Realisation of flood protection measures for the city of Prague [1]

Image from Climate Adapt about this case study [2]

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In 2002, Prague experienced severe flooding with total damage of 24 billion CZK (1 billion euro). This event was recognized as one of the most expensive weather-related disaster in the history of the city with heavy damages on infrastructure, housing and environment. Future climate scenarios predict a change in the number and intensity of extreme events, inter alia, increasing the risk of river flooding. Since the 2002 event, the implementation of flood control measures by Prague municipality substantially speeded up. The flood control system constructed in Prague consists mostly of grey infrastructure, such as fixed and mobile barriers and safety valves in the canalisation network along the Vltava River. The implemented adaptation measures were assessed using a cost benefit analysis which showed that the benefits are greater than the costs even if only one event with a return period of 50 years (Q50) is considered.

Case Study Description

Challenges:

Prague is the capital city of the Czech Republic, located in a temperate climate zone. Vltava River, the longest river in the Czech Republic flows through the historical centre of Prague that has been prone to floods in the past.

Regarding the changing climate, the greatest expected impacts are potentially related to temperature changes, wetter winters, dryer summers, increase in precipitation extremes and in climate variability in general. 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. In 2002, Prague experienced severe flooding (with a return period of 500-year) with total damage of 24 billion CZK (1 billion euro). This event was recognized as one of the most expensive weather-related disasters in the history of the city with heavy damages on infrastructure, housing and environment.

The capital city has yet no strategy to deal with climate change impacts. Some tentative adaptation measures have been very briefly mentioned in the City Strategic plan, which is currently being updated. Prague city recently joined Mayor Adapt initiative and aims to develop adaptation strategy in the coming two years (2017-2018). However, with regard to adaptation in water management, after the 2002 event, Prague municipality has been developing and implementing a variety of flood control and protection measures, which, in practice, contribute to adaptation to climate change in this sector.

Objectives:

The 2002-flood substantially speeded up the development of a more resilient flood risk management system to protect the city of Prague. Although, at that time, the flood protection measures were not presented and named as climate change adaptation measures because climate change adaptation was not a topic issue on the political agenda, the identified measures aimed to increase resilience to flood risk, also in a climate change perspective. In particular, realised measures can cope with flooding events with a return period of 500-years, thus considerably increasing Prague resilience towards extremes events.

Solutions:

The flood protection system of Prague has been now finished and protects most parts of Prague from flood with 1 to 500 years return period. Before the construction of such protection system, the area threatened by floods in

Prague was 57.5 square kilometres (in total 11.6% of the city). Overall 52.5 square kilometres of the previously threatened area is now protected against flooding. The areas with limited flood protection consist of Sedlec and Troja areas and areas of Vltava and Berounka river confluence, which are not densely populated.

To protect the city, its inhabitants and the priceless historical heritage from such great floods there was a need for grey infrastructure, as further described below. Green and blue infrastructure would only serve as some kind of additional support to the flood barriers and can be very useful for example to tackle flash floods caused by extreme precipitation. Greener strategies or approaches have not been realised along the Vltava River. However, these approaches are implemented when revitalizing smaller streams in the city, like for example Rokytka. The specific adaptation measures implemented to control Vltava river floods include:

- Fixed barriers (levees, dykes, earth mounds, solid concrete walls) constructed along the Vltava River. For instance, closure at ?ertovka (Old Town), which is a steel sliding door, 23.5 m length, 4.9 meters height, and weighting 45 tonnes.
- Mobile barriers which are mainly used in the old historical centre, and partly in the surrounding areas. Mobile barriers are stored in a central storage area in Dube? and for smaller parts in Zbraslav. The transport and installation of mobile barriers to the areas potentially affected by flooding is based on the Flood Management Plan of the Prague City. In Dube?, a training area for training of mobile barriers installation is built.
- Other measures, as closures, pumping systems and safety valves in the canalisation network along the Vltava River.

The 2002 extreme flood was a trigger that speeded up the process of the construction of flood protection measures. Based on the 2002 flood experience, the flood control measures were improved and designed to protect city from 2002 flood (Q 2002 = 5160 m^3s^{-1}), which corresponds to a water level of 782 cm with safety reserve of 30 cm. The area of flood protection measures in Zbraslav district was designed for 100 year flood with safety reserve of 30 cm. The construction of the flood control system in Prague was realised throughout 8 phases, each one addressing a specific sector of the Vltava River. The total length of flood protection measures (fixed barriers, solid concrete walls and mobile barriers) after the completion of all stages is approximately 19.255 km, of which 6.925 km are mobile barriers.

Importance and relevance of the adaptation:
OTHER_POL_OBJ;

Additional Details
Stakeholder engagement:
The responsibility for flood protection measures which have been implemented since 1997 is at the national level divided between two institutions: the Ministry of Agriculture, which is responsible primarily for the 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.

At the regional level, Prague City Hall in cooperation with the Povodí Vltavy, a State enterprise, is responsible for implementation of flood control measures on the Vltava River and small watercourses. Some environmentally oriented organizations and local initiatives of citizens raising suggestions are also involved in the adaptation process through consultations. The stakeholders involved include Prague City Hall, affected Prague districts, political representatives, the Czech Hydrometeorological Institute, Povodí Vltavy - Vltava River Basin and professional companies (eg. Hydrosoft).

Success and limiting factors:
The main problems occurred during the approval and permit process of flood control system installation, such as:

- Questions of property rights and relations of land that was in the area of the planned flood control system (needed for purchase or exchange of land). Land ownership and property relations often hinder the implementation of such measures.

- Coping with the requirements of cultural and historical heritage preservation authorities, especially in the historical centre, where the line of the mobile flood control measures was required to be as invisible as possible.
- Conflicting views of investors, designers, and the historical heritage authorities regarding the implementation of flood protection measures, in order to maintain the panoramas in the historical parts of the city.

The success of the implemented flood protection system was proved during 2013 flood event, when great part of the city along Vltava River was protected and only very minor parts were flooded. On the other hand, the 2013 flood event highlighted the “weak points”, such as the capacity of the pumping station on Rokytka creek that is planned to be enlarged based on this flood event.

Budget, funding and additional benefits:
The costs and benefits of the implemented flood protection measures were calculated for particular events with different return period: 20, 50, 100 and 500-year flood. The estimated total cost amounts to 145.94 Million euro (2013) and includes: total cost of the realisation of the flood control system (144.4 Million EUR, 2013), installation costs per event (0.65 Million euro, 2013), annual maintenance and storage costs (0.89 Million euro, 2013). The costs did not include damage to the underground. The estimated benefits include avoided damage costs in Million euros of:

1. Residential buildings, ranging between 332 (Q20) and 1,971 (Q500);
2. Infrastructure and industrial buildings, ranging between 124 (Q20) and 613 (Q500);
3. Equipment, ranging between 42 (Q20) and 254 (Q500);
4. Citizen´s evacuation, cleaning and other costs, ranging between 42 (Q20) and 74 (Q500);
5. Environmental and cultural assets, ranging between 38 (Q20) and 57 (Q500).

Costs caused despite the flood control system are estimated to range between -410 (Q20) and -966 (Q500) Million euros. Total avoided damage costs are (in Million EUR) are therefore between 168 (Q20) and 2,003 (Q500).

If costs and benefits are compared for each event, it is possible to see that benefits are greater than costs for the event with a return period of 50 years (Q50) and more. Benefits are slightly greater than costs also for flood events Q20. However, flood events with a return period of 20 years could appear more times than once in the 80 years (life span of the measures), which would make the comparison negative.

Even if a scenario where there would be just one event of Q50 (or events with longer return period, i.e. Q100 and Q500) during the expected life span of the measures (about 80 years) is considered, the benefits would still overweight the costs, also despite the annual maintenance and storage costs. Based on calculations it is possible to argue that if at least one event of Q50/100/500, or Q20 with a combination with another event (Q20/50/100/500) or any other combination of these occur, the flood control system investment will return.

In the case of Prague an implementation of grey infrastructure including flood barriers was essential in order to effectively protect the city centre. Based on the performed cost-benefits analysis it proved to be a very effective investment. However, there are still possibilities to adopt green and blue measures on small streams (e.g. in Rokytka or Boti?).

Legal aspects:
The relevant legislation for the implemented flooding protection measures includes:

- The Water Framework Directive (EC 2000) and the Flood Directive (EC 2007). The current Czech flood risk management is based on the Strategy for Protection against Floods approved by the government in 2000 and updated in 2006.
- The Plan for the Main River Basins, which is an important strategic document for water planning. Issued by the Ministry of Agriculture in 2007, it includes flood protection among its three main topics. The

document places great emphasis on preventive protection and recognizes that a suitable combination of measures in the landscape that increase natural water retardation and technical measures addressing flood run-off are necessary for effective flood protection.
- The Spatial Development Policy, which is a strategic document for coordination of spatial planning. (e.g. Spatial Plan in Prague).

Implementation time:
The flood protection measures were constructed from 1997 to 2012. The implementation of these measures was rather long-term including design, project preparation and construction of the particular measures.

Reference Information
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Websites:
http://base-adaptation.eu/case-studies [5]

http://www.praha.eu/jnp/cz/o_meste/magistrat/odbory/oddeleni_krizoveho_m... [6]

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Sources:
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Start here

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Case Studies

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Links

[1] https://adaptecca.es/en/realisation-flood-protection-measures-city-prague
[2] https://adaptecca.es/sites/default/files/prague_figure1.jpg
[3] mailto:jaromir.kacer@praha.eu
[4] mailto:lorencova.e@czechglobe.cz
[5] http://base-adaptation.eu/case-studies
[6] http://www.praha.eu/jnp/cz/o_meste/magistrat/odbory/oddeleni_krizoveho_managementu/ochrana_proti_povodnim.htm
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