BASE BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

SEVENTH FRAMEWORK PROGRAMME

CzechGlobe

Subgroup: **City and Infrastructure**

The City of Prague

(CzechGlobe, Czech Republic)

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CzechGlobe

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XX/XX/XXXX

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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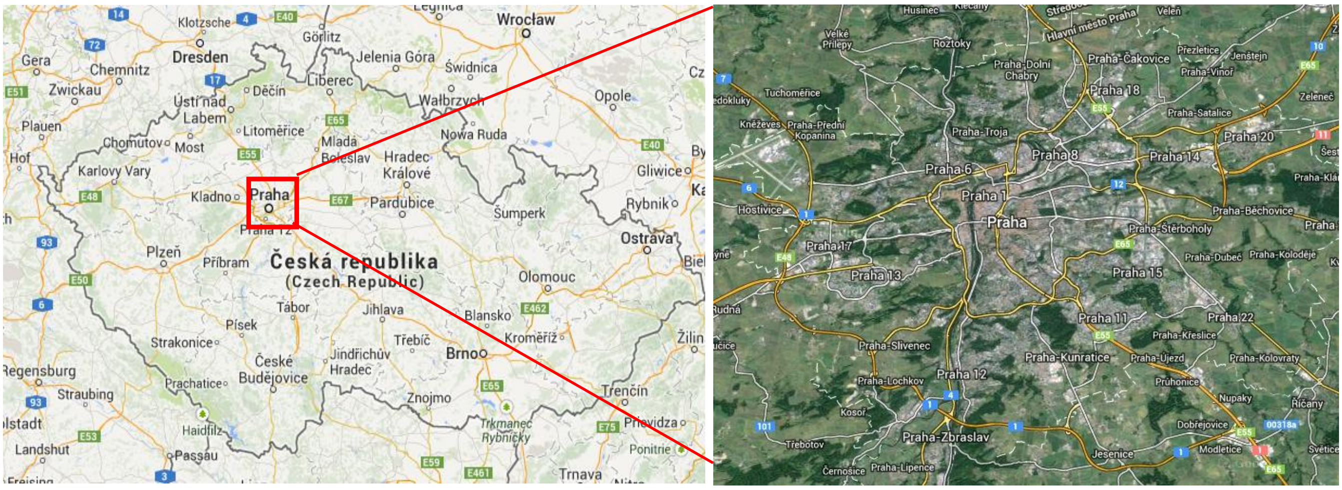
1. General Case Study Description

A. Location

City of Prague



GPS: : 50°05′ N/ 14°25′ E
Area: 496 km^2

B. Case Study Summary

A traditional approach in flood risk management (river training, construction of embankments, reservoirs building) that aims at reducing flood risk than decreasing vulnerability and increasing adaptive capacity still prevails. Therefore, there is a need for a new and more adaptive approach in Czech flood risk management that will better cope with future uncertainty resulting from changing climate.
The case study is focusing on analyzing current flood control system, and concepts for integrative flood risk management under climate change (adaptive water management) in this city. Moreover, adaptation pathways concerning Prague urban heat island are investigated.
The main aims of this case study are:

1) To assess the adaptive capacity of city (from the point of view of adaptation to flooding) and analyse the process of adaptation to climate change in selected key sectors (flood risk management, infrastructure, spatial planning).

2) To apply cost benefit analysis of flood control adaptation measures in Prague

C. Context

In 2002, Prague experienced severe flooding (500-year flood) with total damage of 24 billion CZK (1 billion EUR). This event was recognized as one of the most expensive weather-related disaster in history of the city with heavy damages on infrastructure, housing and environment. Since this event, Prague municipality has been developing and implementing flood control measures. Future climate scenarios predict a change in the number and intensity of extreme events, inter alia, increasing the risk of river flooding.

However, these measures just as current Czech flood management strategies do not adequately correspond to impacts from future climate change and they seem to be more a reaction to past events than an adaptation to future climate change. A common understanding of need for climate change adaptation is yet to be developed.

D. Brief General Information on Climate CHANGE and related issues

Floods have been recognized as a major natural hazard within Central Europe, especially since the end of 1990s, when the whole region experienced several very harmful events (Kundzewicz et al., 2005). According to many authors dealing with the problem of floods, the overall effect of such events is very likely to increase in the future, not only because of changing climate but also due to socio-economic changes in the society (Mitchell, 2003; Kysely et al., 2011; Rojas et al., 2013). Regarding the changing climate, the greatest issues potentially are wetter winters, dryer summers with more precipitation extremes and weather fluctuations in general (Kysely et al., 2011). As mentioned by Rojas et al. (2013), the Czech Republic is one of the countries most threatened by future floods in terms of extent and cost of possible damage, and it is therefore absolutely crucial to invest in adaptation and flood protection measures.

The case study is located in the temperate climate zone. According to the latest research, the average annual temperature has shown a long-term upward trend in the last few decades. The average annual temperature in the last fifty years had significant annual changes, however, there is a trend of gradual increase (less than 0,3 °C/10 years) - significant increases of the temperature have been recorded in summer (0,4 °C/10 years), slow increases have been recorded in winter months (less than 0,1 °C/10 years). The average annual rainfall in the last two decades has increased by approximately 5% when compared to the standard period (1961-1990). The temporal variability of average daily precipitation in the two decades has increased in the warm half of the year and decreased in winter months.

E. Existing Information on Case Study's adaptation history

Recently, the city has no strategy dealing with the climate change adaptation. Some tentative adaptation measures have been very briefly mentioned in city Strategic plan, which is now being updated. A common understanding of need for climate change adaptation is yet to be developed.

However, with regard to adaptation in water management, since 2002 event, Prague municipality has been developing and implementing flood control measures. Future climate scenarios predict a change in the number and intensity of extreme events, inter alia, increasing the risk of river flooding.

The case study was focused on backcasting and therefore did not aim to make any changes in the adaptation process in the city. The measures were quite advanced in terms of efficiency and preparedness to a potential flood of a great extent (up to 500 year flood flow rate). The flood protection system had been planned for decades but the works themselves started just in the beginning of the new millennium. After finishing the first phase of the works (partial protection of historical centre of Prague) the city was hit by a huge flood (500 year flood) and the original plans were subsequently changed in order to make the city resilient even against an event of such extent.

The flood protection system of Prague has been now finished and protects the most parts of Prague from the 500 year floods. It consists mostly of fixed and mobile barriers and safety valves in the canalisation network. Obviously to protect the city, its inhabitants and priceless historical heritage from such great floods there was a need for grey infrastructure. However, any greener strategies or approaches have been basically still missing even though these could bring plenty of co-benefits and besides floods could support an adaptation to other risks connected with a changing climate. It is quite clear that green and blue infrastructure would only serve as some kind of an additional support to the flood barriers but it could be still very useful, for example to tackle flash floods caused by extreme

rainfall. Unfortunately such measures are not included in the flood protection plan and do not seem to be of any priority when it comes to risk management of the city.

At this moment new discussions have arisen especially due to a missing sufficient flood protection system around the Prague Zoo and Troja district. The initiative was put forward by the local representatives and policymakers and by the Prague Zoo. The negotiations are expected to be quite complicated as the Prague city hall does not seem to be very keen on a further flood protection development which is apparent especially from new development plans for the area which do not include any flood control measures. This is quite surprising because the city hall tried to involve businesses and other stakeholders in the planning stage of the existing flood protection system. They were supposed to be involved in order to help to identify such non-residential areas where there was a need for flood protection (e.g. such parts of the city where industries and businesses were within the potentially flooded areas). Based on our information from the city hall, there was not very much activity and interested on the side of industries and they mostly did not want to participate or express their need for flood protection. In reaction to that the concerned areas were eventually not included in the flood control system. Compare to this experience it is quite unclear why the situation is completely the opposite at this moment as there has been a demand by the businesses and local stakeholders since many years ago but it is somehow overlooked by the city hall and policymakers.

F. Connection with other research projects:

Previous research project: FP6 project CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment), 2006-2010, applications of regional climate modelling studies at a resolution of 10 km for local impact studies in key sectors of the region, coordination Dr. Halenka (Charles University in Prague).

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 analyze 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]
Czech Rep. The City of Prague	☑ Objective 1 ☑ Objective 2 ☐ Objective 3 ☑ Objective 4 ☐ Objective 5 ☑ Objective 6 ☑ Objective 7	Example: A Public	☐ Rural ☑ Urban ☐ Coastal ☐ River Basin	☑ Local ☐ Regional ☐ National ☐ Transnational ☐ European /Global	☐ Bottom-Up ☑ Top-Down	☑ Retrospective ☑ 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]

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

☑ Extreme Temperatures ☐ Water Scarcity ☑ Flooding ☐ Sea level Rise ☐ Droughts ☐ Storms ☐ Ice and Snow	☑ Extreme temperatures ☐ Water scarcity ☑ Flooding ☐ Coastal Erosion ☐ Droughts ☐ Soil Erosion ☐ Vector Borne Diseases ☐ Damages from extreme weather related events (storms, ice and snow)	☐ Agriculture and forest ☐ Biodiversity ☐ Coastal Areas ☑ Disaster risk reduction (1) ☐ Financial ☐ Health ☑ Infrastructure (2) ☐ Marine and Fisheries ☑ Water Management (1) ☑ Urban (1)	☐ Agriculture ☐ Biodiversity & Ecosystems ☐ Coastal and Marine systems ☐ Energy ☐ Health and Social Policies ☑ Transport (2) ☑ Production Systems and Physical Infrastructures (2) ☑ Water resources (1) ☐ Tourism	☐ Yes ☐ Ongoing ☑ No	☑ Assessment ☑ 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

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

2. Case study research Methodology

a) Research Goals

The case study City of Prague focuses on two main topics: 1. Analysing the process of adaptation to climate change and urban adaptive capacity and 2. Cost benefit analysis of flood control adaptation measures. The case study aims to answer following research questions:

1. The process of adaptation to climate change, urban adaptive capacity

- What adaptation measures have already been implemented and how they reflect the uncertainty of future climate change (projections)? Were these measures implemented in order to adapt to the impacts of changing climate?
- How is the concept of adaptation to climate change integrated in key sectors (in documents, plans, strategies, policies)?
- Who is the main actor in the process of adaptation to climate change? What are the main factors (drivers) that contribute to the adaptation process in city and what are the factors that hinder the process?

2. Future adaptation measures and pathways:

- What are the potential future adaptation measures and adaptation pathways that will deal with future climate with respect to the effect of urban heat island?
- What are the attitudes/preferences of selected stakeholders for particular types of measures/pathways?

The expected outputs of case study are following:

- Evaluation of the degree of integration of the concept of adaptation to climate change in documents (plans, strategies, policies) in key sectors, description of implemented adaptation measures.
- Cost-benefit analysis of flood control adaptation measures.
- Analysis of the adaptation process (main actors, drivers, obstacles)
- Developing future adaptation measures/pathways, the quantification of these measures/pathways (costs and benefits).

b) Stakeholders involved

A group of various stakeholders with different preferences for potential measures are included in case study research:

- Prague City Hall representatives (Department of Spatial Planning and some other departments) - a key stakeholder in terms of implementation of adaptation measures.
- Water managers (River basin authorities - Povodí Vltavy s.p.) - a key stakeholder responsible for potential measures in water sector.
- Prague Public Transport Company representatives - initiated and already implemented some measures after flood in 2002.
- Local developers developing in flood prone areas.
- Group TIMUR (Initiative for local sustainable development) - a promoter of "green" adaptive measures.

c) Methodology

CBA costs

- The costs of FCS (including installation, maintenance and storage) should be available from the Prague city hall.
- In case of very high flow rates (such as in 2002), there will still be some areas flooded. The potential damage caused even despite the FCS. These costs will be calculated on the same basis as the benefits part (more details below).

CBA benefits – avoided damages and expenditures

- Mixed methodology based on both, own calculations and experiences (costs) from previous flood events, especially in 2002.
- Own calculations based on the methodology by Kok, 2001 and Genovese, 2006.

Calculations (based on Kok, 2001 and Genovese, 2006)

- The main idea: “replacement value” which expresses how much money it would cost to get an identical object (or to fix the object).
- Damage function: a value in the interval 0-1 which describes the extent of a damage depending on the depth of water.
- Data requirements:
  - Cadastral map
  - Map of flooded areas
  - Depth of water
    - Either as a map, if available from IPR or calculated by GIS based on the terrain model (contour lines).

- Market price of apartments (for Prague districts available at: http://www.iprpraha.cz/uploads/assets/soubory/data/UAP/UAP2012/2_8_bydleni.pdf, for Prague as a whole available at: http://www.czso.cz/csu/redakce.nsf/i/ceny_bytu).
- Market price of industrial buildings.
- Cost (per km) of a rail and road construction.
- Question how to sort out the damage on facilities for both, residential and industrial buildings?

Residential areas

- Damages divide in three categories:
  - Buildings
  - Facilities
  - Cars (will be omitted as we suppose they can be moved to safe areas)
- In terms of buildings there may be a difference between family houses and apartment blocks. For our purposes, we will consider all residential building as apartment blocks.

Buildings: DAMAGE = p * A * H * V

p – percentage of urban fabric covered surface in the particular land use

A – area (m2) of the land use

H – water depth damage factor

V – average price for m2 for an apartment

Damage factor for buildings

Depth of water [m]	DF
0	0
0.5	0.06
1	0.08
1.5	0.1
2	0.44
3	0.62
4	0.78

5	0.8
6	1

Damage factor for facilities

Depth of water	DF
0	0
1	0.47
2	0.50
3	0.66
4	0.83
5	1

Urban fabric categories

- Residential continuous dense urban fabric (residential structures cover more than 80% of the total surface).
- Residential continuous medium dense urban fabric (residential structures cover more than 80% of the total surface while less than 50% of buildings have 3 or more floors).
- Residential discontinuous urban fabric (buildings, roads and other artificial surface cover 50 – 80% of the total surface).
- Residential discontinuous sparse urban fabric (buildings, roads and other artificial surface cover 10 – 50% of the total surface).

Industrial areas

- Damages in industry usually count from 75% for damage to property and 25% for a productivity loss.
- If we assume that in the flooded areas there are mainly administrative buildings and such industries which do not involve heavy machinery, we can use the same function as for residential buildings.
- As for productivity loss, we can either count a loss on GDP (which would be, however, very complicated) or we can use the proportion mentioned above and calculate the productivity loss based on the damage to property.

Buildings: DAMAGE = p * A * H * V

p – percentage of urban fabric covered surface in the particular land use

A – area (m2) of the land use

H – water depth damage factor

V – average price for m2 for an industrial building

Damage factor

Depth of water	DF
0	0
1	0.4
2	0.8
3	0.9
4	1

Infrastructure

- For our purposes, we will include roads and railroads.
- Instead of per area, the numbers will be per length.

Buildings: DAMAGE = l * H * V

l – length of roads/railroads in the area

H – water depth damage factor

V – average cost per km of a constructed road/rail

Damage factor

Depth of water	DF
0	0
5	1

Data from previous events

Environment, cleaning, evacuation

- The costs cannot be calculated by the same method as in the previous cases as the damages are not so dependent on the inundation depth.
- We will use the costs from 2002 (as we suppose that the proportion of parks and green areas has not changed much since 2002) and adjust them in respect to the inflation rate.

- Note: Partners/Case Studies using PRIMATE tool will be using CBA (to prioritize) and/or MCA (with stochastic PROMETHE II) and the Monte Carlo Uncertainty Analysis, so please check these boxes.

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)	(Y)
Real option analysis	
Climate risk management process	
D) Participatory Methods	
Scenario Workshop	
Participatory Cost Benefit Analysis (PCBA)	
Participatory add-ons to CBA	
Participatory add-ons to Multi Criteria Decision Analysis	
Participatory add-ons to Adaptation Pathways	(Y)
Other (add extra lines if necessary):	

(Máx 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

	2013				2014				2015			
Phase 1: Analysis of current adaptation measures												
Establishing contacts with relevant stakeholders: initial meetings, contacting via e-mails			x	x	x							
Analysing the process of adaptation to climate change in city, assessing the urban adaptive capacity				x	x	x						
Data collection						x	x					
Cost benefit analysis of selected flood control measures						x	x	x				
Phase 2: Future measures and pathways												
Development of adaptation measures through adaptation pathways approach					x	x	x	x				
Prioritizing of alternative adaptation pathways								x	x			
Phase 3: Results dissemination												
Scientific manuscript										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):

Case: Venice — Person: Margaretha Breil

Case: Rotterdam — Person: Marjolijn Haasnoot, Mark Zandvoort

Case: Copenhagen — Person: Anne Jenson, Bjorn Bedsted

Case: Cascais Person: Filipe Alves

Case: Leeds Person: Dabo Guan, Xin Li

Case: Jena Person: Oliver Gebhardt

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

Name: Volker Meyer, Oliver Gebhardt ; Partner: UFZ

Name: Marjolijn Haasnoot ; Partner: Deltares

Name: Filipe Alvez ; Partner: FFCUL

f) Research Outputs

a. Scientific Publications

not specified yet

- Interim reports + final case study report for D5.5 (Month 30)

- Scientific papers: #

Provisional Title: ____

____; Month/Year: ___/_______

(add more papers in case you need)

b. Other Publications

- Books/Books Chapters: # 1

Provisional Title: ____

____; Month/Year: ___/_______

c. Other

- Scientific conferences: # ___

Provisional Title: poster - Exploring adaptation pathways: Case of Prague urban heat island Conference: Deltas in times of climate change II Month/Year: 09/2014

Provisional Title: ____ ________________________ Conference: ________________________________ Month/Year: ____/______

- Invited seminars, presentations at local events, etc…

3. Participation in Climate Change Adaptation

a) Process overview

As our case study was not directly focused on the application of participatory methods, in our case the use of these methods was rather supplementary and marginal. In this section, we analyse participation within the process of development and implementation of flood control system (FCS) after the 2002 flooding. We have created a short survey in order to map and analyse this process of adaptation measures planning and the decision making process. This part therefore does not directly relate to our cost benefit analysis but it should help us to understand the activities and processes which were crucial for the whole adaptation system in Prague. It is also important to mention that our case study was rather back casting in terms of decision making process and the realisation of the adaptation measures as such. In general, we created a survey to map the mechanism behind the past decision making process.

b) Participation in the Process Phases

(Please uncover the role of all participants in the process of implementing adaptation measures. The adaptation implementation has been divided into four phases for purposes of ease: 1) Initiative/decision to act, 2) Development of potential adaptation options, 3) Decision-making, and 4) Implementation. The process phases are to be filled out with information corresponding to each participant. I.e. if experts were not consulted in the 'decision-making' phase, then describe why they were not included. It is also important that a wide array of participants is described, including those that were excluded from parts of the process.)

Make a bullet point for each of the five participant categories below (and distinguish between for example different stakeholder or expert groups) and be as descriptive as possible how, why/why not were they involved.

Democratic and political tradition for participation

During the communist period in the Czech Republic (1948-89) the centralized command and control were absolute and planning without involving stakeholders and the public has been heavily employed.

Despite no longer been a communistic country, public participation in spatial planning, esp. at the regional level, is still missing the greater involvement of local stakeholders and citizens in the decision-making process. For example, the flood adaptation measures are often organized by the state administration without wider public involvement.

Historical event been important for the local engagement in climate change adaptation

The experience of a series of disastrous floods in a relatively short period of time (eight extreme flood events in the last 16 years) in the Czech Republic has stimulated a greater engagement in climate change adaptation. In particular, the floods in 2002 and later in 2013 may be considered important landmarks that initiated a profound shift in the perception of climate change among public and triggered changes in approaches to climate change adaptation.

The institutional setting within which adaptation takes place

The responsibility for flood protection measures which have been implemented since 1997 is at the national level divided between two institution — the Ministry of Agriculture (responsible primarily for implementation of technical measures) and the Ministry of the Environment that together with various non-governmental organizations and local initiatives are the main promoters of ‘’green’’ adaptation measures. Governance responsibilities are highly fragmented between these two actors, which results in rather inefficient performance in climate change adaptation process.
At the regional level, Prague City Hall in cooperation with the Povodí Vltavy is responsible for implementation of flood control measures on the Vltava River Prague and small watercourses. Some environmentally oriented organizations and local initiatives of citizens raising suggestions are also involved in the adaptation process. In case of Prague, the stakeholders involved include Prague City Hall, affected Prague districts, political representation, the Czech Hydrometeorological Institute, Povodí Vltavy - Vltava River Basin and professional firms (eg. Hydrosoft).

Problems that occurred mainly during the approval and permit process of FCS installation were especially:
- Questions of property rights and relations of land that was in the area of planned FCS
- Coping with the requirements of heritage preservation authorities (especially in the center and Troja area where the line of the mobile flood control measures was required to be as invisible as possible
- During the installation of FCS minimizing intervention into green areas

Process phases:

1. *Initiative/decision to act*

Stakeholders – It was expected to see entrepreneurs and businesses in this phase. They, however, did not really express any greater interest and therefore were not a part of the forthcoming phases.

Citizens – Prague districts which were affected by the flood risk.

Politicians – Politicians at national, regional and local level.

Officials/legislators – Safety and crisis management department (involved in the initiation process) of the Prague hall

2. *Development of potential adaptation options*

Stakeholders – Povodí Vltavy (a state company responsible for the administration of Vltava river basin), ecologists

Experts - Czech hydro meteorological office, expert companies

Officials/legislators - Safety and crisis management department of the Prague city hall (responsible for the identification of areas to be protected and suitable measures)

3. *Decision-making*

Citizens – City districts involved

Politicians – The main actors of this phase.

4. *Implementation*

Experts – expert companies

Officials/legislators

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)

Strengths	Weaknesses
- **Even though there were people from all the sectors mentioned above involved, the whole process ended up by some kind of a final decision.**	- **There is no proof about transparency of the project, especially due to poor participation in the final phases.** - **In such a city as Prague, where there is a serious threat to residential and industrial areas, but also to the historical centre, there were many compromises made. As a result, the protection is probably not as efficient as it could be (which is hard to evaluate as every group involved has their own priorities).**
Opportunities	**Threats**
- **More stakeholders and citizens could probably be involved.**	- **Participants will not be interested in the process. This happened especially with entrepreneurs who did not express any interest. That's why some industrial areas are not as protected as they could have been if they had co-operated.**

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 case, participation did not really influence any of the strategies or measures as we in fact did not intent to create any. They did, however, for sure influence the current flood protection system in Prague. It was, obviously, local officials and politicians who had the greatest influence, as well as experts. Also, as the historical centre of Prague was involved and affected by the FCS, the preservationists had a great influence in terms of the design of mobile barriers and their exact trajectory.

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

The participatory process could be improved through enhanced communication between individual actors in spatial planning/adaptation process, which would support discussion and help to raise public awareness.

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

No

4. Climate Change Adaptation Measures and Strategies

a) Adaptation Measures under analysis in your case study

(Please identify your Adaptation Measures considered in this case-study and provide a short description of each)

Adaptation Measure(s):

1) Flood control system
   a. Fixed barriers (levees, dykes)
   b. Mobile barriers
   c. Other measures (closures and pumping systems in the canalisation)

b) Adaptation Measures selection and data availability prior to BASE

These measures were selected because they are comprised in the official flood control system for the city of Prague. The baseline for the analysis is the state from 2002 when these measures were not in place and the city was hit by the greatest flood in its modern history. As most of the flood control system is already in place, we can compare the situation without (2002) and with the measures (2014) for the flow rate from 2002.

c) Full description of Adaptation Measures

(Please provide a full description on each of the Adaptation Measures regarding this 21 leading questions under. If more than one Adaptation Measure please copy paste the structure provided.)

<u>Process</u>

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

The measure is already in place, it was implemented by the Prague Council.

II. Does the measure initiate further activities for adaptation to climate change? **N**

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

IV. Is the measure effective under different climate scenarios and different socio-economic scenarios? **Y**

V. Is the adaptation measure iterative? **Y**

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**

a. Please describe briefly how

The flood control system enables socio-economic and demographic development in such parts of the city that would have been otherwise too threatened by floods to be actually attractive for both, inhabitants and businesses.

VII. Can adjustments be made later if conditions change again or if changes are different from those expected today? **Y**

Outcome

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 importance is absolutely crucial. Floods are expected to be not only more frequent but also stronger due to the changing climate. The measure protects buildings, infrastructure (including the Prague metro), environment, historic values and sites, and public health.

IX. What portion of the targeted potential damages can be avoided by implementing the measure? **80%**

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)

The economic analysis has not been finished yet. At this moment, we are in the process of data collection.

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

We have not obtained the data about administrative costs yet. Nevertheless, the measures can be subsidised from EU funds.

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? **N**

XIII. Does the measure have effects on employment? **N**

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

XV. What is the timeframe during which the measure will have an effect? **It depends on the lifespan of particular parts of the control system and their maintenance but in general in terms of decades.**

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

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

No, the measure is only connected with flood protection, but can have side-effect on other environmental issues (e.g. changes in flow could affect river fauna, flora, fish migration).

Equity

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

The distribution of the effects of the flood control system is equal within particularly protected areas.

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

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.

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

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

The Czech Republic is one of the European countries most threatened by future floods in terms of extent and cost of possible damage, and it is therefore absolutely crucial to invest in adaptation and flood protection measures (Rojas et al., 2013). In recent years, Prague has experienced an increased frequency and strength of these events (the greatest one in 2002) and regarding to future climate projections, this trend is very likely to continue.

Adaptation measures to minimise the vulnerability of the city to these events are absolutely crucial. The most threatened are especially buildings, infrastructure (including Prague metro), businesses, public health, environment and historical heritage.

Measures already in place (only measures within the area of the city are taken into consideration):

- Non-structural measures: disaster response management, risk transfer tools, monitoring and management
- Structural: Improving flood defenses (engineering)

The risks change due to both, climate and socio-economic change. The changing climate can significantly increase the character of future events, especially in terms of frequency and flow rate. Socio-economic change may change the risk in terms of development/settlement or abandonment of potentially flooded and therefore threatened areas.

Drivers: precipitation

- Clusters: infrastructure, human health, water management

Scenarios: The case study is rather static and is based on the city local plan and therefore does not use any climate or socio-economic scenarios.

Which adaptation tipping points can be identified?

The tipping points are very difficult to be defined for this case study and our approach as the measures are already in place and these should withstand even a very extreme event such as a 500-year flood.

The point where protection standards can no longer be met financially (as flood risk and required investments in protection are becoming too high) is quite unlikely to be reached in any closer future, especially within current urban plan of the city. If there were any extreme changes (for example massive settlement in unprotected areas in flooded zones), the critical levels might be reached more easily and sooner, however this situation is very improbable.

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?

The primary objective of the adaptation is to protect the city from floods and to prevent damages which could be potentially caused by such events. The objective is not only physical protection but also to create such an integrated risk management approach which would enable to deal with these events in the most efficient and controllable way.

Potential measures are of two kinds, structural (engineering solution = flood control system) and non-structural measures (awareness raising, disaster response management, risk transfer tools, monitoring and management).

For the baseline strategy it is assumed that the flood protection is maintained on the same level as it was in 2002 before the great flood event. The baseline includes no adaptation measures and no increasing threats caused by climate change are taken into account. The baseline includes neither backlog of investment realised before 2002 nor autonomous/non-planned adaptation.

Measures are fully compatible and interdependent, so they need to be bundled in order to be efficient and work properly.

What are alternative adaptation pathways?

The measures should handle the flow rate of 500-year floods and it is therefore not very likely that they will fail to meet the objectives in any closer future (in case the management measures work properly).

In general, there are no such measures which would be competitive with the current system, mainly due to the extent of floods Prague has to face. The current system could be for sure enhanced and/or complemented by some ecosystem-based measures. These would, however, not be able to provide such a protection as the conventional measures and would only serve as a supplement to the original system.

Developing adaptation pathways: Urban heat island in Prague

The number and intensity of hot days have considerably increased in the last three decades and it is nearly certain that there will be more frequent hot extremes in the second half of the 21st century.
The impact of heatwaves is particularly strong in cities and towns due to the UHI effect. In Europe, in the last decades, heatwaves have caused the most human fatalities of the natural disasters (EEA 2012). In 2003 the European heat wave resulted in 40,000 excess deaths (García-Herrera et al. 2010)

Moreover, in the future, urban areas are expected to suffer more due to the combined outcome of climate change and the urban heat island (UHI) effect (IPCC 2014). UHI effect shows the increased urban air

temperature compared to surrounding rural areas, where the temperature difference can be up to 10 °C or more (EEA 2012). The most common effect of UHI is accumulation of heat in urbanized areas which results in higher temperatures, especially at night, compare to the surrounding non-built up areas (IPCC 2013). UHI effect rises the number of hot days (and nights), duration of heat waves, affects health impacts and, subsequent mortality (Salcedo Rahola et al. 2009).

In order to respond to the UHI effect in the urban area, it is necessary to implement suitable adaptation measures. The table 1 below provides comprehensive overview of particular adaptation measures related to heat stress.

Table 1: Overview of particular adaptation measures to heat stress (based on EEA 2012; Runhaar et al 2012)

Adaptation measures to heat stress		
Green measures	**Soft measures**	**Grey measures**
Support of green infrastructure ▪ **Green areas** ▪ **Street vegetation** ▪ **Green roofs** ▪ **Green facades** ▪ **Ensure sustainable watering**	Support to vulnerable groups (identification, distribution, targeted action) Information on adapting behaviour during heatwaves particularly to vulnerable Preparedness of medical care	Urban design to provide shade (orientation/reduce sun exposure/wind direction, compact buildings)
Support of blue	Considering UHI reduction in	Building insulation

infrastructure ▪ **Open water, fountains** ▪ **Small ponds**	urban planning	
Ensuring wind flow ▪ **Fresh air form greenery outside the city can flow in**	Heatwaves warning systems Heat action plans including appropriate institutional structures Monitoring and inspection	Cooling (air conditioning) Passive cooling of the buildings Blinds, shutters to provide shade
Wetting streets and roofs	Awareness raising, ensuring broad participation	Increase albedo (reflecting levels) of roofs, pavements
	Adapting building codes to include insulation and shadowing against heatwaves	
	Mapping of UHI and cool places	
	Move to cooler areas	

Case of Prague UHI

In the case of Prague, urban heat island has already occurred and is becoming more serious. According to the outcomes of UHI project (http://eu-uhi.eu/), its annual average intensity during the period 1961-2012 was 2.2°C with a peak during June and July (2.4°C). The intensity of the heat island has been increasing in last years, especially during summer months, almost by 0.5°C.

Research objective

Taking into account impact of climate change, potential adaptation measures and spatial planning, we aim to explore adaptation pathways of Prague UHI, within the time frame 2014-2100.

Methods

Study area: For modelling purposes, we selected particular area in Prague 6 - Dejvice (see Figure 1 and 2 below)

Figure 1: Selected case study area in Prague (source:Google maps)

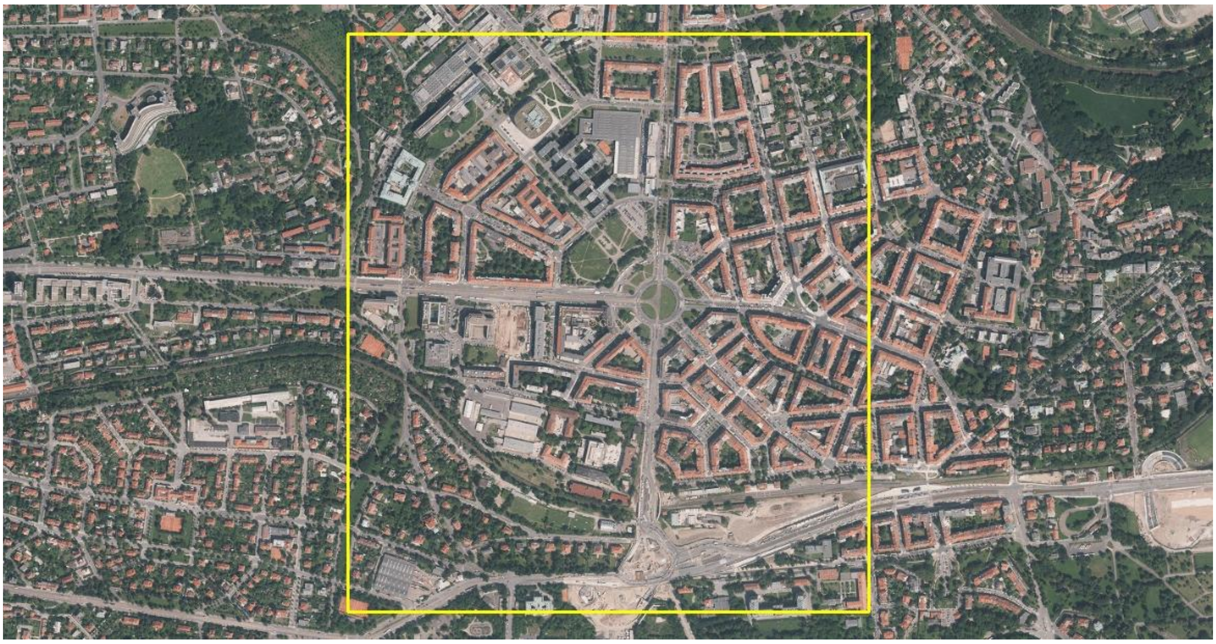


Figure 2: Selected case study area – ortophoto(source: Zabaged)

Table 2: Classification of current land use (LU)

LU categories	**Area covered (%)**
Impervious area without buildings	14,5
Impervious area with buildings	39,3
Water area	0
Lawn/meadow area	6,5
Shrub area	0
Tree area	5,6
Buildings mixed type I*	28,3
Buildings mixed type II**	5,8

(apart from buildings include 10% tree area, 10% meadow)*

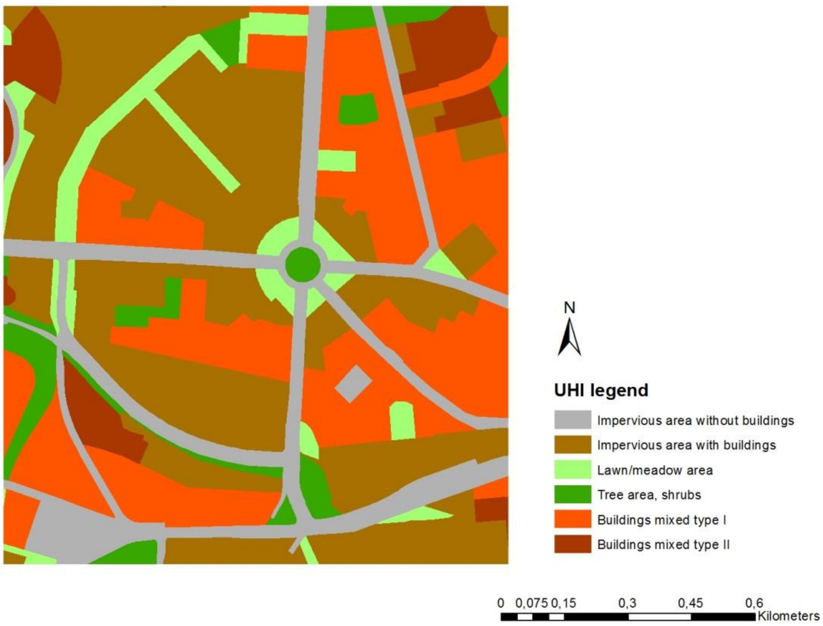


Figure 3: Land use classification (based on Spatial plan of Prague)

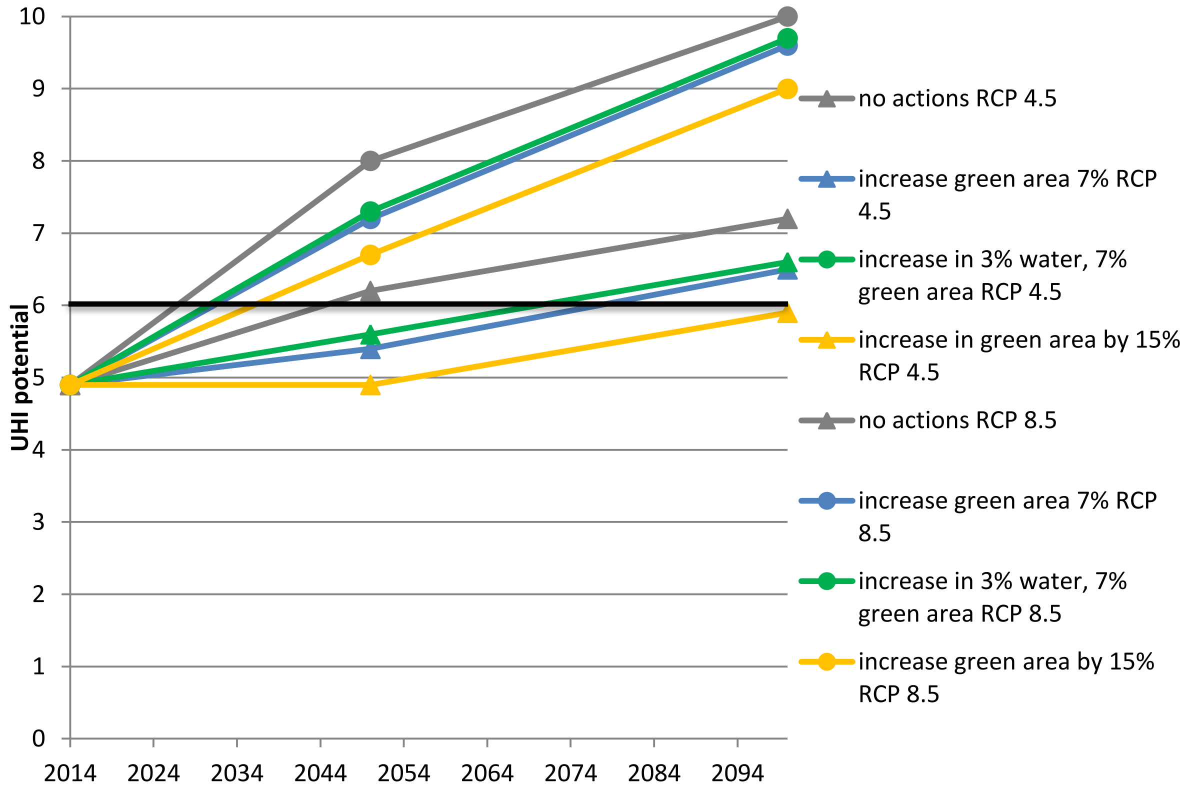


Figure 4: Calculation of adaptation tipping points

Adaptation pathways approach was applied to assess future climate change impacts and potential adaptation measures. Firstly, we calculated tipping points for particular actions and scenarios - RCP 4.5, RCP 8.5 (see Figure 4).

Adaptation pathways were developed for the three selected adaptation measures:

(1) Increase in green area by 15%,

(2) Water area increased by 3%, green area by 7%

(3) Increase in green area by 7%,

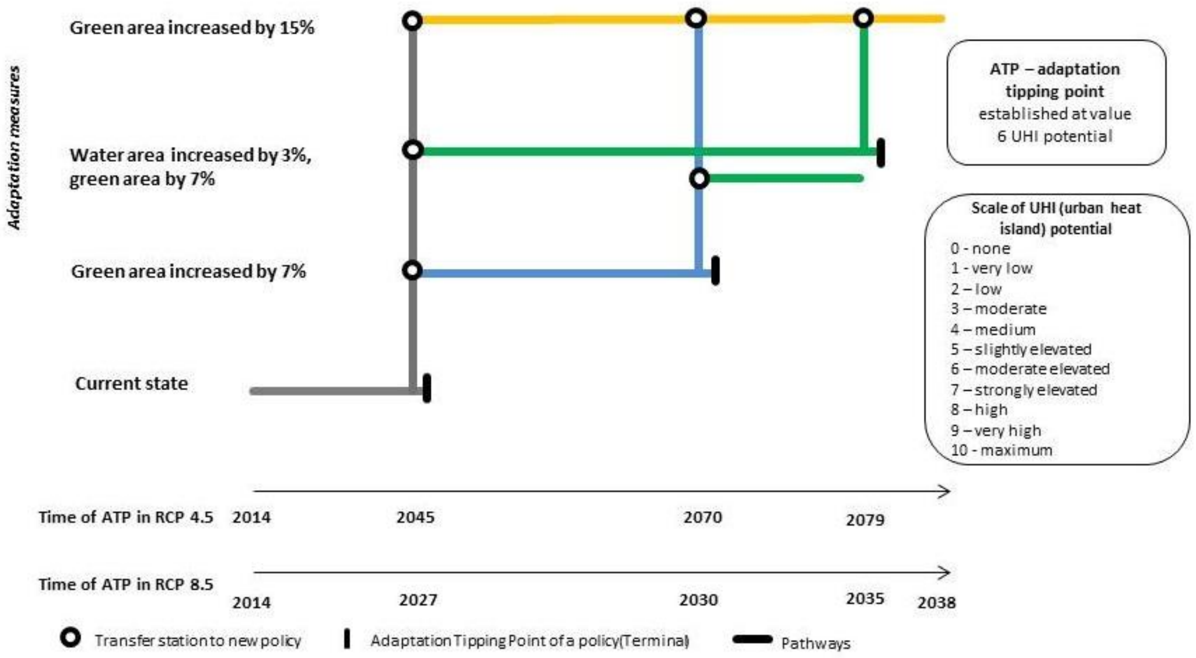


Figure 5: Adaptation pathways – UHI in Prague

Some of the findings:

- Moderate elevated value (6) of UHI potential selected as adaptation tipping point
- In case of RCP 4.5, adaptation measures have substantial impact on UHI reduction
- UHI potential is significantly increasing in RCP 8.5, adaptation measures sufficient only to year 2033. Therefore, need for other adaption options.

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

Step 3a Selection of evaluation criteria

Which evaluation criteria should be used?

Costs: cost of planning and realisation of the measures (specifically the costs of flood control system), costs of installation (in case of an event occurrence), costs of maintenance and storage. Also, some minor damages may occur even despite the FCS, especially during greater events. These need to be considered as well.

Benefits: avoided costs on damaged/destroyed buildings, infrastructure, and industries, avoided costs of damaged equipment and machinery, avoided costs of evacuation, avoided costs of cleaning, avoided costs on damaged environment and cultural damage.

All the costs and benefits mentioned will be measured and compared in monetary terms.

Step 3b Selection of evaluation method(s)

What is the appropriate evaluation method?

Cost-benefit analysis

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

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

Not applicable

e) Step 4 - Data collection (max 2000 words)

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

The main data used for this case study are information about costs of the adaptation measures, flood maps, historical data about the costs caused by the floods in 2002. The data were not publicly available which caused a slight delay. We have, however, already received all the data we needed for the case study. The costs and benefits are described in the table below. Particular calculations can be found in the Annex.

	Item	Source	Q20	Q50	Q100	Q500	Units
costs	Total cost of FCS	Prague council	144.4	144.4	144.4	144.4	Million EUR (2013)
	Installation[4] (per event)	Prague council	0.65	0.65	0.65	0.65	Million EUR (2013)
	Maintenance, storage (annual)	Prague council	0.89	0.89	0.89	0.89	Million EUR (2013)
	TOTAL COSTS		**145.94**	**145.94**	**145.94**	**145.94**	**Million EUR (2013)**
benefits	Avoided costs of residential buildings	Own calculation based on data by Institute of planning and development in Prague, Czech association of estate agencies[5]	332.27	697.6	1 349.22	1 971.31	Million EUR (2013)
	Avoided costs of infrastructure	Prague council, own calculations	40.28	66.07	106.6	143.07	Million EUR (2013)
	Avoided costs of industrial buildings	Prague council, own calculations	84.71	222.5	344.47	470.69	Million EUR (2013)
	Avoided costs of equipment	Prague council, own calculations	42.19	102.14	171.14	254.16	Million EUR (2013)

[4] Most of the costs are fixed no matter what the final flow rate is.
[5] http://cenovamapa.gekonsro.cz/

	Avoided costs of evacuation	Prague council, own calculations	0.04	0.07	0.15	0.25	Million EUR (2013)
	Avoided costs of cleaning and other costs[6]	Prague council, own calculations	42.36	51.69	62.66	73.49	Million EUR (2013)
	Avoided costs of cultural damage	Prague council, own calculations	21.84	30.5	37.82	42.93	Million EUR (2013)
	Avoided costs of environmental damage	Prague council, own calculations	16.55	18.03	19.62	13.66	Million EUR (2013)
	Costs caused despite FCS	Own calculations (for details see Annexes)	-409.57	-525.89	-627.58	-966.12	Million EUR (2013)
	TOTAL BENEFITS		**170.67**	**662.71**	**1464.1**	**2003.44**	**Million EUR (2013)**

If we compare the costs and benefits for each flow rate, we can see that the benefits are greater than costs for the flow rate of Q50 and more. Even if we considered such a scenario where there would be just one event of Q50 (or more) during the expected life span of the measures (about 80 years), the benefits would still overweight the costs even despite the annual maintenance and storage costs. Based on our calculations we can say that if there occur at least one event of Q50/100/500, or Q20 with a combination with another event (Q20/50/100/500), or any combination of these, the FCS investment will return.

It is also important to mention that this analysis does not consider any possible impacts of floods on mental health and comfort of people affected by the event. These aspects are very hard to describe and measure and even harder to put a value on.

[6] Other costs include costs of demolitions, refill of the grit underlying inrastructure

What is the evaluation time frame?

We assume that the lifespan 80 years and therefore we calculated the future prospect till 2095.

Which discount rate should be applied?

There is no national guideline for climate change adaptation measures in the Czech Republic. The discount rate applied would be 3% with a sensitivity test of 1 and 5%.

How to deal with data uncertainty?

Data uncertainty is quite high and therefore average or "as close as possible" data will be used for the analysis. Such items where the uncertainty is too high (e.g. impact on businesses) will not be included in the analysis.

f) Step 5 – Evaluation and Priorization (max 1500 words)

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

Even without the future climate scenarios it is quite obvious that the benefits of the FCS are greater than the costs. The overall comparison however depends on the frequency and strength of forthcoming events, especially due to some fixed costs which occur annually and independently on any climate development. We considered an event to occur approximately every twenty years.

- For cost-benefit analysis:

What is the net-present value (discounted benefits – discounted costs)?

The ADD equals to 37 million Euros. The results are following:

- For 3% discount rate: NPV=918 million Euro.

- For 1% discount rate: NPV=1 872 million Euro.

- For 5% discount rate: NPV=599 million Euro.

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

In this analysis we focused on the flood protection of the most endangered parts of Prague. The whole FCS is quite massive and absolutely adequate to the potential risk and vulnerability. In general there are no different options to ensure flood protection of Prague at such a level. Probably some minor adjustments or changes, implementation of more green measures or other management systems. These would, however, only have small effects and within the context of to the current FCS costs would be rather negligible.

- Is there and, if so, to what extent uncertainty in the ranking of options? Not relevant
- 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)? Not relevant

What are the main lessons learnt from your case study?

e.g.:

- transferable results?

In general, the results are not very transferable due to the unique case of every city (e.g. structure, geographic position and climate conditions). We could, however, assume that such an adaptation system (not particular measures but rather the overall approach) may be suitable for a city which could be affected in a similar way as Prague.

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

The main lesson is probably the fact that it all depends on the input data and their quality. In our case it would not be feasible to undergo an in-depth evaluation because the extent of the study would be enormous and way beyond the scale of this project. On the other hand, we believe that for our purposes the method was perfectly appropriate.

- feasibility of methods?

The methods were feasible but only in the extent mentioned above. The results are rather approximate than precise. This is caused not only by the high limitations of our data (most of the values were rounded and even the flood maps

provided by the Institute of planning and development in Prague are only based on mathematical models and are probably not very precise). Besides that, it is very important to keep in mind that the whole FCS is managed by people and is strongly dependent on their judgement, access to information and flexibility.

Another point is the suitability of this method for this evaluation in general. It would be probably better to apply some combined method which would enable an interpretation of non-monetary values or socio-economic and cultural consequences as well. For example due to the FCS in Prague, there are greater damages caused to the environment, mainly because the flood barriers prevent the river to burst its banks in residential areas and rather pushes it to green spots around the city. Measures similar to this one are very difficult to measure in monetary terms because any further consequences and wider context are omitted.

- important data sources?

Two most important data sources for the flood case study were especially Prague council and the Institute of planning and development in Prague. Both these institutions were great sources of data and information.

- etc...

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**	4
ii. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	2
iii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	4
iv. **Local and regional context** (e.g. culture, history, geography, environment,	1

economy)	
v. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	3
vi. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	2
vii. **Resources** (e.g. financial, human)	1
viii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	3
ix. **Other** (specify ____)	

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

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

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

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

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

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)

See section 1E

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 main driver of the implementation process in Prague was clearly the increasing risk and occurrence of destructive flood events not only in Prague but also across the whole country. Even though the system was planned since the 1990s and the development started just before the beginning of new millennium, the greatest debate and essential changes to the dimension of the system were made after 2002 when Prague was hit by a 500 year flood which caused a damage of over 1 billion EUR. With the future prospect of increasing strength and frequency of these events there was obviously a need to protect the city of Prague with its citizens, businesses and cultural/historic heritage. However, these measures just as current Czech flood management strategies do not adequately correspond to impacts from future climate change and they seem to be more a reaction to past events than an adaptation to future climate change. A common understanding of need for climate change adaptation is yet to be developed.

Clearly the process was an outcome of a mixture of factors including following:

- Future climate development and connected risks of floods in the city. This was obvious from recent developments with a series of extensive flood events not only within the city of Prague but also across the country and region. There is, however, a big concern about the real reason of the flood protection system as it is quite possible that it was rather a reaction to the past events than an adaptation to the future climate changes.
- The need for protection in cultural and historical context. This point would include both, lessons learnt from the history (for example destructive floods from 14. and 15. century, one of them swept away five pillars of Charles Bridge) and the need to protect the city, especially its historical and residential parts.
- Policy development, political and institutional context, and requirements within the European Union.
- The accessibility and availability of funds at both, national and European level. Even though the first stages were financed by the city itself the latter ones were financed mainly from the budget of the Czech Republic and also by European structural funds.

The process itself was led by the Prague city hall representatives, mainly by the Safety and crisis management department. Of course, politicians at both, national and regional levels were also involved. Citizens were mostly represented by particular city districts and their local governments. Besides that, researchers and engineers were involved as well, especially in the phases concerning the flood rate dimension and technical solutions.

There is no proof about transparency of the project, especially due to poor participation in the final phases. In such a city as Prague, where there is a serious threat to residential and industrial areas, but also to the historical centre, there were many compromises made. As a result, the protection is probably not as efficient as it could be (which is hard to evaluate as every group involved has their own priorities).

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 main obstacles could be divided into the groups listed below. In general we could say that the main barriers were a result of a mixture of these particular factors.

- **Actors**: More or less, the final representation of actors involved always partially depends on the political situation within the city. In general, the actors from the city hall and its departments were no obstacles to the result of adaptation process and the same applies to most other actors as well (Povodí Vltavy, Czech hydro meteorological office). The only issues were probably connected with an involvement of citizens and businesses from the affected areas. Based on our information provided by the city hall there was a lack of interest among businesses and entrepreneurs who had been approached in order to discuss potential flood prevention in a non-residential but industrial areas in the upper part of Prague riverside.
- **Framing of climate adaptation**: Based on our findings and impression of the whole process of flood protection system implementation we are not very sure that the flood control system is actually an outcome of a climate adaptation process within the city. Rather than an adaptation to future climate it seems like a reaction to past events, no matter what their major cause was. At this moment there is still no final complex adaptation strategy for both, the city of Prague and the whole Czech Republic. On the other hand, the Troja district together with Prague zoo (this issue is discussed above) has recently developed a study estimating the impacts of climate change on flood frequency and extent within their area. The study was supposed to be a strong argument to give the thumbs-up to the new flood protection development within the district. However, the negotiations have not came to any conclusion and the protection system for that area has not been approved.
- **Local and regional context**: Clearly, the geographical and spatial layout of city together with the historic background was a great challenge as such, especially in the stage of planning and designing the most suitable options. Not only there was an urge to protect the priceless historical monuments and heritage in the very centre of Prague but it was also necessary to implement such a system which would not disturb the historical character and particular sites within the city.
- **European, national, regional and local regulatory framework**: We have not found any regulatory framework which would be a major obstacle to the adaptation process.
- **Institutional context**: Within the context of our case study we perceive the institutional context to be highly interconnected with the actors' part, especially due to the institutions being major stakeholders.
- **Resources**: Resources were, for sure, a key element within the adaptation process. Luckily Prague managed to put their own money into the adaptation process but also to receive funding from Czech and European structural funds. Clearly the financial aspect might be one of the reasons for the obstacles with further flood protection development.
- **Nature of adaptation measures**: This part is strongly related to what was described within the local and regional context part. The nature of measures had to be designed in accordance to the character (both spatial and historical) of the city.

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

n/a

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

Based on the outcomes of case study we can conclude that the flood protection of the city of Prague is on a very high level. There might be, however, some issues in partially and not protected parts of the city (Lahovice, Troja) which should be discussed. We can expect a subsequent development and negotiations regarding particularly these two districts even though the outcomes are highly unpredictable and uncertain.

The focus will (or should) be also given to ecosystem based flood adaptations, mainly within minor streams. Even though the city is at this moment well protected against river floods from the Vltava river, there is still a high risk of damage caused by small streams.

As floods are not the main threat and city is well protected at the moment, there is a space to consider adaptations to other phenomenon such as flash floods (caused by rainfall) or urban heat island and heatwaves. The latter will probably play a major role in climate change adaptation process within the city in next couple of years. As mentioned above, adaptations to these effects of changing climate will most likely lie mainly in green and blue infrastructure and soft measures. Even though such events do not cause great direct damages to property they have significant effects on people's health and the functioning of the national economy.

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 would probably be that there needs to be a greater emphasis on the involvement of stakeholders and on non-structural adaptation measures.

The ongoing adaptation process is focused more on grey infrastructure and does not consider alternative measures (such as ecosystem based ones). Even though in the case of Prague an implementation of grey infrastructure including flood barriers was essential in order to effectively protect the city and based on our analysis was proved to be a very effective investment, there is still a window of opportunity to adopt green and blue measures which are usually cheaper and versatile. These could supplement the existing and forthcoming grey infrastructure and improve the overall resilience of the city not only in terms of flood risk but also other phenomena connected with climate change.

Regarding the planning and decision making process, even though the city hall declares that there are stakeholders involved, there is probably a problem rather with their selection than with their number. The group of stakeholders involved in the adaptation process comprised mostly members of various city hall departments and stakeholders in terms of receivers of the protection measures were scantily represented. Besides that, there are also a plenty of opportunities how to involve citizens in the adaptation process, especially when it comes to adaptation of households and information dissemination.

Checklist

When answering the above questions ensure you consider each factor listed in the checklist below that might have had a role to play in the implementation of your case study; please mark in the table what factors you have covered in your answers. The

checklist might not be all-inclusive, so feel free to discuss other factors that might not be listed. Mark 0 – 5 (0 being not relevant and 5 being extremely relevant), or not applicable (N/A)

Checklist	
Specify sectors covered *(e.g. coast, city, agriculture)*	City
Specify adaptation measures covered *(e.g. altering cultivation practices, building defences; explain why they were chosen)*	Builing defences
Specify climate change impacts covered *(e.g. flooding, heat stress, sea level rise)*	Flooding
Specify main results of activities *(e.g. changes, outputs)*	
Key factors influencing implementation:	**Mark as: 0 – 5, or N/A**
x. **Knowledge and information about climate adaptation**	4
xi. **Actors** (e.g. leadership, perceptions, understanding of climate adaptation, participation, decision making, stakes, conflicts/synergies)	2
xii. **Framing of climate adaptation** (e.g. as sustainability concern, (urban) planning or environmental issue, disaster risk mitigation topic)	4
xiii. **Local and regional context** (e.g. culture, history, geography, environment, economy)	1
xiv. **European, national, regional and local regulatory framework** (e.g. be specific about laws, strategies, policies)	3
xv. **Institutional context** (e.g. integration of adaptation into existing structures/activities/strategies, decision making, conflicts/synergies, governance arrangements, incentives for engagement)	2
xvi. **Resources** (e.g. financial, human)	1
xvii. **Nature of adaptation measures** (e.g. no regret, flexibility, important co-benefits, side-effects)	3
xviii. **Other** (specify ______________________________)	

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10. Annexes

10.1. Calculations of the costs

a) Total costs

The data about total costs of Prague FCS were provided by Prague council. The flood control system was built in seven stages and was finished in 2013. The overview of the whole system including costs is described in the table below. The total value was calculated in 2012, before finishing the last stage of the FCS. These costs are fixed and the same for any flow rate.

FSC in 2014	**Extent**	**Units**
Fixed measures	12 460	Meters
Mobile measures	6 795	Meters
Heavy mobile measures	130	Meters
Measures- sum	19 255	Meters
Total costs	**3 700 000 000**	**CZK**

The value in the 2013 prices would be (using average annual inflation rate[7] 1.4%): **3 751.8 million CZK**

The value in EUR would be (using average annual exchange rate for 2013[8] 25.987 CZK/EUR): **144.4 million EUR**

b) Installation

According to Prague council, the costs of installation of all mobile and heavy mobile measures (including the sealing of the harbour in Prague-Liben, Certovka channel and Rokytka river - a tributary of the Vltava, and the activation of water pumps in the canalisation system) is **17 million CZK** which means **0.65 million EUR**. These costs are fixed and the same for any flow rate.

c) Maintenance and storage

According to the Prague council, the costs of maintenance and storage equal **23 million CZK** (**0.89 million EUR**). As stated by the council, these costs can rise even by a few millions CZK in case any technical problems or reparation costs occur. As these extra costs are unpredictable, we have decided not to take them into account and only consider the costs of storage and maintenance. These costs are fixed and the same for any flow rate.

d) Costs caused despite the FCS

For all the categories, we calculated costs of damage which occur even despite the FCS. The results are shown in the following table in both, original CZK values (2013 levels) and EUR (converted by the average exchange rate in 2013).

In the case of residential building where we were able to calculate the costs directly using GIS (as mentioned in section 11.2.a).

[7] Czech Statistical Office: http://www.czso.cz/csu/redakce.nsf/i/mira_inflace
[8] EUROSTAT: http://epp.eurostat.ec.europa.eu/portal/page/portal/exchange_rates/data/main_tables

For infrastructure, industries, cultural and environmental costs (the categories where there was not enough data to calculate their costs for different flow rates) we used the Q2002 costs as a referral point. For each category we calculated a share of area affected within different flow rates in GIS and then applied these shares for the costs from 2002 (at their 2013 levels). The main reasons to use this method were a lack of data and an assumption that the prices and location of these have not changed too much.

For equipment we calculated the proportion of all residential and industrial areas flooded compare to the flooded areas in Q2002. Then we compared these spatial proportions with the costs of damaged equipment from the referral point (Q2002 at 2013 price levels).

For the costs of evacuation we compared spatial proportions of flooded residential areas to the referral point (Q2002) and based on these shares we calculated the costs of evacuation (at 2013 price levels).

For the “Other” category we compared spatial proportions of the total flooded area to the referral point (Q2002) and based on that we calculated the costs of this category (at 2013 price levels).

The detailed costs are described in the first table. The second table shows the total costs for each flow rate.

		Residential	Infrastr.	Industries	Equipment	Evacuation	Other	Cultural	Envi.
Q20	CZK (mil)	5 222.23	991.89	1 715.57	792.76	0.58	1 029.98	503.87	394.16
	EUR (mil)	200.96	38.17	66.02	30.51	0.02	39.63	19.39	15.17
% of Q2002		*N/A*	27	14	12	9	54	45	111
Q50	CZK (mil)	6 191.81	1 373.08	2 802.86	1 182.48	0.7	1 139.51	558.69	417.81
	EUR (mil)	238.23	52.84	107.86	45.5	0.03	43.85	21.5	16.08
% of Q2002		*N/A*	37	23	18	11	60	50	117
Q100	CZK (mil)	7 288.91	1 772.7	3 480.39	1 456.83	0.83	1 259.83	604.43	445.13
	EUR (mil)	280.48	68.21	133.93	56.06	0.03	48.48	23.26	17.13
% of Q2002		*N/A*	48	29	22	13	66	54	125
Q500	CZK (mil)	14 313.06	2 199.89	4 093.95	1 994.24	1.67	1 362.31	673.45	468.21
	EUR (mil)	550.78	84.65	157.54	76.74	0.06	52.42	25.91	18.02
% of Q2002		*N/A*	59	33	30	26	71	60	132

	Q20	Q50	Q100	Q500
CZK (million)	10 650.17	13 666.94	16 309.05	25 106.78
EUR (million)	409.57	525.89	627.58	966.12

10.2. Calculations of the benefits

a) Avoided costs of residential buildings

The final rates were calculated in GIS in following steps:

1. Based on the data provided by the Institute of planning and development in Prague (flood maps for different flow rates with and without the FCS, terrain map and local plan) we calculated the depth of water in flooded parts of the city for particular flow rates and use/absence of FCS.
2. We collected information regarding market prices of residential buildings in the flood-prone areas from Czech association of estate agencies.
3. We used the methodology by Genovese (2006) to calculate the final damage on residential buildings. This method is based on a formula described below. The data on facilities and equipment of households are a part of separate category.

Buildings: DAMAGE = p * A * H * V

p – percentage of urban fabric covered surface in the particular land use

A – area (m^2) of the land use

H – water depth damage factor

V – average price for m2 for an apartment

4. The values were calculated in 2013 prices for particular flow rates with following results described in the table. The values were also converted to Euros using the average exchange rate for 2013.

	Q20	Q50	Q100	Q500
CZK (million)	8 634.75	18 128.42	35 062.21	51 228.46
EUR (million)	332.27	697.6	1 349.22	1 971.31

b) Avoided costs of infrastructure

The costs of damaged infrastructure were, according to Prague council, **2 893 million CZK** during the event in 2002. This amount includes costs of damaged bridges, roads, rails, telecommunications, engineering sites and buildings, water bodies and other infrastructure units.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **3 717.9 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	1 046.63	1 716.85	2 770.21	3 717.9
EUR (million)	40.28	66.07	106.6	143.07
% of Q2002	28	46	75	100

c) Avoided costs for industries

The costs of industrial damage were, according to Prague council, **9 517.9 million CZK** during the event in 2002. This amount includes costs of damaged industrial buildings and factories. The costs of damaged equipment are a part of the equipment category.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **12 231.8 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	2201.39	5 782.22	8 951.78	12 231.8
EUR (million)	84.71	222.5	344.47	470.69
% of Q2002	18	47	73	100

d) Avoided costs of equipment

The costs of damaged infrastructure were, according to Prague council, **5 137 million CZK** during the event in 2002. This amount includes costs of damaged machinery, vehicles and equipment, manufacturing stocks, commercial stocks, and indoors households equipment.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **6 604.8 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	1 096.51	2 654.28	4 447.3	6 604.8
EUR (million)	42.19	102.14	171.14	254.16
% of Q2002	17	40	67	100

e) Avoided costs of evacuation

The costs of evacuation were, according to Prague council, around **5 million CZK** during the event in 2002. Even though there were around 50 000 people who lived in the flooded areas at that time, only 10% of them used the evacuation services and shelters provided by the city districts involved. A majority of the inhabitants affected stayed at their relatives or summer houses.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **6.4 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate. For the costs of evacuation we compared spatial proportions of flooded residential areas to the referral point (Q2002) and based on these shares we calculated the costs of evacuation (at 2013 price levels).

	Q20	Q50	Q100	Q500
CZK (million)	0.96	1.92	3.84	6.4
EUR (million)	0.04	0.07	0.15	0.25
% of Q2002	15	30	60	100

f) Avoided costs of cleaning and other expenses

The costs of damaged infrastructure were, according to Prague council, **1 486 million CZK** during the event in 2002. This amount includes costs of cleaning, demolitions, refill of the grit underlying inrastructure and other costs which are not a part of any other category.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **1 909.7 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	1 100.78	1 343.14	1 628.25	1 909.7
EUR (million)	42.36	51.69	62.66	73.49
% of Q2002	58	70	85	100

g) Avoided cultural costs

The costs of damaged infrastructure were, according to Prague council, **868 million CZK** during the event in 2002. This amount includes costs of damaged works of arts, library collections, teaching aids and leisure facilities.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **1 115.5 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	567.59	792.71	982.96	1 115.5

EUR (million)	21.84	30.5	37.82	42.93
% of Q2002	51	71	88	100

h) Avoided environmental costs

The costs of damaged infrastructure were, according to Prague council, **277 million CZK** during the event in 2002. This amount includes costs of damages to natural functions of water streams, damages to migration passableness and ecological stability, other damages to water streams, costs of soil decontamination and of the decontamination of surface and underground water.

The costs were adjusted for the prices in 2013 based on the average annual inflation rate of 2.31%: **355 million CZK**

The costs were adjusted for particular flow rates. These numbers were calculated as ratios of the original amount and the proportion of area flooded by particular flow rate.

	Q20	Q50	Q100	Q500
CZK (million)	430.15	468.5	509.93	355
EUR (million)	16.55	18.03	19.62	13.66
% of Q2002	121	132	144	100