to its unique natural assets and high conservation importance. Its status has been recognized by IUCN (category II – National Park) and reflected in several international conventions, e.g. Ramsar convention designating the most valuable peat bogs as wetlands of international importance. The Šumava NP is also a part of the Natura 2000 network.

Since the establishment of the NP, the concept of the area's management has been repeatedly changing, which resulted in e.g. several substantial changes in zonation and conservation approaches. The management of the national park is a subject of several conflicts, especially between the administration of national park, environmental green groups, scientists and local interest groups, including representatives of municipalities and businesses. Currently, the legislation designing the national park is being revisited.

The Šumava NP presents a very complex area, with contrasting interests of a high number of involved stakeholders. Generally, various stakeholder groups fail to reach an agreement on the desirability of different conservation approaches. Therefore, the attempts to find a shared future vision of this valuable area have failed so far. An example is a recent study by EFTEC on An outline of economic impacts of management options for Šumava national park, which has been promoted by science community but dismissed by the NP administration.

Local communities, local political representatives and other stakeholders have been involved in numerous discussions and media interest in the past two decades. Since they tend to favour rather non-protectionist attitudes (Gorner et al., 2012), the involvement of scientists and researchers in the area has been perceived as unwelcome.

d) Brief General Information on Climate CHANGE and related issues

Current climate of the Šumava NP

Temperatures

The temperature gradient in the Šumava Mountains is changing primarily with the altitude (600–1378 m a.s.l.). The average local temperature is approximately 6 °C at 750 m a.s.l. and 3 °C at 1300 m a.s.l. However, the temperature in terrain depressions and mountain valleys is noticeably lower than on mountain ridges and tops due to temperature inversion. The coldest and warmest months are usually January and July, respectively. The periods with average temperatures below zero start in the beginning of November (end of October) in the highest altitudes and end at the end of March (beginning of April).

Precipitation and water

Cumulative annual precipitation grows with increasing altitude. The average annual precipitation ranges between 800-1600 mm. The highest precipitation is present in the central part of the Šumava (1486-1552 as a 30-year average) and differs significantly on the windward and leeward side of the mountain range.

Local vegetation is influenced by the duration and magnitude of snow cover, which is mainly influenced by altitude and relief. A continuous snow cover lasts for 120-150 days in the highest altitudes. Potential risk of avalanches is present only in glacier cirque walls. The average atmospheric humidity is approximately 80%.

Extreme weather events

In terms of extreme weather episodes, the Šumava NP has suffered most from windstorms, particularly in 2007 (Kyrill) and 2011. These storms have resulted in large losses of forest cover in the Šumava Mountains, with subsequent outbreaks of bark beetle.

Climate projections for the Šumava NP

At present, no local projections of climate change and its impacts on the ecosystems of the Šumava Mountains have been conducted. However, it is possible to derive some information from national-wide assessments and local research studies.

Temperature

Air temperature in the Czech Republic is gradually increasing, with the approximate speed of increase in average annual temperatures over the past 50 years approximately 0.3 ° C/10 years. The most significant trend of increasing temperature has been observed in summer months, the smallest in the period from September to November (EEA, 2010).

The short-term estimate (midpoint in 2030) shows that the average annual air temperature in the Czech Republic will increase, according to the ALADIN-CLIMATE/CZ model, approximately by 1 °C. In medium-term timeframe (midpoint in 2050), the simulated warming becomes more significant. Temperature will rise the most in the summer (by 2.7 °C) and to a lower extent in the winter (by 1.8 °C) (ME, 2013).

Precipitation and water

Average annual and monthly precipitation has not had a statistically significant trend since the 1960s. However, some changes in the temporal and spatial distribution of precipitation have been observed. Spatially specific heavy rains, floods and droughts are getting more frequent, which relates to the overall increase of the climate extremity (EEA, 2010).

In the future, a decrease in average flow rates of 15–40 % is expected in many Czech river basins, which might lead to substantial changes in the overall hydrological regime. In the Šumava watersheds, the expected decrease in runoff is approximately 20 % (Hanel et al., 2012), mainly due to increased evapotranspiration, caused by higher temperatures.

Higher winter temperatures are supposed to reduce snowpack and increase evaporation, leading to shifts in annual water outflows. On the other hand, both winter runoff and subsequent risk of spring floods is expected to increase, since water storage in the form of snowpack will be reduced. The period of snow melting is likely to shift from early spring to late winter months (Hanel et al., 2012).

A substantial decrease in summer precipitation is projected; however, intensive precipitation events occurring during summer thunderstorms may result in a greater risk of flash floods at the same time (OECD, 2013; Hanel et al., 2012).

Extreme weather events

Although the occurrence of hot days (maximum temperature over 30 °C) is projected to rise from 5.4 days per year in average for the period 1961–2000 to 28 days per year in the period 2071–2100, e.g. and average increase by 2 hot days per 10 years, the change in the Šumava region is likely to be lower than the country average.

On the contrary, the number of frost days (minimum temperature goes below 0°C) is projected to decrease in the whole period 1961–2100 by 4.4 days per 10 years. The number of ice days (maximum temperature stays below 0°C) is projected to decrease by 2 days per 10 years (Štěpánek et al., 2011).

Other expected extreme weather events are spring flood episodes (see above) and higher occurrence of windstorms (Beniston et al., 2007).

Link to other ecosystem change drivers

The Šumava NP has been impacted by acid deposition and bark beetle calamites which lead to deterioration of more than 50% of forest canopy. These drivers exacerbate the impact of climate change on the Norway spruce (*Picea abies*) forests of the Šumava NP, which become substantially vulnerable towards future climate changes (Hlásny et al., 2012). Therefore, the regeneration of forest in the light of climate change is important aspect of cultural ecosystem services (e.g. recreation and aesthetic perception of ecosystems).

Another important effect of climate change influencing the Šumava Mountains is potential spread of allochtonous and invasive species, affecting locally specific species composition.

The provision of ecosystem services in Šumava is highly dependent on its land use and land cover (LULC). However, Šumava has been undergoing a considerable LULC change recently and conflicts about the desirable proportion of various LULC types have arisen, with recreational landscape being growingly pronounced at the expense of forested area. This trend further enhances the effects of climate change and natural disturbances, e.g. bark beetle outbreaks or windstorms. Therefore, the assessment of changes in ecosystem service levels, caused by developing LULC, is of increasing interest from both the scientific and governmental point of view. The present case study brings an opportunity to utilize various models (e.g. InVEST) to evaluate based on the adaptation scenarios the levels ecosystem services in the study area, with an emphasis on regulating and provisioning services, such as carbon sequestration, nutrient retention, sediment retention and timber production. The results will contribute to the current debate and will bring valuable knowledge from the ecosystem perspective.

e) Existing Information on Case Study's adaptation history

As this case study is prospective, it does not have any long adaptation history. At the national level, national adaptation strategy has not been approved yet and discussion regarding climate change adaptation is only slowly emerging. The study area does not have a regional adaptation strategy.

f) Connection with other research projects:

Numerous research projects focused on plant and animal ecology and forest management have been conducted in the study area of the Šumava NP. However, none of these projects has directly addressed the impact of climate change on the ecosystems and society of the Šumava Mountains or potential adaptation to climate change in this area.

g) Case ID, Typologies and Dimensions

Having in mind the following BASE Objectives; Categories of Case Studies, please fill in the following table.

BASE OBJECTIVES
1. Compile and analyse data and information on adaptation measures, their effectiveness. (...)
2. Improve current, develop new and integrate methods and tools to assess climate impacts, vulnerability, risks and adaptation policies (...).
3. Identify conflicts and synergies of adaptation policies at different levels of policy making with other policies (including climate mitigation) within and between sectors. (...)
4. Assess the effectiveness and full costs and benefits of adaptation strategies to be undertaken at local, regional, and national scales using innovative approaches (mainly by integrating bottom-up knowledge/assessment and top-down dynamics/processes) with particular attention on sectors of high social and economic importance.
5. Bridge the gap between specific assessments of adaptation measures and top-down implementation of comprehensive and integrated strategies.
6. Use and develop novel participatory and deliberative tools to enhance the effective use of local contextualized knowledge in adaptation strategies to assess perceptions of adaptation pathways and their co-design by citizens and stakeholders.
7. Disseminate findings by sharing the results of the project with policy-makers, practitioners and other stakeholders. (...)

CASE STUDIES CATEGORIES	
A.	Public administration (municipality, regional, national, European)
B.	Research and education Centres (universities, research centres, projects and groups, schools)
C.	Public companies
D.	Companies (farms, SMEs, big businesses)
E.	Social enterprises (cooperatives, non-profit companies, woofing farms, etc.)
F.	Consortiums (partnerships, campaigns),
G.	NGOs (environmental NGO, local development NGO, charities, etc.)
H.	Transition Initiative
I.	Ecovillage
J.	Informal groups, Movements

Case ID			Typologies and characterization				
Country & Name of CS	BASE Objectives to be answered by the CS	Category of case study	Territorial zones	Scale	Process Direction	Temporal Definition	Timescale[1]

[1] Please insert year of start and year of end of case study.

	[x] Objective 1 [ ] Objective 2 [x] Objective 3 [ ] Objective 4 [x] Objective 5 [x] Objective 6 [x] Objective 7	[A] Public administration	[x] Rural [ ] Urban [ ] Coastal [ ] River Basin	[x] Local [ ] Regional [ ] National [ ] Transnational [ ] European /Global	[x] Bottom-Up [x] Top-Down	[ ] Retrospective [x] Prospective	2013 – 2016

h) Impacts, Sectors and Implementation

Please tick the relevant boxes for impacts and implementation and insert the number 1 for primary sector and the number 2 for secondary sector.

Impacts		Sectors		Implementation	
Primary CC Impacts (Climate-Adapt)	Primary CC Impacts (BASE)	Primary and Secondary Sector (Climate Adapt)	Primary and secondary Sector (BASE)	Implemented[2]	Phase of Implementation[2]
[x] Extreme Temperatures [ ] Water Scarcity [ ] Flooding [ ] Sea level Rise [ ] Droughts [x] Storms [ ] Ice and Snow	[ ] Extreme temperatures [x] Water scarcity [ ] Flooding [ ] Coastal Erosion [x] Droughts [ ] Soil Erosion [ ] Vector Borne Diseases [x] Damages from extreme weather related events (storms, ice and snow)	[x] Agriculture and forest (2) [x] Biodiversity (1) [ ] Coastal Areas [ ] Disaster risk reduction [ ] Financial [ ] Health [ ] Infrastructure [ ] Marine and Fisheries [ ] Water Management [ ] Urban	[ ] Agriculture [x] Biodiversity & Ecosystems [ ] Coastal and Marine systems [ ] Energy [ ] Health and Social Policies [ ] Transport [ ] Production Systems and Physical Infrastructures [ ] Water resources [x] Tourism	[ ] Yes [ ] Ongoing [x] No	[x] Assessment [x] Planning [ ] Implementation [ ] Monitoring [ ] Evaluation

i) Importance and Relevance of Adaptation

Please tick the relevant box for the case study.

[ ] Case developed and implemented as a climate change adaptation measure

[ ] Case developed and implemented and partially funded as a climate change adaptation measure

[x] Case mainly developed and implemented because of other policy objectives, but with significant consideration on climate change adaptation aspects

[2] When the case study consists of a public administration with a top down approach, implementation can be an approved legislation or regulation. When the case study is about practical adaptation measures like a sand dune, for example, implementation should be considered finished when the dune is built in situ.

2. Case study research Methodology

a) Research Goals

Research objective:

To analyse the potential climate change impact on biodiversity and ecosystem services sector (together with tourism and forestry sector), with the aim to propose integrated adaptation measures that would support climate change adaptation in the region from ecosystem services perspective. The main aim is to analyse current adaptation action, assess potential future impacts, propose adaptation measures and analyse their feasibility. Engagement with local stakeholders and participatory development of adaptive scenarios is integral part of this research.

Main research questions:

a) Analysis of current status of the study area Šumava of the current adaptation measures and potential future climate change impacts:

- What current adaptation measures are employed in Šumava? Was the primary motivation of their adoption climate change impacts?
- How is climate change adaptation represented in local sectors (e.g. tourism, forestry) and strategic documents?
- What are the potential climate change impacts with regard to ecological and socio-economic indicators?

b) Specification of adaptation measures (short-, medium-, long-term) with respect to expected climate change impacts based on scenario workshop.

- What adaptation measures are proposed by relevant stakeholders? What scenarios and adaptation measures are not well accepted by the stakeholders?

c) Assessment of proposed adaptation measures and actions costs and benefits (choice of appropriate method?)

- What is the impact of proposed adaptation measures on biodiversity and ecosystem services?

d) Analysis of proposed adaptation measures and actions implementation potential, barriers and opportunities.

What are the barriers and opportunities of proposed adaptation measures?

b) Stakeholders involved

At present, there is not any adaptation process or activity led by local stakeholders or local policy makers. The Green Roof case study therefore serves as the initial step in a potential future adaptation process, aiming at proposing feasible adaptation measures and analysing their impact on the provision of ecosystem services. The only stakeholders involved in this case study are those participating in the scenario workshops organized by CzechGlobe.

Stakeholders involved in scenario workshops:

The stakeholders involved in the scenario workshops within this case study include all relevant sectors and interest groups, which may influence the prospective adaptation process in the region.

Sector	Institution/Agency
Local authorities	Mayors of the municipalities in the South Bohemian Region
Conservation	The Administration of the National Park and Protected Landscape Area of Šumava

Regional development	Regional Development Agency of the Šumava Region
Science/Research	The University of South Bohemia in České Budějovice
Energy	Local energy production agency
Water management authorities	The Vltava Catchment
Agriculture	Local private agricultural enterprises
Tourism/Recreation	Local guides/private touristic enterprises

Scenario workshop

The first session of the scenario workshop took place in July 2014. Following the initial contact with stakeholders and first discussions, the most relevant stakeholders were invited to a group session where potential impacts of climate change were presented and various adaptation options introduced (both based on previous review). The participants were then encouraged to discuss different adaptation options and to choose the most favourable scenario from their specific point of view. After eliciting this information, the scenarios were finalized and will serve as the basis for ecosystem-service modelling with the InVEST suite of modelling tools. The workshop was organized with reference to the input from DBT.

A second session with stakeholders will took place following the finalization of the results of the Green Roof case study in November 2014 to disseminate the results and discuss their implications.

c) Methodology

The methodology of this case study is based on four steps:

1) Analysis of the current status of adaptation measures and potential future climate change impacts – local strategic documents, legislation.

This step included a review of currently existing strategic documents and available scientific studies addressing potential impacts of climate change on the study area. Furthermore, the current state of adaptation processes was assessed.

2) Constructing scenarios of potential future development in the study area with a special focus on the level of climate change adaptation. Proposing locally specific adaptation measures within a participatory scenario workshop.

In this step, a participative scenario workshop with local stakeholders was organized in order to elicit stakeholders' opinions and preferences regarding the future development of the area. A set of scenarios was created, based on stakeholders' input, which subsequently serves as the basis for ecosystem service modelling. The scenarios include potential development in various sectors while emphasizing plausible extent of land use change and the intensity of adaptation processes.

Locally specific potential adaptation measures were defined by the stakeholders attending the participative scenario workshop, organized within this case study. A list of adaptation measures suitable for the study area was prepared prior to the workshop based on a literature review, which was finalized and matched to the scenarios at the workshop. For further details, see sections 2. b) and 3. a).

3) Potential impacts of different scenarios on the provision of ecosystem services.

Different scenarios originating from the scenario workshop, accomplished in the previous step, were supposed to have various effects on the provision of ecosystem services. These effects were analysed using the InVEST suite of modelling tools, which have been developed to assess the level of ecosystem services provision under different future scenarios. For more information on the InVEST models, see Deliverable 3.2.

Data needs

In the present case study, various types of ecosystem services were evaluated, with an emphasis on regulating and provisioning services, which are influenced by LULC-based adaptive measures to a large extent. Individual InVEST tools aimed at these types of services were thus utilized, namely Carbon sequestration, Nutrient retention, Sediment retention and Hydropower production.

The basic data inputs, common for all the above mentioned tools, were current land use maps and future scenarios, the development of which was based on the collaboration with local stakeholders. The utilized sources of LULC maps were CORINE Land Cover data sets.

Subsequent data needs depended on specific tools utilized. In general, various ecological and socio-economic parameters of the study location, mainly in the form of raster maps and table databases, were required. The data were gained from national-scale and localized studies, performed by Czech and European research and academic institutions. For further detail on the data requirements of the InVEST models, see Deliverable 3.2.

4) Cost-benefit analysis

All adaptation measures included in this case study were ecosystem-based. Therefore, in the cost-benefit analysis we focused solely on the aspects of provision of ecosystem services and management costs necessary for the implementation of ecosystem-based adaptation measures.

A cost-benefit analysis was performed for all scenarios, created by local stakeholders at the participative scenario workshop. The types of costs and benefits included in the analysis were:

Costs:

Costs related to ecosystem services

Sediment dredging

Nitrogen retention

Costs of the implementation of ecosystem-based adaptation measures

Inland marshes and peat bogs restoration

Forest management, operation costs

Maintenance of touristic paths

Benefits:

Benefits related to ecosystem services

Hydropower production
Carbon sequestration

Benefits of the implementation of ecosystem-based adaptation measures
Timber sales
Sales of services related to hunting

5) A second participatory workshop with local stakeholders was assembled in November 2014, in order to disseminate the outcomes of the study and to analyse the implementation potential of proposed adaptation measures in collaboration with stakeholders. For further details see the The Green Roof – Participative Scenario Workshop Report.

METHODS to be used in Case Studies[3]	YES // NO
A) Methods for prioritizing adaptation options	
Cost-Benefit Analysis (CBA)	Y
Cost-Effectiveness Analysis (CEA)	
Multi-criteria Analysis (MCA)	
Analytic Hierarchy Process (AHP)	
B) Quantification of impacts and relationships between factors affecting adaptation	
Causal Diagrams	
Influence Diagrams	
Process-based Modelling	
Welfare variation analysis under restrictions	
C) Uncertainty and sensitivity analysis	
Probabilistic multi model Ensemble	
Monte Carlo simulations (PRIMATE uses this method)	
Real option analysis	
Climate risk management process	
D) Participatory Methods	
Scenario Workshop	Y
Participatory Cost Benefit Analysis (PCBA)	
Participatory add-ons to CBA	

[3] For descriptions and references of the Methods please refer to Milestone 8. For data requests from specific Work Packages please refer to Deliverable 4.1

Participatory add-ons to Multi Criteria Decision Analysis	
Participatory add-ons to Adaptation Pathways	
Other (add extra lines if necessary): PRIMATE for CBA	(Y)

(Max 500 words) *Please highlight if you have any special need or focus regarding any of these methods and their use on your case study.*

d) Case study Timeline

(Please insert and image/graph of the Timeline of your Research Approach, highlighting important milestones and deliverables.)

Green Roof	**2013**				**2014**				**2015**			
Phase 1: Current adaptation measures												
Contacting stakeholders (e-mail)				x	x							
Analysis of relevant strategic documents			x	x								
Analysis of potential climate change impacts in the study area			x	x	x							
Phase 2: Future adaptation measures and scenarios												
Proposal of adaptation measures, scenario workshop					x	x						
Data for assessment of adaptation measures					x	x						
Data for economic assessment					x	x						
Economic assessment of adaptation options						x						
Phase 3: Possibilities for implementation												
Discussing potential for adaptation measures implementation with stakeholders							x					
Journal article								x	x	x	x	x
BASE reporting												
D5.1 Climate change, impact and adaptation scenarios for case studies					x							
D5.2 Impacts, costs and benefits of adaptation measures								x				
D5.3 Case specific adaptation strategies and measures								x				
D5.4 Methodologies and tools for adaptation planning and implementing adaptation in cases										x		

e) Collaboration with other Partners and Case studies

Collaboration with BASE case studies (see list in EMDESK):

Collaboration with other BASE case studies includes proposed sharing of knowledge on the use of InVEST modelling tools with other case studies aimed at the impacts of adaptation measures on ecosystems and biodiversity.

Further collaboration is planned with the case studies that include biodiversity and ecosystem services as second sector, namely Ecosystems services and biodiversity in the SW of England – Dartmoor case study; contact person: Duncan Russel.

Collaboration within BASE partners/researchers (EX: for a specific competence):

Name: scenario workshop – assistance with preparation
Partner: DBT

Name: PRIMATE
Partner: UFZ

f) Research Outputs

a. Scientific Publications

- Interim reports + final case study report for D5.5
- The Green Roof – Participative Scenario Workshop Report
- Scientific papers: # 1

Provisional Title: Evaluation of ecosystem services in the Šumava National Park under different climate change adaptation scenarios; Month/Year: 3/2015

b. Other Publications

- Books Chapters:

Cost-benefit analysis of ecosystem based adaptation and disaster risk reduction in a national park. In: The Role of Ecosystems in Disaster Risk Reduction II.

c. Other

- Scientific conferences:

Title: Exploring ecosystem-based approaches to climate change adaptation

Conference: 2nd Science for the Environment Conference, Aarhus, Denmark

Month/Year: 10/2013

Title: Impact of Climate and Land Use Change on Ecosystem Services in the Šumava National Park, Czech Republic

Conference: 13th International Swiss Climate Summer School "Linking Land Use, Land Cover, and Climate"

Month/Year: 09/2014

Provisional Title: ____

________________________ Conference: ________________________________ Month/Year: ____/______

- Invited seminars, presentations at local events, etc…:

Participatory scenario workshop „Visions for potential future development of the Šumava Biosphere Reserve“

Venue: Vimperk, Czech Republic

Month/Year: 28 July/2014

Participatory scenario workshop „Visions for potential future development of the Šumava Biosphere Reserve II“

Venue: Čkyně, Czech Republic

Month/Year: 5 November/2014

3. Participation in Climate Change Adaptation

a) Process overview

Within the Green Roof case study, we have utilized the approach of participative scenario workshops. Since the Green Roof is a prospective case study, one of its main aims is to create a set of scenarios describing potential future development and adaptation measures which might be potentially implemented. These scenarios will be subsequently used as the basis for ecosystem service modelling with InVEST tools. To fulfil this aim, two scenario workshops involving main local stakeholders are planned. The first workshop, aimed at introducing the case study and eliciting stakeholders' preferences and opinions regarding future development of the study area, took place in July 2014. The second workshop followed the finalization of the case study in autumn 2014 and was focused on the dissemination of case study results among the stakeholders and eliciting feedback.

Since climate change adaptation has not been a mainstream issue in the Czech Republic, there has not been a pronounced adaptation process in the Šumava Mountains so far. The scenario workshop organized by CzechGlobe presented the first initiative introducing potential threats posed by climate change to local stakeholders and eliciting their opinions on feasible adaptation measures.

Since the issue of environment and nature protection remains rather sensitive in the area, our intention was to assemble a group of stakeholders able to collaborate and discuss the issue without extensive controversy. The management of the national park is a subject of several conflicts, especially between the administration of national park, environmental green groups, scientists and local interest groups, including representatives of municipalities and businesses. The park is split into three zones: Zone I is the most valuable and strictly protected part of the NP (which should be equivalent to the core zone under Czech legislation), Zone II includes the natural ecosystems that in the past were variously influenced by human activities, and Zone III has areas which allow a wide variety of activities on them. At present, the core-zones of the national park are small-scale and disconnected, scattered around the area of the National Park, while some of them are partly non-interventionist. Currently, the legislation designing the national park is being revisited. The Šumava NP presents a very complex area, with contrasting interests of a high number of involved stakeholders. Generally, various stakeholder groups fail to reach an agreement on the desirability of different conservation approaches. Therefore, the attempts to find a shared future vision of this valuable area have failed so far. An example is a recent study by EFTEC on An outline of economic impacts of management options for Šumava national park, which has been promoted by science community but dismissed by the NP administration. Local communities, local political representatives and other stakeholders have been involved in numerous discussions and media interest in the past two decades. Since they tend to favour rather non-protectionist attitudes (Gorner et al., 2012), the involvement of scientists and researchers in the area has been

perceived as unwelcome. Therefore, we have excluded the stakeholders from the edges of the opinion range, with sharply contradictory attitudes, since we were afraid they might make a productive discussion impossible.

We aimed to assemble approximately 15 participants covering all key sectors in the area. The number of participants was chosen in order to enable a personalized approach to each stakeholder while ensuring representative composition of local key stakeholders. Based on preliminary scoping and expert input from a local development agency, we decided not to address stakeholders with extremely strict opinions, since their involvement in the workshop could bring contradiction and make the discussion unproductive. Nevertheless, the invited participants represented the whole range of opinions. In the first turn, we addressed 20 selected stakeholders; however, we had to address another 10 stakeholders in the second turn due to a low response rate, eventually gaining 13 attendees.

The invitation letter for the stakeholders contained a statement of workshop purpose and a brief description of the workshop's background including the BASE project and the Green Roof case study. We decided not to include the description of preliminary scenario storylines which were to be further developed during the workshop, since we were aware that the idea of scenario building would be completely new for the stakeholders and we wanted to prevent confusion of the stakeholders and the risk they might feel overwhelmed by the demands of the workshop in advance.

Since local stakeholders had been frequently invited to workshops and discussions on environmental topics and the general approach to such activities is quite reluctant, we consider this number of participating stakeholders as satisfying. Moreover, it allowed us to collaborate more closely with the attendees during the workshop.

The participants were assembled in the town of Vimperk, which is a local centre of the Šumava region. We have appointed a skilled moderator from outside the CzechGlobe team to guide the participants throughout the workshop in order to ensure a detached approach.

The workshop consisted of three parts, aimed at:

1. Constructing visions of future development of the study area in terms of demographic and economic development, tourism/recreation, agriculture and nature conservation, etc.
2. Proposing adaptation measures suitable for the study area and matching them to the previously constructed visions.
3. Mapping the areas most suitable for the implementation of previously proposed adaptation measures.

In the first part of the scenario workshop, three scenarios of future development were created, including two extreme scenarios and one scenario describing a shared future vision. The two extreme scenarios, labelled as a "green" and a "red" scenario, captured the ideas of an intensive economic development and, on the other hand, nature conservation. The third scenario, conveying a shared vision of the area's future development favoured by the majority of the stakeholders, suggested a moderate level of economic development, with an emphasis on long-term sustainability, small scale development, stable population growth and ongoing nature conservation. This exercise

took place in two turns, first in groups assembled from stakeholders sharing a similar point of view on the development of the area; second, the stakeholders were re-grouped to create mixed groups of people with contrasting attitudes. Since we did not expect much consensus among the stakeholders, we originally did not insist on reaching an agreement on one vision and expected each group to produce its own scenario storyline. Subsequently, the groups presented their output to the rest of the participants. However, in both group exercises, the resulting storylines were very similar and after solving some minor differences they created a “Shared vision” for the future of the study area. This consensus was quite surprising and was not originally expected, because most of the stakeholders tended to prefer either a strictly pro-development or a pro-conservation attitude in the beginning. Eventually, both within the groups of similar background and in mixed groups, the participants preferred a third way of development.

The aim of the second part of the workshop was to introduce the concept of climate change adaptation and to elicit whether the stakeholders perceive the need for climate adaptation. Subsequently, a list of potential adaptation measures (based on a previous review of available European reports and research studies) was presented to the stakeholders, who chose the measures most suitable for the area and proposed additional ones. The finalized list of adaptation measures will be available in a forthcoming scenario workshop report.

The third part of the workshop focused on a participative mapping exercise, during which the stakeholders were asked to map the areas most suitable for various types of adaptation measures. Since this was the first experience of the stakeholders with participative mapping, this part of the workshop was considered only as an introductory exercise.

Each part was started by an introductory presentation of its topic and an explanation of the approach applied in each exercise. All three parts were based on group collaboration, while the first two included semi-structured discussions and the third part represented a participatory mapping exercise.

Workshop programme summary

9:30 – 10:00	**Registration of participants**
10:00 – 10:45	Welcome and introduction
10:45 – 11:15	Visions for a sustainable development of Šumava Biosphere Reserve – introduction and preparation
11:15 – 11:30	Coffee break
11:30 – 12:15	Creation of visions
12:15 – 13:00	Lunch

13:00 – 13:30	Finalizing visions, feedback
13:30 – 14:15	Climate change impacts in Šumava Biosphere Reserve
14:15 – 14:30	Coffee break
14:30 – 15:30	Adaptation measures
15:30 – 16:00	Concluding session

More details on the scenario workshop and its results are available within a separate report The Green Roof Case Study – Participative Scenario Workshop.

b) Participation in the Process Phases

Since climate change adaptation has not been a mainstream issue in the Czech Republic, there has not been a pronounced adaptation process in the Šumava Mountains so far. Although local stakeholders have confirmed to perceive climate change on the local scale, local initiatives have aimed at climate change only indirectly through other environmental issues so far. Therefore, the initiative arisen from the activities of CzechGlobe within the BASE project has been the first adaptation-related action in the area. Unfortunately, it is not likely that the measures suggested in this case study will be implemented within the BASE project duration. A practical implementation of adaptation measures is a part of a top-down process in the Czech Republic and local stakeholders are usually not able to start an adaptation process of a larger extent. Therefore, the main asset of the workshop was awareness raising and drawing attention to different adaptation possibilities, and all adaptation measures developed within this case study will be potential, to provide the basis for ecosystem services modelling and a cost-benefit analysis.

Process phases:

1. *Initiative/decision to act*

No direct initiative linked to climate change adaptation (neither from the side of political representatives, for from the public) and decisions have been present in the case study area.

2. *Development of potential adaptation options*

Potential adaptation measures elaborated within this case study are developed by CzechGlobe in collaboration with local stakeholders, participating at scenario workshops. No other adaptation measures outside the Green Roof case study have been developed.

Following groups of stakeholders have been addressed to participate in the first scenario workshop within this case study:

Politicians: Local Mayors

Stakeholders: Local farmers, touristic and recreational infrastructure owners, representatives of the national park and protected landscape area, energy production and water managers

Citizens: Regional Development Agency Šumava

Experts: Scientists involved in research activities in the study area

For further information about the stakeholders involved, see chapter 2. b) and the Participative Scenario Workshop report.

3. Decision-making

Since the adaptation process in the Czech Republic is mostly top-down, the actual implementation of specific adaptation measures depends on the implementation of National Adaptation Strategy, which is currently in the preparatory process. Therefore, the adaptation activity on the regional and local level is very limited.

The participative scenario workshop within the Green Roof case study presented the first introduction to the adaptation concept for local mayors. Since most of them agreed they have perceived the impacts of climate change on local environment and communities, it can be expected that an adaptation process will be developed in the study area in the long term. However, it is hard to predict the time frame of such activities, which will probably not start before the approval of National Adaptation Strategy in mid-2016 and will definitely be a part of a top-down process.

Political elections to local authorities took place between the first and the second workshop, which meant that some members of local municipality councils and some mayors were replaced during autumn 2014. These elections take place regularly every four years but usually do not break the continuity of governance in local villages. Both current and future mayors were invited to the second workshop. However, we do not expect that local authorities would start a practical adaptation process triggered by the scenario workshop immediately, because of the above described reasons. Therefore, we do not think the elections will play a major role in the local adaptation process.

4. Implementation

No implementation process has been present in the case study area.

c) Participation Experience

(Please report with regards to your case study and the implementation of Participatory Methodologies using a traditional SWOT analysis – Strengths; Weaknesses; Opportunities and Threats)

Participative scenario workshop:

Strengths	**Weaknesses**
– The possibility to assemble the majority of relevant stakeholders at one spot and to elicit a shared vision. – Materials for stakeholders serving as a guide for the	– Rather a negative approach of local stakeholders to activities and workshops on issues linked to nature conservation, which is a sensitive topic in the area. – The stakeholders were rather unfamiliar with the

creation of visions, e.g. a list of sectors to focus on and questions to address. – The participative scenario workshop turned out to bring much more concordance than originally expected. It seemed that the concept of climate adaptation, which was quite new for the stakeholders, helped to avoid traditionally negatively accepted environmental topics and brought about the ground for easier agreement. – Appointing a workshop moderator from outside the CzechGlobe team, which ensured the atmosphere of objectivity.	concept of a vision/scenario. It was necessary make clear the difference between forecasting the future and expressing preferences towards the future. – The stakeholders had negative impression about the real impact of previous stakeholder meetings they attended in the past and had doubts about the effect of the present scenario workshop. – Due to the complexity of the topics and the novel character of the topic for the stakeholders, it was suggested that the groups should have more time for discussion. – The workshop should be substantially shorter. The duration of 6 hours (although including coffee and meal breaks) seemed too demanding for the stakeholders, who did not have enough motivation for the last exercise
Opportunities – To stress that the scenario approach and participative scenario building in particular are a widely recognized and used technique. – In order to make it easier for stakeholders to distinguish projections and scenarios, it might be helpful to ask them to create one of each: a projection, i.e. what they consider as the most probable future development, and a vision, i.e. what development they would prefer in the future. Subsequently, only the visions would be used for the preparation of future scenario storylines. – To emphasize very strongly that *stakeholder scenario* building is based on own opinions and preferences and does not require a comprehensive knowledge of all trends and factors necessary to create a *prediction*. – To apply the SWOT approach on the creation of visions in the future. – To add the finalized scenario storylines in the invitation letter for the second workshop, so that all stakeholders could prepare their comments and feedback.	**Threats** – The issues of climate change and adaptation to climate change have not had strong and continued support by recent political representations in the Czech Republic. Political and to a certain extent also social atmosphere has been restrained to the importance and currentness of climate change and tended to disregard its effects on nature and society. – The elections scheduled for autumn 2014. New mayors are likely to become a part of the decision-making process.

Participative mapping exercise:

Strengths	**Weaknesses**
– The possibility to let the stakeholders think outside the box and perceive the landscape from the new perspective of climate change adaptation.	– The participative mapping exercise was found demanding by the stakeholders, perhaps since they were unfamiliar with this approach and tired after

	the previous activities. – The stakeholders perceived their own knowledge of the whole extent of the study area as too limited for the participative mapping exercise.
Opportunities – Using the participatory mapping exercise to spatially allocate already existing problems, e.g. areas of excessively intensive tourism or hot-spots of other problems, not prospective measures, which are hard to imagine and spatially allocate for the stakeholders. – To place the participative mapping exercise earlier in the programme in order to avoid participants' tiredness. – To determine beforehand which locations would be suitable for different adaptation measures in the maps used for participative mapping and to ask stakeholders to choose among them. (It seemed too demanding to require the stakeholders to make up the most suitable locations by themselves.) – To provide the stakeholders with a separate list of specific adaptation measures to map during the participative mapping exercise and ask them to supplement it with their own ideas. Not to require the stakeholders to come up with all the adaptation measures to map by themselves.	**Threats** – NA

d) Learning through Participation

In order to capture how participation could improve the climate change adaptation process, please report with regards to your case study:

a) Your view whether and how participation influenced the strategies and measures decided in your case?

In our study area, any strategies and measures have not been decided up till now. However, the approach of participative scenario workshop seem to have seeded the topic of climate change adaptation among local stakeholders and will probably shift the approach of stakeholders to environmental issues, which they previously considered as not linked to climate change. This change may hypothetically lead to a bottom-up implementation of adaptation measures in the future.

b) How you think the participatory process in your case could be/have been improved?

Since the issue of climate adaptation is perceived as quite novel in the study area, we think that the new terminology and concepts introduced at the participatory workshop might have been quite demanding for some of the stakeholders. In the future, we think it might be beneficial to focus on a smaller number of exercises and consequently to give the stakeholders more time to discuss their ideas.

Some of the stakeholders had difficulties understanding the concept of a scenario/a vision. It proved hard for them to distinguish between being asked to predict or forecast the most probable future development and to formulate the most favourable alternative of the future development. Therefore, we think it might be beneficial to ask the stakeholders to do both, so that the difference between a prediction and a vision became clearer.

c) Any novel (use of) participatory methods observed in the case studies

During the participative workshop, we employed the approach of led group discussions and participatory mapping, both of which have been previously documented in research studies. The motivation to employ these approaches was that we aimed to assemble a group of stakeholders with different background and facilitate an open discussion and sharing of opinions. The participative mapping exercise did was originally designed to spatially allocate the adaptation measures developed within the workshop. Unfortunately, the area of the Šumava Biosphere Reserve is rather extensive (almost 1000 km2) and most of the stakeholders perceived the limitation of not being familiar with the conditions in the entire area. Despite detailed maps available for the mapping exercise, the participants found a responsible allocation of adaptation measures to different localities infeasible.

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

In this case study, we focus on a bundle of ecosystem-based adaptation strategies, consisting of three approaches:

1) Sustainable forest management: choice of native tree species, promotion of diverse age classes, game regulation, selective thinning, etc.
2) Peat land and water course restoration: restoration actions to promote water retention in the landscape and increase carbon storage
3) Enhancement of ecosystem resilience: enlargement of core protection areas

b) Adaptation Measures selection and data availability prior to BASE

The idea of applying ecosystem-based adaptation measures stems from the fact that the study area is an extensive mosaic of natural and semi-natural forests, currently protected under several national and international regimes. Since the area is extremely valuable in terms of natural assets, the idea behind its research within BASE was that such an area would be suitable for studying the potential of ecosystem-based measures in depth. The above mentioned potential adaptation measures have been compiled based on an extensive review of European adaptation research articles and adaptation reports. Only those measures directly aimed at forested protected areas with similar conditions as the Šumava NP were included in the final list, following a discussion with the Administration of the Šumava NP. The final list of adaptation measures included in analysed scenarios was compiled by local stakeholders during participative scenario workshops. No adaptation measures have been implemented in the study area so far; therefore, the baseline is represented by extrapolating the current state without adaptation measures to the future.

c) Full description of Adaptation Measures

1) Sustainable forest management

Process

I. Would, or at which part would, institutions and private stakeholders implement the measure autonomously to adapt to climate change (Adaptive capacity)?

The Šumava NP administration implements sustainable forest management, peat land and water course in some parts of the study area as one of approaches to the management of a protected natural area. However, particular practices have been widely discussed and are not directly linked to adaptation at present. In general, it is preferred to intervene as little as possible in natural processes in local forests.

II. Does the measure initiate further activities for adaptation to climate change? (~~Y~~/N)

III. Does adaptation aim for flexibility and reflexivity (i.e. the ability to change as CC and other factors develop)? (Y/~~N~~)

a. Please describe briefly how

Ecosystem-based adaptation provides the possibility of reacting on the development of climate change. Moreover, they usually present a no-regret solution, as many of their side-effects enhance the resilience of ecosystems and the provision of ecosystem services. The only drawback is that ecosystem-based adaptation measures usually include long-term processes, so it can be unfeasible to react on sudden and immediate changes caused by climate change.

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? (Y/~~N~~) N/A

a. Please describe briefly how

The ecosystem-based measures selected have been modelled for the climatic scenarios derived from RCP 4.5; however, it can be assumed that they would be beneficial even under other climatic scenarios, possibly with adjusted approaches such as different species composition.

V. Is the adaptation measure iterative? (Y/~~N~~)

a. Please describe briefly how

The ecosystem-based measures can be and do not need to be iterative. For instance, peat-bog restoration may be necessary to conduct repeatedly, while forest restoration and/or designing non-intervention zones for spontaneous ecosystem development are one-off long-solutions. Nevertheless, sustainable forest management as the basis of ecosystem-based approaches requires iterative activities.

VI. Does the measure contribute to overall sustainable development, alleviate already existing problems and bring benefits for other social, environmental or economic objectives than adaptation (no regret measures)? (Y/N)

a. Please describe briefly how

Ecosystem-based measures present no-regret type of adaptation, as they generate a number of environmental benefits, such as the enhancement of ecosystem resilience and ecosystem services provision. Furthermore, since the one of the main motivations of park visitors is its pristine nature, the promotion of ecosystem-based measures can potentially enhance the economic benefits derived from the area. Therefore, the measures proposed contribute to overall sustainable development.

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? (Y/~~N~~)

<u>Outcome</u>

Relevance and effectiveness of adaptation measures

VIII. How important is the climate change threat addressed by the measure? What economic values, ecosystem functions and socio-cultural values are at stake, and to what extent are they affected by climate change impacts? Is there an indication of overriding public interest, e.g. critical infrastructures, public health?

The climate change threat in the study area is highly uncertain and not evaluated at the moment, probably leading to the exacerbation of the state and functioning of local natural ecosystems and a decrease in the provision of related ecosystem services, e.g. water retention, carbon sequestration and cultural values. Climate change can exacerbate the impacts of extreme weather events such as wind storms by facilitating bark beetle outbreaks by rising temperatures. This can bring about substantial environmental and economic impacts. However, the exact impact of climate change on bark beetle outbreaks has not been quantified in the study area yet. The other impact of climate change at stake, intensively perceived by local stakeholders, is the threat of water shortages. At present, the opinions of local stakeholders on ecosystem-based adaptation measures are diverse, strongly preferred by some and rejected by others.

IX. What portion of the targeted potential damages can be avoided by implementing the measure? (0-100%) N/A

Efficiency

X. How high are the benefits of the measure relative to the costs? Are the costs justified by the benefits (Please refer to results of economic evaluation in chapter 5)

All ecosystem-based adaptation measures have been evaluated in a bundle for four land use and land cover/adaptation scenarios. For the benefit/cost ratios, see the table below. When taking into account the value of ecosystem services generated by the ecosystem-based measures (Green scenario and Shared vision), the benefits exceed costs more than in the scenarios without the implementation of ecosystem-based adaptation measures (Business-as-Usual and Red scenarios).

	Scenario			
	BaU scenario	**Green scenario**	**Shared Vision**	**Red scenario**
Net present value at 5% discout rate	**264,730,342**	**327,834,382**	**281,180,453**	**233,221,793**
Difference to BaU	**0**	**63,104,040**	**16,450,110**	**-31,508,549**
Benefit/cost ratio	**7.56**	**15.77**	**8.54**	**6.10**

XI. What are the costs of the administrative implementation of the measure? Are there potential funding under the umbrella of other European policies (e.g. CAP/Cohesion policy?

The ecosystem-based adaptation approaches analysed in this study have been in a smaller scale applied by the Administration of the NP and PLA Šumava within the regular management of the protected forests. Therefore, no substantial administrative changes would need to be introduced in order to implement ecosystem-based adaptation measures. The average annual costs of different ecosystem-based adaptation measures included in our analyses are as follows:

Forest management, operation costs	1,159,000 EUR/year
Infrastructure	795,000 EUR/year
Peat-bog and marshlands restoration	1,409,000 EUR/year

XII. Does the measure give an incentive for innovation to different actors (e.g. SMEs) / can it deliver a competitive advantage for the local economy? (Y/~~N~~)

XIII. Does the measure have effects on employment? (Y/~~N~~)

XIV. How long is the time-lag between implementation of the adaptation measure and the effect of the measure?

> This question cannot be easily answered by our modelling approaches. However, ecosystem-based adaptation measures in our study focus on forest growth and peat-bog formation, therefore, their effects begin to emerge immediately; however, their full impact will probably be evident on the scale of decades.

XV. What is the timeframe during which the measure will have an effect?

> Decades to centuries.

XVI. Does the measure create synergies with mitigation (i.e. reduce GHG emissions or enhance GHG sequestration)? (Y/~~N~~)

XVII. Does the measure alleviate or exacerbate other environmental pressures? (Explain briefly)

> Ecosystem-based measures enhance local ecosystem resilience, alleviate the impacts of pollution and the introduction of allochtonous species, decrease water run-off, enhance water retention in the landscape, etc.

Equity

XVIII. What are the impacts on different social or economic groups, are there expected impacts on particularly vulnerable groups? (distributional impact)

> The measures are perceived variously by different stakeholder groups. For instance, sustainable forest management is perceived as less profitable and convenient by some of the local stakeholders, e.g. logging companies and local forest owners. On the contrary, it enhances the value of forest for tourism and recreation. No impacts on particularly vulnerable groups are assumed.

XIX. Does the measure enhance well-being and quality of life (e.g. in the urban environment)? (Y/~~N~~)

5. Impacts, Costs and Benefits of Adaptation measures

(This section of the CSLD follows the Economic Assessment Steps put forward by UFZ and thoroughly described in D4.1, chapter 4. Please check D4.1 for any doubts or questions. In case of duplication of information with previous sections of the CSLD feel free to copy paste.) For more detailed guidance (incl. two examples) please see the above mentioned chapter 4 of D4.1. Please do not hesitate to contact volker.meyer@ufz.de, oliver.gebhardt@ufz or Filipe Alves if you have questions about how to fill out this section.

a) Step 1 – Preliminary Risk Assessment and identification of adaptation tipping points (max 1500 words)

(Some of these questions might be already answered in section 1 – if so, just copy&paste)

What is the climate change related problem/risk you would like to reduce by adaptation?

- *Which problems already exist, what is/are the current risk/s?*

Since the study area is situated in a national park, the most important threat linked to climate change is the deterioration of local valuable ecosystems due to increased temperatures, changes in precipitation regimes, more frequent wind storms and bark beetle outbreaks, etc. Concerning local population, local stakeholders perceive water shortages as the most important pressure, which might be potentially caused by climate change in the area in the future. This study aims to assess the costs and benefits of possible ecosystem-based adaptation measures, which could enhance the resilience of local ecosystems and address the issue of water shortages.

- *Which assets and sectors are at risk under current climate variability?*

Since the study area presents a national park, the most threatened assets are natural ecosystems and related forestry and tourism sectors.

- *Which adaptation or protection measures are already in place? (refer to typology of measures in D6.1, table 2)*

None.

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

These risks are likely to be intensified and exacerbated by climate change such as changing temperature and precipitation regimes. Furthermore, the growing pressure on the economic utilization of the area in terms of tourism and forestry might further affect the state of local ecosystems.

- *What are the main drivers, impacts and affected sectors (refer to BASE impact and sector categories, see also Table 1 of D6.1)*

Impacts: Damages from extreme weather related events

Sectors: Biodiversity and ecosystems, Forestry, Tourism

- *Which climate and socio-economic scenarios are used?*

In this case study, we applied the approach of *complex adaptation scenarios* to 2050, which incorporated various socio-economic and ecological aspects, namely:

1. Basic socio-economic dynamics – incorporated through the European ALARM scenarios, on which our locally-specific scenarios were based. ALARM scenarios present a European-scale dynamic spatially explicit scenarios of land use and land cover change, modelled by extrapolating current population dynamics and expected development of

international trade, according to EU environmental and agricultural politics (Rounsevell et al., 2006; Settele et al., 2005; Spangenberg, 2007; Dendoncker et al., 2006).

2. Land use and land cover change – incorporated through the above introduced ALARM scenarios and based on locally-specific trends defined by stakeholders.

3. Adaptation measures to climate change – incorporated as distinctive bundles of land use-based adaptation measures for each scenario, participatively developed by the stakeholders.

Specifically, a set of three scenarios has been developed during a participative scenario workshop with local stakeholders, consisting of a Green scenario prioritizing nature conservation, a Red scenario prioritizing economic development and a Shared vision, characterized by sustainable economic development, maintained level of nature conservation and a focus on small-scale businesses and local production. Each of the scenarios was characterized by a different level of land use change and a different intensity of adaptation measures. **While the Red scenario complies with SSP5 storyline, building on the assumptions of population growth and economic development, the Green scenario and the Shared vision are in line with SSP2, presuming no rapid changes and a moderate socio-economic development extrapolating current trends.** Since the economic indicators assessed in this study did not have a direct connection to the level and pace ofsocio-economic development, but solely to the level of investments in ecosystem-based adaptation measures, we considered the SSP scenarios more as the information basis for participative scenario development by local stakeholders. However, by incorporating three scenarios (Green, Shared vision and Red), based on both SSP2 and SSP5 storylines, we have covered the range of socio-economic assumptions used within the BASE project.

Additionally, a fourth Business-as-Usual scenario to 2050 was introduced as the baseline for comparison with the first three scenarios in the cost-benefit analysis. This scenario presumed that no substantial climate and land use/land cover change will be present in the study area and no adaptation measures will be implemented. In addition, ecosystem services were assumed to be provided at the same level as in the current landscape, and regular management costs were assumed to remain at the current level.

These scenarios were created and processed in a geographic information system platform and further used for ecosystem services modelling and the cost-benefit analysis.

The impact of climate change was not incorporated at the stage of scenario building, but later in the process, at the stage of ecosystem services modelling. The influence of climate change was incorporated through the RCP4.5 and RCP8.5 climatic projections provided by CMCC within the BASE project, specifically through the levels of precipitation and evapotranspiration, required in some of our ecosystem service models (namely nitrogen retention and hydropower production). The RCP4.5 and RCP8.5 scenarios were chosen since they present the basis of common base scenario storylines, developed within the BASE project and applied in the case studies. For the performance of each adaptation scenario under different climate futures, see the results section.

Which adaptation tipping points can be identified?

- *Can adaptation tipping points, critical levels for adaptation, be defined for this current strategy? (=when objectives are not met anymore due to changes)*
  Refer to otherwise expand on Table 3 of D6.1

Not with the current level of knowledge.

- *When (roughly) will these critical levels be reached due to climate change or socio-economic change*

N/A

- *Give appropriate period (2015-2030, 2030-2050, after 2050) for each considered combination of climate and socio-economic scenario.*

In this case study, we assessed one period, 2006-2050.

b) Step 2 – Identification of Adaptation Measure and Adaptation Pathways (max 1500 words)

(Some of these questions might be already answered in section 4 – if so, just copy&paste)

What are the alternative adaptation measures?

- *What are the primary and secondary objectives of adaptation?*

The main objective is to maintain a favourable state of local ecosystems and to preserve natural ecosystem processes.

- *What are potential measures to meet these objectives?*

Mainly ecosystem-based adaptation measures such as sustainable forest management, peat land and water course restoration and enhancement of ecosystem resilience, specifically the enlargement of core protection zones.

- *What is your baseline option (the "business-as-usual"-option)?*

Our Business-as-Usual (BaU) scenario assumes preserving the current state of landscape with no implementation of adaptation measures and actions. Furthermore, it assumes only negligible change in climate.

On the other hand, various adaptation options are included in the potential future adaptation scenarios (Green, Red and Shared vision), which are created and assessed in terms of ecosystem services provision within this case study.

  - What is the ambition level of this baseline strategy?: Maintaining current risk levels or current protection levels (implying with CC risks may increase)?

Our BaU scenario depicts the current strategy in the area, where no adaptation measures have been/are being implemented.

  - Is current backlog of investments for adaptation measures included or excluded?

A current backlog of investments for adaptation measures does not exist in the study area.

  - Does it include only planned adaptation or also autonomous, non-planned adaptation?

Our BaU scenario does not include the implementation of any adaptation measures.

- *Are there complementary measures? Is it appropriate to bundle these measures?*

No complementary measures.

What are alternative adaptation pathways?

- *What is the "sell-by"-date of the measures or bundles of measures? I.e. when will they – under conditions of climate change – not any longer be able to meet the defined objectives?*

In this case study, we do not apply the concept of adaptation pathways.

- *What would be alternative measures or bundles of measures at these "tipping points"?*

In this case study, we do not apply the concept of adaptation pathways.

c) Step 3 - Evaluation Criteria and Method (max 2000 words)

i. Step 3a Selection of evaluation criteria

Which evaluation criteria should be used?

- *What are the relevant positive and negative properties of the measures (costs and benefits) to be considered in the evaluation process (economic, ecological and social effects)? (see D4.1, chapter 4 for examples)*

In this case study, we quantified the costs and benefits of ecosystem-based adaptation measures, i.e. adaptation measures created by changing or influencing the state of ecosystems (e.g. the area of various ecosystem types, management intensities, etc.). For each scenario (Green scenario, Shared vision, Red scenario, BaU) we calculated the costs and benefits of a bundle of adaptation measures, corresponding to each scenario's storyline. Specifically, each scenario assumed a different level of area occupied by forests, and different intensity of ecosystem restoration and forest management.

Costs:

1. Investment costs (peat-land restoration)
2. Maintenance and operation costs (sustainable forest management)
3. Infrastructure (paths for tourists and foresters, tourist information facilities, etc.)
4. Costs influenced by the provision of ecosystem services (sediment dredging, nitrogen removal) under two different climate scenarios (RCP 4.5 and 8.5)

Benefits:

1. Benefits generated by the provision of ecosystem services (carbon sequestration, hydropower production) under two different climate scenarios (RCP 4.5 and 8.5)
2. Benefits generated by the implementation of adaptation measures (timber sales, sales of services related to hunting)

- *What is the appropriate unit to measure each of these criteria? Is the performance of the adaptation options measured in qualitative, monetary or other quantitative terms?*

Both costs and benefits have been measured in monetary terms.

ii. Step 3b Selection of evaluation method(s)

What is the appropriate evaluation method?

- *Is it possible to express all relevant cost and benefit criteria in monetary terms?*
  (→ cost-benefit analysis)

Since all relevant costs and benefits were possible to assess in monetary terms, we conducted a cost-benefit analysis in this case study.

iii. Step 3c Weighting of evaluation criteria (applicable only to multi-criteria analysis)

We do not aim to conduct a multi-criteria analysis in this case study.

What are the preferences of stakeholders regarding the different evaluation criteria?

- Are there different stakeholder groups with varying preferences regarding the evaluation criteria?
- Which weight do stakeholders and/or decision makers attach to a substantial change in the performance of the adaptation options regarding each evaluation criterion?
  (see D4.1, chapter 4.10.2 for guidance for the Swing-Weight method)

iv. Step 4 - Data collection (max 2000 words)

What are the costs and what are the benefits of the alternative adaptation options?

- *What potential data sources are available, including damage & impact assessment methods or existing CBA studies on adaptation measures?*

For our study area, we have utilized following data sources:

Type of value:	**Data source:**
Costs:	
Costs related to ecosystem services: The costs of adaptation measures related to the provision of ecosystem services were quantified using the InVEST suite of models. Specifically, the InVEST ecosystem-service models quantify the proportion of pollutants (discharged from a landscape through water run-off) reaching the stream network. The notion of ecosystem services here is incorporated in the way that the ecosystems are able to remove a part of pollutants from the run-off water and thus decrease the pollutant load finally reaching the streams. Therefore, the higher the intensity of the ecosystem service provided by the landscape, the lower the amount of pollutant reaching the stream. Subsequently, the pollutants reaching the stream (which have NOT been removed by the ecosystems) need to be removed through the process of artificial water purification. That incurs costs for the removal of pollutants, which were previously not retained by the landscape. Therefore, we added sediment dredging and	

nitrogen removal on the side of costs, because they in fact describe hypotetical costs spent on water purification in the future under different ecosystem service scenarios. The lower these costs (and the higher the level of corresponding ecosystem services), the better. If these numbers were moved to the benefit side, they would have to be transformed to their negative values, otherwise the interpretation would be incorrect.	
Sediment dredging	Result of ecosystem-service modelling with InVEST tools (see above). 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 removal	Result of ecosystem-service modelling with InVEST tools (see above). Economic value based on costs of nitrogen removal from water run-off, calculated within a Central European study by Rybanič et al. (1999).
Costs of the implementation of ecosystem-based adaptation measures	
Inland marshes and peat bogs restoration	Derived from available Annual reports of the Administration of the NP and PLA of Šumava.
Forest management, operation costs	
Maintenance of touristic paths (Infrastructure)	
Benefits:	
Benefits related to ecosystem services:	
Hydropower production	Result of 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	Result of 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	Derived from available Annual reports of the Administration of the NP and PLA of Šumava.
Sales of services related to hunting	

No existing CBA studies or damage/impact assessments are available for the area.

- *If no relevant data sources are available and modelling cannot be undertaken: Which experts can estimate proxies for assessing the performance of measures regarding the respective criterion?*

We did not need to apply expert opinion approach in this study.

- *How do the adaptation options perform with regard to each of the cost and benefit criteria selected in step 3a?*

In this case study, we did not apply weighting criteria.

What is the evaluation time frame?

- *What is the lifespan of the measure with the longest lifetime?*

Since we are planning to assess long-term ecosystem-based adaptation measures, the concept of longest life-time is not applicable. Our modelling exercise within this case study was conducted to 2050.

Which discount rate should be applied?

- *Which discount rate is recommended by national guidelines for climate change adaptation measures (or public investments)?*

No national guidelines for climate change adaptation are available. The discount rate for public investment projects has usually been around 5 % as recommended by European Commission. Therefore, a discount rate of 5% has been used in this case study. Additionally, we conducted a sensitivity analysis at 1% discount rate.

- *Is it a linear discount rate or any other type (i.e. declining, hyperbolic, etc.)*

N/A

- (In addition, for testing the sensitivity of the results with regard to the discount rate(s) used, also apply a low and high discount rate (1% and 5%)).)

How to deal with data uncertainty?

- *Can uncertainties related to the performance of the measures regarding certain evaluation criteria be described by a range (min-max), a triangular distribution (min, most likely, max) or any other kind of probability distribution?*

We dealt with data uncertainty in several ways.

1. At the stage of scenario and ecosystem services modelling:

a. We modelled the ecosystem services separately for two climatic projections, RCP4.5 and RCP 8.5. The difference between these two climate scenarios was taken into account in two ecosystem models which require climatic parameters, nitrogen retention and hydropower production.

b. We subjected all model parameters to a thorough review of scientific sources. However, there are still a few unavoidable sources of uncertainty, namely in some the ecological parameters required by the models (soil parameters, carbon pools, nitrogen loading, erosion coefficients, etc.). Since for some of them only a single data source (map) is available, the degree of uncertainty originating from this point cannot be quantified.

2. At the stage of cost-benefit analysis:

a. We calculated the costs and benefits for the mean, minimal and maximal marginal values of individual ecosystem services and management approaches (based on literature review)

v. Step 5 – Evaluation and Priorization (max 1500 words)

What is the ranking order of alternative adaptation options (measures, bundles of measures or pathways)?

- *For cost-benefit analysis: What is the net-present value (discounted benefits – discounted costs) of the alternative options? What is the benefit-cost ratio?*

In this case study, we compared four scenarios, ranging from no implementation of adaptation measures and no land use change (BaU), limited level of adaptation measures and existing land use change (Red scenario), moderate adaptation measures and existing land use change (Shared vision) and extensive adaptation measures and existing land use change (Green scenario). All of these combinations were modelled (a) for two climate scenarios, RCP4.5 and

8.5, and (b) the mean, minimum and maximum marginal values of each ecosystem service and management option (based on literature review; see Table 1). The results are provided in Tables 2 and 3 below.

Table 1: Economic parameters used in the cost-benefit analysis

Type of NPV calculated	Value (in 2010 prices)				Source
	Mean	Min	Max	Unit	
Nitrogen retention	2.69*	-	-	EUR kg N^{-1} $year^{-1}$	Rybanič et al. (1999)
Sediment dredging	25.64	12.10	52.91	EUR t^{-1} $year^{-1}$	Czech public procurements in a database administered by the Ministry of Regional Development of the Czech Republic.
Carbon sequestration	84*	-	-	EUR t C^{-1} $year^{-1}$	Hönigová et al. (2012)
Forest management, operation costs	1,158,642	617,000	1,805,074	EUR $year^{-1}$	Annual reports of the Administration of the NP and PLA of Šumava.
Infrastructure	794,721	327,667	1,250,306	EUR $year^{-1}$	Annual reports of the Administration of the NP and PLA of Šumava.
Hydropower production	0.09	0.07	0.11	EUR kWh^{-3} $year^{-1}$	Subsidies for energy generation in water hydropower plants specified by the Energy Regulatory Office of the Czech Republic.
Timber sales	4,379,891	3,849,567	4,893,723	EUR $year^{-1}$	Annual reports and supplementary data provided by the Administration of the NP and PLA of Šumava.
Sales of services related to hunting	35,956	31,129	39,407	EUR $year^{-1}$	Annual reports and supplementary data provided by the Administration of the NP and PLA of Šumava.

*For carbon sequestration and nitrogen retention, we based our analyses on nationally-specific marginal values (social costs of carbon and nitrogen removal costs); therefore, for these services we did not use a range of values and provide only one estimate per a climate projection.

Table 2: Cost-benefit analysis at 5% discount rate for four scenarios under RCP4.5 and RCP8.5 (net present value 2006-2050, EUR)

					Scenario							
					RCP4.5				RCP8.5			
					BaU	Green scenario	Shared Vision	Red scenario	BaU	Green scenario	Shared vision	Red scenario
Discount rate 5%	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		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		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**

		baseline (BaU)		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**

Table 3: Cost-benefit analysis at 1% discount rate for four scenarios under RCP4.5 and RCP8.5 (net present value 2006-2050, EUR)

					Scenario							
					RCP4.5				RCP8.5			
					BaU	Green scenario	Shared Vision	Red scenario	BaU	Green scenario	Shared Vision	Red scenario
Discount rate 1%	Costs	Costs related to ecosystem services	Sediment dredging	mean	5,722,357	3,703,002	5,780,332	5,966,522	5,722,357	3,703,002	5,780,332	5,966,522
				min	3,146,938	2,036,419	3,178,821	3,281,214	3,146,938	2,036,419	3,178,821	3,281,214
				max	11,808,512	7,641,421	11,928,147	12,312,364	11,808,512	7,641,421	11,928,147	12,312,364
			Nitrogen retention		1,774,000	1,497,117	1,812,683	1,954,279	1,774,000	1,497,376	1,813,165	1,954,891
		Annual management costs	Inland marshes and peat bogs restoration	mean	163,992	238,095	163,992	0	163,992	238,095	163,992	0
				min	72,253	104,902	72,253	0	72,253	104,902	72,253	0
				max	664,843	965,262	664,843	0	664,843	965,262	664,843	0
			Forest management, operation costs	mean	42,238,819	22,098,114	38,636,814	48,376,094	42,238,819	22,098,114	38,636,814	48,376,094
				min	22,493,015	11,767,687	20,574,875	25,761,236	22,493,015	11,767,687	20,574,875	25,761,236
				max	65,804,794	34,427,142	60,193,150	75,366,191	65,804,794	34,427,142	60,193,150	75,366,191
			Infrastructure	mean	28,971,912	15,157,256	26,501,270	33,181,513	28,971,912	15,157,256	26,501,270	33,181,513
				min	11,945,237	6,249,398	10,926,581	13,680,873	11,945,237	6,249,398	10,926,581	13,680,873
				max	45,580,476	23,846,371	41,693,504	52,203,292	45,580,476	23,846,371	41,693,504	52,203,292
		Sum		mean	78,871,080	42,693,583	72,895,092	89,478,408	78,871,080	42,693,843	72,895,574	89,479,020
				min	39,431,443	21,655,523	36,565,214	44,677,602	39,431,443	21,655,782	36,565,696	44,678,213
				max	125,632,625	68,377,313	116,292,328	141,836,127	125,632,625	68,377,573	116,292,810	141,836,738
		Sum of costs compared to baseline (BaU)		mean	**0**	**-36,177,497**	**-5,975,988**	**10,607,328**	**0**	**-36,177,237**	**-5,975,506**	**10,607,940**
				min	**0**	**-17,775,920**	**-2,866,229**	**5,246,159**	**0**	**-17,775,661**	**-2,865,747**	**5,246,770**
				max	**0**	**-57,255,312**	**-9,340,297**	**16,203,502**	**0**	**-57,255,052**	**-9,339,815**	**16,204,113**
	Benefits	Benefits related to	Hydropower production	mean	435,006,840	483,288,487	484,541,493	487,837,218	435,006,840	471,417,048	472,749,784	476,308,257
				min	322,227,289	357,991,472	358,919,625	361,360,902	322,227,289	349,197,813	350,185,025	352,820,931

ecosystem services		**max**	537,045,482	596,652,453	598,199,375	602,268,171	537,045,482	581,996,356	583,641,709	588,034,885
	Carbon sequestration		0	128,902,202	4,797,074	-110,500,512	0	128,902,202	4,797,074	-110,500,512
Annual market benefits	**Timber sales**	**mean**	159,670,900	83,535,142	146,054,624	182,870,986	159,670,900	83,535,142	146,054,624	182,870,986
		min	140,337,708	73,420,581	128,370,111	160,728,693	140,337,708	73,420,581	128,370,111	160,728,693
		max	178,402,910	93,335,181	163,189,222	204,324,746	178,402,910	93,335,181	163,189,222	204,324,746
	Sales of services related to hunting	**mean**	1,310,778	685,761	1,198,999	1,501,234	1,310,778	685,761	1,198,999	1,501,234
		min	1,134,836	593,713	1,038,060	1,299,727	1,134,836	593,713	1,038,060	1,299,727
		max	1,436,590	751,582	1,314,082	1,645,326	1,436,590	751,582	1,314,082	1,645,326
Sum		**mean**	595,988,518	696,411,592	636,592,190	561,708,926	595,988,518	684,540,153	624,800,481	550,179,965
		min	463,699,833	560,907,968	493,124,870	412,888,810	463,699,833	552,114,310	484,390,271	404,348,839
		max	716,884,981	819,641,418	767,499,752	697,737,730	716,884,981	804,985,321	752,942,086	683,504,445
Sum of benefits compared to baseline (BaU)		**mean**	**0**	**100,423,073**	**40,603,672**	**-34,279,592**	**0**	**88,551,634**	**28,811,963**	**-45,808,553**
		min	**0**	**97,208,136**	**29,425,037**	**-50,811,022**	**0**	**88,414,477**	**20,690,438**	**-59,350,994**
		max	**0**	**102,756,437**	**50,614,771**	**-19,147,251**	**0**	**88,100,339**	**36,057,105**	**-33,380,537**
Benefits - Costs		**mean**	517,117,438	653,718,008	563,697,098	472,230,518	517,117,438	641,846,310	551,904,907	460,700,945
		min	424,268,390	539,252,446	456,559,656	368,211,208	424,268,390	530,458,528	447,824,575	359,670,626
		max	591,252,356	751,264,105	651,207,424	555,901,604	591,252,356	736,607,748	636,649,277	541,667,706
NPV (Difference to BaU), i.e. $NPV_{scenario} - NPV_{BaU}$		**mean**	**0**	**136,600,570**	**46,579,660**	**-44,886,920**	**0**	**124,728,872**	**34,787,469**	**-56,416,493**
		min	**0**	**114,984,056**	**32,291,267**	**-56,057,181**	**0**	**106,190,138**	**23,556,185**	**-64,597,764**
		max	**0**	**160,011,749**	**59,955,068**	**-35,350,753**	**0**	**145,355,392**	**45,396,920**	**-49,584,650**

- *What are the uncertainties associated with the performance of the different options?*

The uncertainty analysis included calculation of CBA for two levels of discount rate (5% and 1%), for two climate scenarios (RCP4.5 and 8.5) and for different marginal values of ecosystem services and management (mean, minimum, maximum, based on literature review). In all cases, the Green adaptation scenario performed as the most beneficial, followed by the Shared vision. The Red scenario proved to be the most undesirable option. This ranking of scenarios has not changed while using different economic and climatic parameters.

Different climate scenarios influenced two aspects of the cost-benefit analysis: the level of nitrogen retention and hydropower production. Nevertheless, these did not substantially influence the final ranking of the scenarios.

Is there and, if so, to what extent uncertainty in the ranking of options?

The ranking of the options (the Green adaptation scenario performed as the most beneficial, followed by the Shared vision; the Red scenario proved to be the most undesirable option) was robust to the uncertainty analysis and remained the same for all parametrizations.

- *Is it possible to determine which option most likely performs best or is it necessary to gather further information to reduce uncertainty (go back to step 4)?*

In terms of ecosystem-based adaptation to climate change, the Green scenario most likely performs the best.

What are the main lessons learnt from your case study?

- Transferable results?

The results of our case study are not easily transferable to other areas for several reasons:

1. We analysed solely ecosystem-based adaptation options.
2. All scenarios we used for the analyses stem from very specific local conditions (an extensive forested mountain ecosystem, national park and related restrictions, …).
3. The costs and benefits of ecosystem-based measures were quantified solely in terms of ecosystem services and management costs related to these measures.
4. The final results are based on a specific value of management costs in the study area.

- Lessons learnt with regard to the process of economic evaluation?

1. The cost-benefit analysis focusing on ecosystem-based adaptation options brings several sources of uncertainty, which were, however, reduced by the sensitivity analysis:

a. The uncertainty stemming from the parameterization and modelling procedures of ecosystem-service models.

Since only two modules of the InVEST model require climatic data and the differences between RCP4.5 and 8.5 were not substantial in the study area, the overall impact of different climatic projections on the cost-benefit analysis was small.

The remaining uncertainty stemmed mainly from the ecological inputs into the InVEST models. Regarding those we depend on available data sources, which unfortunately usually provide only single source value without confidence intervals (e.g. soil maps, rainfall erosivity and soil erodibility indices, etc.).

b. The uncertainty stemming from economic inputs to the cost-benefit analysis such as the marginal value of abatement costs for various ecosystem services. We reduced this type of uncertainty by eliciting all marginal values from a thorough review of available data and calculating the cost-benefit analysis for mean, minimum and maximum marginal values.

We were more successful in reducing the uncertainty stemming from the economic evaluation (by calculating the costs and benefits at two discount rate levels and at different levels of marginal values) than in reducing the uncertainty stemming from modelling (by using two climate change scenarios).

2. The economic valuation was facilitated by close cooperation with local stakeholders, namely the Administration of the NP and PLA Šumava. Some data sources on management and operation costs used in our analysis are not publicly available.

- Feasibility of methods?

The methods applied in this study, namely ecosystem services modelling with InVEST, and subsequent cost-benefit analysis based on the compilation of avoided costs/benefits of ecosystem services, management and operation costs, are data and time consuming, but feasible and widely applicable in the conditions of natural and semi-natural areas and national parks. The approach can be recommended in the cases where the implementation of ecosystem-based adaptation measures is considered.

- Important data sources?

The most important data in this case study were:

1. Data needed for ecosystem services modelling, which included national-wide climatic, soil and hydrological datasets. Where national sources were not available, parameters were derived from international reports and research studies.

2. Economic data, derived from local sources (such as the Administration of the NP and PLA Šumava), which were vital for the feasibility of the cost-benefit analysis.

6. Implementation Analysis

The aim of this section is to establish whether adaptation measures can be implemented in the real world context of case studies, and what the key obstacles and opportunities are in doing so. To ensure the answers provided in this section are comprehensive and in line with WP2 and WP7, a checklist is provided below with the main factors that all case holders need to consider in their answers If relevant to the implementation of your case study.

Checklist

When answering the main questions below ensure you consider each factor listed in the checklist below that might have had a role in the implementation of your case study work. Write in the table how important each factor has been to the implementation of your BASE work and adaptation in general at your case study; where 1 = unimportant, 2 = slightly important, 3 = Important, 4 = Very important, and 5 = Critical). The checklist might not be all-inclusive, so feel free to discuss other factors that are not listed.

Key factors:	Rank from 1 – 5
i. **Knowledge and information about climate adaptation**	2
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	5
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	2
iv. **Local and regional context** (e.g. culture, history, geography, environment, economy)	4
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	5
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	5
vii. **Resources** (e.g. financial, human)	4
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	2
ix. **Other** (specify ____)	N/A

Summary Information (based on your answers to the questions below)

a) Specify sectors covered (e.g. coast, city, agriculture):

Biodiversity and Ecosystems, Tourism

b) Specify adaptation measures covered (e.g. altering cultivation practices, building defences; explain why they were chosen):

a) Sustainable forest management

b) Peat land and water course restoration

c) Enhancement of ecosystem resilience

These measures were chosen by local stakeholders as the most suitable for the study area based on previous review of available adaptation reports and scientific literature.

c) Specify climate change impacts covered (e.g. flooding, heat stress, sea level rise):

Water scarcity, Droughts, Damages form extreme weather related events

d) Specify main results of activities (e.g. changes, outputs):

Ecosystem-service provision modelling based on participative adaptation scenarios and awareness-raising

Questions

Answer these six questions giving specific evidence and examples where possible. In principle all implementation activities should be included, i.e. adaptation activities supported by BASE partners as well as those by other actors. If it is possible to inform about the implementation of those adaptation measures assessed for task 5.2, it is very important to do so in order to comply with the DoW. The measures covered can be extensive and/or particular to a case study. They can include for example, the development of plans and strategies, vulnerability/risk assessments, economic assessments such as CBA, MCA, the development of participatory processes/public dialogue, through to the implementation of actual measures including physical measures such as engineering developments and land use change, incentives/subsidies for behavioural change, etc. This list is not all-inclusive and is merely a guide. Your own case study may have very different measures. However, **you must be clear what measures you are refereeing to when answering these questions.**

1. How have climate change adaptation measures and strategies been advanced in the case study? Describe the process! *Note:* Retrospective case studies will not answer this question, but have to update their answer to question 1 E of this document on the history of adaptation at their case study. (Approximately 500 words)

In Šumava National Park, adaptation measures have been neither developed nor implemented apart from the BASE project so far. Therefore, the activities taken by the CzechGlobe team within the Green Roof case study present the first adaptation activity in the area.

Specifically, two scenario workshops have been organized as a part of the case study, assembling key stakeholders influencing the study area. A list of adaptation measures potentially suitable for the study area has been compiled during the workshops. Subsequently, the impact of these measures on the provision of ecosystem services in the area was modelled.

Although the case study resulted in an array of suitable adaptation measures, the adaptation process in the Czech Republic is top-down driven and local stakeholders do not have much influence on the initiation of adaptation activities. At the same time, the issue of climate change has not been very high on local political agenda. Therefore, the adaptation measures developed in the Green Roof case study will serve mainly as an input into ecosystem-service modelling and as a way of awareness-raising, informing the stakeholders about various adaptation possibilities in the study area.

The list of potential adaptation measures and all details of the workshop are provided in the Green Roof Participative Scenario Workshop report.

2. What and who drives (or enables) the adoption and implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

The implementation of adaptation measures in the Czech Republic depends mainly on the approval of the National Adaptation Strategy planned in mid-2016, which means that the adaptation process is primarily top-down driven.

Knowledge and information, Actors: Among the general population, climate change is not perceived as a major threat or a limiting current issue (Eurobarometer, 2014). Majority of environmental problems such as flooding tend to be perceived as disconnected from the issue of climate change. At the same time, climate change does not have a prominent position in political agenda. The most plausible reasons are general scepticism towards climate change nested in Czech political representation and an absence of an unambiguous trend in weather and local climate conditions which could be attributed to climate change

(such as sea level rise in coastal areas).Therefore, only very limited adaptation activity takes place before the approval of the National Adaptation Strategy.

Framing of climate adaptation (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)**:** In the study region, no adaptation measures have been implemented hitherto. Rank 2 in the check-list has been attributed to general framing of climate adaptation since namely disaster risk mitigation might present a driving force which might contribute to potential adoption of adaptation measures in the future in the study area. During stakeholder workshops, the participants stated they were concerned about potential impact of droughts, extreme weather events and less snow cover; however, they do not connect these issues to climate change in general. Therefore, if some adaptation measures are implemented in the future, they are likely going to be framed as disaster risk reduction measures.

Local and regional context: Although some of the local stakeholders at the participative workshops, carried out within the BASE project, mentioned they have observed possible impacts of climate change on the local scale, the adaptation process in the Czech Republic is mainly top-down driven. Therefore, any specific adaptation measures have not been implemented in the study area yet.

We acknowledge local and regional context as very important, since it has hindered the implementation of adaptation measures so far:

The Šumava National Park (NP) was established in 1991 owing to its unique natural assets and high conservation importance. Its status has been recognized by IUCN (category II – National Park) and reflected in several international conventions, e.g. Ramsar convention designating the most valuable peat bogs as wetlands of international importance. The Šumava NP is also a part of the Natura 2000 network.

Since the establishment of the NP, the concept of the area's management has been repeatedly changing, which resulted in e.g. several substantial changes in zonation and conservation approaches. The management of the national park is a subject of several conflicts, especially between the administration of national park, environmental green groups, scientists and local interest groups, including representatives of municipalities and businesses. Currently, the legislation designing the national park is being revisited.

The Šumava NP presents a very complex area, with contrasting interests of a high number of involved stakeholders. Generally, various stakeholder groups fail to reach an agreement on the desirability of different conservation

approaches. Therefore, the attempts to find a shared future vision of this valuable area have failed so far. An example is a recent study by EFTEC on An outline of economic impacts of management options for Šumava national park, which has been promoted by science community but dismissed by the NP administration.

Local communities, local political representatives and other stakeholders have been involved in numerous discussions and media interest in the past two decades. Since they tend to favour rather non-protectionist attitudes (Gorner et al., 2012), the involvement of scientists and researchers in the area has been perceived as unwelcome.

As this case study is prospective, it does not have any adaptation history. At the national level, national adaptation strategy has not been approved yet and discussion regarding climate change adaptation is only slowly emerging. The study area does not have a regional adaptation strategy.

European, national, regional and local regulatory framework: The adaptation process in the Czech Republic is mainly driven by European legislative, namely EU Adaptation Strategy (Communication: "An EU Strategy on Adaptation to Climate Change", COM (2013) 216) and the necessity to comply with European climate change adaptation policies. Therefore, European regulatory framework and the planned National Adaptation Strategy (to be approved by mid-2016) present the main adaptation drivers.

Institutional context, Resources: Since the study area presents a national park, the main institutional body responsible for managing the area is the Administration of the National Park. Nevertheless, this institution focuses mainly on nature protection and conservation; therefore, since climate change has not been perceived as directly influencing the area, no direct adaptation measures have been implemented hitherto. Some of the proposed green adaptation measures (such as sustainable forest management, peat bog restoration and enhancing ecosystem resilience) have been implemented within current nature conservation management practices.

Nature of adaptation measures: Since the Green Roof is a prospective case study, none of the proposed adaptation measures have been adopted yet. However, most of the measures proposed by local stakeholders were ecosystem-based, simultaneously serving the purposes of climate change adaptation and nature protection. Nevertheless, hitherto it does not seem that the nature of potential adaptation measures would play a role in the local decision-making process on potential implementation of adaptation measures; therefore, this aspect has been marked as less important.

3. What obstacles were encountered during the adoption or implementation of adaptation measures and strategies/policies? Please explicitly refer to the factors mentioned in the checklist, highlighting the factor in bold, and be specific about any relevant policies! (Approximately 500 – 1000 words)

The Green Roof presents a prospective case study; therefore, no adaptation measures have been implemented in the area yet. However, there are several potentially limiting obstacles which can be expected to appear during the implementation in the future.

1) Limited interest in issues connected to climate change (and environmental issues in general) among population and political representatives, mainly due to ambiguous projections of future climate change impacts in the Czech Republic and lack of political interest in climate issues.

2) The approval of National Adaptation Strategy postponed to 2016.

3) The fact that climate adaptation is not a cross-sectional topic in the Czech Republic and has not been integrated into existing structures.

4) Limited financial resources allocated to environmental issues.

4. If any obstacles were overcome, how was this achieved? (Approximately 500 words)

The Green Roof presents a prospective case study; therefore, no adaptation measures have been implemented in the area yet.

5. What are the future prospects of the climate change adaptation activities in the case study? (Approximately 200 – 500 words)

Potential future adaptation activities will probably not take place earlier than after the implementation of the National Adaptation Strategy in 2016. Afterwards, they might be implemented in the form of new nature conservation measures and adjusted forest management in the Šumava National Park. However, it can be expected that such changes will be gradual, since the area face several conflicts regarding a desirable level of nature protection and all conservation approaches tend to be conservative and widely discussed before implementation.

6. What is the key message from this case study (and which could work in other cases as well)? Don't forget to consider any specific policy recommendations that arise in your case study! (Approximately 200 – 500 words)

The key message of this case study is that a successful implementation of adaptation measures in case of low interest in this issue among the public and political representation requires awareness-raising and knowledge sharing on all governance levels. It is important to communicate with both local stakeholders and regional/national authorities and draw their attention to various environmental and socio-economic issues connected to climate change. In the context of the Czech Republic, it proved useful to base the communication with stakeholders and authorities on issues which they perceived as important (e.g. local conflicts linked to nature conservation, regional water management and flooding) and to elucidate their connection with climate change subsequently.

7. References

Beniston, M., Stephenson, D.B., Christensen, O.B., Ferro, C. a. T., Frei, C., Goyette, S., Halsnaes, K., Holt, T., Jylhä, K., Koffi, B., Palutikof, J., Schöll, R., Semmler, T., Woth, K., 2007. Future extreme events in European climate: an exploration of regional climate model projections. Clim. Change 81, 71–95.

Dendoncker, N., Bogaert, P., Rounsevell, M., 2006. A statistical method to downscale aggregated land use data and scenarios. Journal of Land Use Science 1, 63-82.

EEA, 2010. The European environment – State and Outlook 2010: Czech Republic Country Assessment. Available from < http://www.eea.europa.eu/soer/countries/cz >.

Eurobarometer, 2014. Standard Eurobarometer 81: National Fact Sheets. Available from < http://ec.europa.eu/public_opinion/archives/eb/eb81/eb81_en.htm >.

Gorner, T., Najmanova, K., Cihar, M., 2012. Changes in Local People's Perceptions of the Sumava National Park in the Czech Republic over a Ten Year Period (1998–2008). Sustainability 4: 1354–1370.

Hanel, M., Vizina, A., Máca, P., Pavlásek, J., 2012. A Multi-Model Assessment of Climate Change Impact on Hydrological Regime in the Czech Republic. J. Hydrol. Hydromechanics 60, 152–161.

Hlásny, T., 2012. The influence of climate change on Norway spruce forests in the Czech Republic [in Czech]. Lesnická práce 91/1: 29–31.

Hönigová, I., Vačkář, D., Lorencová, E., Melichar, J., Götzl, M., et al., 2012. Survey on grassland ecosystem services. Report to the EEA – European Topic Centre on Biological Diversity. Prague: Nature Conservation Agency of the Czech Republic. 78 pp.

ME CR, 2013. Sixth National Communication of the Czech Republic under the United Nations Framework Convention on Climate Change. Ministry of Environment of the Czech Republic.

OECD, 2013. Czech Republic Country Profile. In: Water and Climate Change Adaptation – Policies to Navigate Uncharted Waters. 112 pp.

Rounsevell, M.D.A., Metzger, M.J., 2010. Developing qualitative scenario storylines for environmental change assessment. Wiley Interdisciplinary Reviews: Climate Change 1, 606–619.

Rybanič, R., Šeffer, J., Čierna, M., 1999. Economic valuation of benefits from conservation and restoration of floodplain meadows. In Šeffer, J., Stanová, V. (eds.), Morava River Floodplain Meadows – Importance, Restoration and Management. DAPHNE – Centre for Applied Ecology, Bratislava, pp. 147-160.

Settele, J., Hammen, V., Hulme, P., Karlson, U., Klotz, S., Kotarac, M., et al., 2005. ALARM: assessing Large-scale environmental risks for biodiversity with tested methods. Gaia 14, 69–72.

Spangenberg, J., 2007. Integrated scenarios for assessing biodiversity risks. Sustainable Development 15, 343–357.

Štěpánek, P., Skalák, P., Farda, A., Zahradníček, P., 2011. Climate change in the area of the Czech Republic according to ALADIN-Climate/CZ simulations, in: Bioclimate: Source and Limit of Social Development, International Scientific Conference, 6th – 9th September 2011, Topolcianky, Slovakia.