Chapter 12
Urban Wetlands Restoration in Floodplains: A Case of the City of Pilsen, Czech Republic

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The chapter deals with the importance of implementing small-scale NBS for flood protection in cities. It turns out that, although NBS bring multiple environmental and social co-benefits, their real-world implementation comes up against numerous barriers, particularly if private land is needed for their implementation. Insufficient awareness of the benefits of such measures reduces stakeholders' willingness to consider their implementation (including negotiations with private owners about provision of land for these purposes). If it is necessary to use private land for NBS implementation in cities (thus public funds for compensations to the private owners), the social benefits of such measures have to be demonstrated to stakeholders in a clear and transparent manner. In regard to the case study of Lobezská louka, where an NBS in the form of urban wetlands has already been partly implemented, we demonstrate the potential of economic assessment in the form of a cost-benefit analysis to facilitate decision-making for further application of NBS in cities. In our case, the analysis showed that the social benefits of the measure realized in the first phase exceed the costs 25 times. The result is a supporting argument for implementation of the next two phases on private land.

Introduction

Urban areas are among territories where manifestations of climate change have very significant adverse (economic) impacts, and adaptation to such change (in the form

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of more frequent floods or droughts, heat waves or urban heat islands) incurs considerable social costs.

Until recently, "traditional" adaptation of cities to climate change has relied mostly on technical measures ("grey infrastructure") such as mobile flood barriers, canalisation/culverting of watercourses, construction of dams and dikes (upstream of the city), insulation of building envelopes, and installation of air-conditioning. Alternative solutions to technical measures are NBS, which can be seen as complements to technical measures and can be implemented directly in the urban area. "The fundamental belief is that NBS can represent more efficient and cost-effective solutions than traditional approaches" (Lafortezza et al. 2017). One of the reasons is that implementation of NBS may bring multiple co-benefits (McVittie et al. 2018) improving the well-being of inhabitants. More widespread application of NBS in cities also has strong support from the European Commission (Faivre et al. 2017). Ever more cities thus reach for NBS, although their implementation does face numerous barriers. Once of them is the space requirement of NBS. Compared to grey infrastructure, these measures tend to interfere with privately-owned land more often.

This chapter is focused on the main challenges of and obstacles to NBS[1] implementation as part of flood event adaptation in cities from an economic and institutional point of view (assuming that the city's goal is to build a conceptual system of flood protection). From this point of view, the main question can be defined as follows: How to support the planning and implementation process of NBS in cities, especially if they should be implemented (at least partly) on private land? One possible solution is demonstrated on a case study of the city of Pilsen. This city decided to implement NBS to solve its flood protection.

In general, awareness about NBS and the benefits brought by their implementation is limited. Solving this issue involves three different levels of stakeholders:

- decision makers (especially local politicians),
- private landowners,
- public administration, NGOs and other stakeholders.

Implementation of flood protection measures (and especially "novel" measures such as NBS) depends heavily on support from decision makers and other stakeholders. This means that one of the main challenges is to convince the municipal government of the benefits and importance of NBS implementation, because members of the municipal government make the decisions on spending the public budget. Politicians prefer short-term results compared to long-term ones due to the political cycle and the effort to be re-elected. In the current term, the decision makers have shown preference for measures related to recreation. Moreover, in the last three years, the Czech Republic has been more affected by droughts than by floods. Floods are thus not perceived as a significant risk, or at least not by the current municipal representation. This is in contradiction with the extensive damage caused by floods in the previous 20 years.

[1] Or sometimes referred to as nature-based flood protection measures (NFPM).

Another important issue for a city's successful adaptation is related to private ownership of land in cities. A large part of land in urban areas is owned by private entities. Designing and implementing measures on (previously) private land seems to be a key challenge on the road to a successful adaptation process. Decision makers are restrained from negotiating with private owners, because transaction costs and compensations to landowners for using the land for NBS increase the time and costs of implementation.

A third group of stakeholders is composed of entities that are not directly involved in the process of NBS implementation but may significantly influence the results of negotiations about new measures, such as creating a new urban wetland. NGOs often have a strong position in the civil society and can influence local inhabitants' perception regarding NBS. On the other hand, many entities in public administration (such as a municipal environmental or urban development department) are either directly involved in the decision-making process, or prepare inputs for the municipal government.

The rest of the chapter is organised as follows: the second section presents the broader context of flood-related issues in the city of Pilsen followed by a detailed description of the case study (Lobezská louka urban wetlands restoration). The third section very briefly presents the three perspectives that have to be taken into account in the NBS planning and implementation process (hydrology, economics and stakeholders). The following section is focused on one of these perspectives: economics of NBS. The last section discusses the role of economic analysis (comparing costs and multiple co-benefits of NBS) in the process of NBS implementation in cities, especially where private land is needed for measures.

Pilsen Case Study: Small-Scale Nature-Based Solution—An Answer to Regular Flooding of the City

The city of Pilsen (Plzeň) is situated in the western part of the Czech Republic, with a population of 170 000, making it the fourth biggest city in the country. Four smaller rivers flow through the city (Úhlava, Úslava, Radbuza and Mže) and form together the Berounka river. Water has historically been one of the main factors influencing the development of the city of Pilsen. On the one hand, the water was used for centuries as a fundamental source for industrial development (brewery, heavy industry, etc.); on the other hand, water has brought regular destruction to the city.

Floods are one of the most serious threats to the city in relation to climate change. The flood zones of the four smaller rivers are depicted in Fig. 12.1. Pilsen has dealt with floods on a regular basis—there have been seven big floods between 2002 and 2014. In 2002, Pilsen was one of the cities in the Czech Republic most affected by floods: 11% of the city's area was flooded, and damages exceeded EUR 21.5 million.

Based on this experience, Pilsen has faced the challenge of finding a solution to flood damage. The public demand for flood risk reduction was high, but was mostly

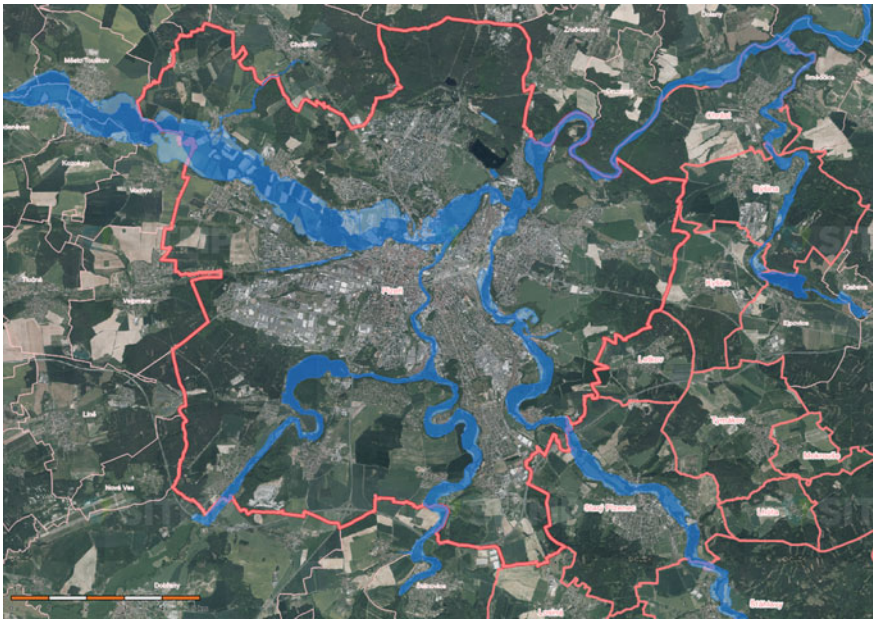

Fig. 12.1 Flood zones in the city of Pilsen (SITMP 2017)

concerned with large-scale structural measures (building dams or dikes) or small-scale technical measures such as demountable flood protection barriers. The same was true for policymakers, who were concerned about the issue, but not informed about all possible solutions. Implementation of large-scale flood protection measures (dikes and other measures based on grey infrastructure) mostly extends beyond the city's cadastral area and requires accord of a wide range of stakeholders at the trans-municipal and trans-sectoral level. This kind of comprehensive planning should take into account the upstream-downstream relations (Macháč et al. 2018), and it is a long-term process. The confluence of four rivers complicates the problem because regular flooding cannot be resolved by one large-scale upstream measure, but instead it would be necessary to implement measures on each tributary. Thus, decision makers in the city of Pilsen decided to implement small-scale NBS inside the city.

The process of designing and implementing a system of NBS for flood protection (consisting mainly of urban wetlands) started in Pilsen in 2008, when most of the measures were designed within the international project REURIS (2008–2011). Later on, many of the NBS designed (e.g., revitalisation of Božkov Island, creation of the park Lobezská louka with four wetlands and Pod Vyšehradem wetlands) were implemented continuously in the period 2009–2015 (partly financed by EU funds—Operational Programme Environment). By implementing these measures, the city of Pilsen pursued four main objectives: (i) design of appropriate nature-based flood protection measures, (ii) revitalisation of the river areas (streams and floodplains), (iii) finding suitable utili-

sation for a large area of floodplains and river banks, (iv) creation of conditions for implementing the territorial system of ecological stability.

At the present time, the municipal system of urban wetlands in Pilsen extends over an area of 14 ha. In this first phase, the measures have been mostly implemented on land owned by the city, without the need for negotiation with private owners. A large number of other measures that have not yet been implemented are located on privately owned land. For the next phases, the challenge of privately owned land that is suitable for further NBS should be solved.

Although the system of NBS in Pilsen is a small-sized green infrastructure solution with relatively little impact (from the flood protection point of view), it is combined with a recreational function, and hence it brings multiple benefits for the community (see later on). This kind of information could play a crucial role in the decision-making process on implementing of further measures, especially in case private land is needed for their implementation.

Small-Scale Nature Based Solution Implementation in "Lobezská Louka" Park

In the case study, we would like to present a method of expressing the societal benefits of urban NBS and use this information for supporting further development of similar measures also on (previously) private land.

The "Lobezská louka" park with four wetlands is one of the NBS implemented in the city of Pilsen. It was formerly an area of neglected greenery; the original unmanaged green areas on the site gradually overgrew with herbs and tree seedlings, and illegal dumps also occurred. It is located in the immediate vicinity of the Úslava river. Almost 10 000 people live in the neighbourhood of the area. The current "Lobezská louka" park is only a part of the measures designed for this area. The implementation of this first phase is the result of long-term efforts by the city of Pilsen for a suitable and modern design of the embankment of the Úslava river inside the city. According to Atelier Fontes (2010), the initial plan of possible measures covered an area of approximately 14 ha. Only a small part of the land is owned by the city, the rest by private owners. The owners have limited opportunities for land use due to the floodplain, the Q_{100} active zone and the land-use plan. With regard to ownership, the original project was divided into several phases (see Fig. 12.2). The project objective is to establish water bodies in the wide alluvial plain in order to both reduce the flood flow rates by means of a nature-based measure and to increase the aesthetic value of the area and make a place for recreation.

The total area consists of 44 plots of which 21 are in private ownership and 23 are owned by the municipality of Pilsen. The area of former horticulture (central part of the area) was selected as an appropriate site for the first phase. One of the reasons is that all the seven plots were owned by the municipality. The initial situation regarding ownership is captured in Table 12.1. Only 46% of the total area was owned by the

municipality. The measures in the second and third phases have been planned as different options with regard to land availability. The final form of the NBS depends on negotiations with other private owners. The result may be different from the plan in Fig. 12.2.

The first phase covers an area of 2.0 ha. Initially, the first phase was designed on an area of 3.5 ha. The decision-makers decided to build wetlands only on land owned by the city. This step was chosen primarily for reasons of easier grant application. According to the requirements of EU funds—Operational Programme Environment—the owner has to agree with the implementation of measures. If the phase were to be built on private land, it would be necessary to buy out the land. The project implemented as the first phase involved the establishment of four wetlands with water retention potential (wetland biotope) and an adjoining park. In contrast with other "common parks" with a lake, the park in our case study differs in its range of services and benefits that it provides. The area is used daily by the local inhabitants. A specific feature of this area is that it combines functions of flood retention (wetlands), education (educational trail with information boards) and recreational functions, such as opportunities for swimming in these wetlands and other types of recreation (relaxation, sports, walking). A cycle path along the river that connects different parts of the city is also a part of the project. The wetlands have no feeder or drain canals and are only filled with groundwater and rain. The four wetlands (Fig. 12.3) have the capacity to accommodate around 8000 cubic metres of water. The first phase was completed in the summer of 2015. Implementation of the first

Fig. 12.2 Plan of the "Lobezská louka" area and division of measures into phases 1–3 (Útvar koncepce a rozvoje města Plzeň 2015)

Table 12.1 Land ownership regarding the phases

Owned by	Phase 1 (ha)	Phase 2 + Phase 3 (ha)	Total area (ha)
Municipality	2.0	4.5	6.5
Private owners	–	7.5	7.5

Source Based on Atelier Fontes (2011)

phase was not without problems. The groundwater was deeper than expected, which led to problems with filling the wetlands with water. This was caused mainly by a drought that affected the Czech Republic in 2015.

Currently, the revitalisation of a nearby forest park is under preparation. The implementation of the other two phases "Lobezská louka" is hampered by complicated property relations. It is necessary to buy out the privately owned land or to negotiate with private owners about utilisation of their plots. Currently, a part of the plots for the second and third phase has been bought out from private owners. At the moment, not enough support for the project has been obtained from the city council as only the local district town hall supports the realisation, but the city district does not have sufficient financial resources. The 4.5 ha of land owned by the city can be used for developing the NBS. Furthermore, it is essential to convince the public and decision-makers about the need for small NBS.

Three Perspectives of NBS Implementation

To answer the main question concerning support to the NBS planning and implementing process in cities (on private land), it is necessary to deal with three different perspectives: hydrology, economics and stakeholders (see Fig. 12.4). Each of them plays an important role in the process of NBS implementation.

Fig. 12.3 Urban wetlands "Lobezská louka" in Pilsen (Provided by Útvar koncepce a rozvoje města Plzeň)

The first perspective that has to be assumed in the process of NBS implementation in cities is a hydrological analysis, which produces a description of the current hydrological conditions and helps to design appropriate and efficient measures in the context of physical flood protection.

From the point of view of economic analysis, we distinguish between two main aspects: the financial aspect and the aspect of (net) social benefits resulting from implementation of the measures. The financial aspects are closely interconnected with those individuals who decide on the available budget for implementing measures and are able to ask for additional money from the state budget in the form of subsidies. The other aspect of economic analysis is focused on assessment of the net social benefits resulting from the measures. Net social benefits can be used for argumentation in the social debate about implementation of NBS, because besides a primary purpose (flood protection in our case), applications of NBS provide further multiple environmental benefits (Nesshöver et al. 2017) such as improvement of air quality, habitat for species, soil erosion control, etc., and other economic and social benefits (e.g., increase in aesthetic value, energy/water cost savings, etc.).

The last perspective includes all stakeholders and especially decision makers and landowners, whose decision holds the most weight about the implementation. Their awareness of NBS benefits plays the most important role in the implementation process. A stakeholder analysis is an appropriate tool to identify their preferences and attitudes but also barriers and challenges towards water management measures (especially NBS), taking into account different points of view of particular stakeholder groups.

The second and last perspectives are important for the problem of privately owned land. There are significant synergies between these two perspectives (economic argument and communication between stakeholders), which can motivate both stakeholders and decision makers to agree with NBS and the implementation.

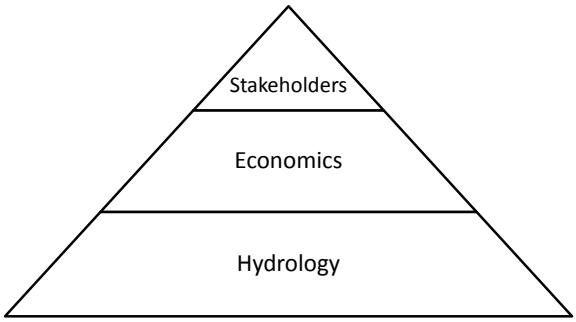

Fig. 12.4 Perspectives of NBS implementation in cities

The Need for Strong Arguments

In our case, the stakeholder analysis showed that perception of environmental issues differs across the stakeholders (likewise, the perception of different NBS), but there was agreement on the point that flooding is the most important problem in Pilsen. One barrier to tackling floods in the city more effectively is that less area is available than required for effectively implementing measures (availability of vacant municipal land, complicated property relations outside municipal land, high prices of private land). Another crucial barrier to NBS implementation (on private land) is a lack of political support (thus, lack of funds for implementation of such measures), although many officials from related municipal departments are interested in innovative solutions (such as construction of wetlands in cities). The low level of awareness regarding the importance of NBS and their benefits leads to their marginalisation as a meaningful solution to the issues.

According to McVittie et al. (2018), "the demonstration of multiple co-benefits may be important both where these co-benefits provide private benefits for land managers and wider societal benefits that can attract a variety of funding sources" and political support. We assert that economic analysis (cost-benefit analysis in our case) and appropriate communication of its outputs in the NBS planning phase could help to overcome the above-mentioned barriers, particularly the problem of insufficient awareness among politicians and other stakeholders about the (direct and indirect) benefits of these measures.

As mentioned above, a complex (but rather small-scale) system of urban wetlands was designed on the site of our case study, and its implementation was divided into three phases. Thanks to financial support from EU funds and because the land needed for the first phase of implementation was in municipal ownership, the first four wetlands together with revitalisation of part of the park were implemented. However, the land for the remaining two phases is mostly in private ownership. Since new urban wetlands do not bring net benefits for private owners, implementation of these measures will require additional financial resources from public budgets. In addition to the investment costs for implementing measures, the landowners should be compensated for providing the land (e.g., buyouts, long-term leases or some kind of so-called payments for ecosystem services). To persuade the decision makers (mostly municipal politicians) and other stakeholders to implement the further phases of urban wetland construction in the "Lobezská louka" area, there is a need for strong arguments about the multiple benefits provided by NBS for the whole society.

To demonstrate the environmental and social benefits of urban wetlands restoration, the first phase of the "Lobezská louka" project was valuated. The assessment of the society-wide benefits of the measure implementation was based on the economic cost-benefit analysis (CBA) method, which takes into account not only private financial benefits and costs of the implementing entity, but also the costs and benefits resulting for society as a whole (non-financial and indirect costs and benefits). In addition to the primary benefit consisting in direct contribution to flood protection (flood risk reduction), NBS bring numerous co-benefits contributing to the popu-

lations' well–being (e.g., property value increase, support to biological diversity, spaces for recreation and meditation, etc.). The identification of benefits is based on the ecosystem services approach. Besides ecosystem services divided into 4 groups (supporting, regulating, provisioning and cultural services; see Fig. 12.5), other benefits such as biodiversity (habitat creation) were also taken into account.

A cost-benefit analysis consists of several steps (see Fig. 12.6). In the first step, the evaluated measure is described. In the next step, individual costs and benefits are identified using the concept of ecosystem services. Benefits are quantified using biophysical indicators and expressed in monetary value using appropriate methods. The costs are set according to project budgets (investments costs) and estimated operating costs.

The comparison of costs and benefits used the annualised value of costs and benefits. The concept of annualised costs and benefits is derived from the concept of real value of money and the opportunity to invest funds elsewhere (Jacobsen 2005). The known present costs and benefits are transformed into a future flow of the same values based on annual costs, which (when cumulated) match the known present value.

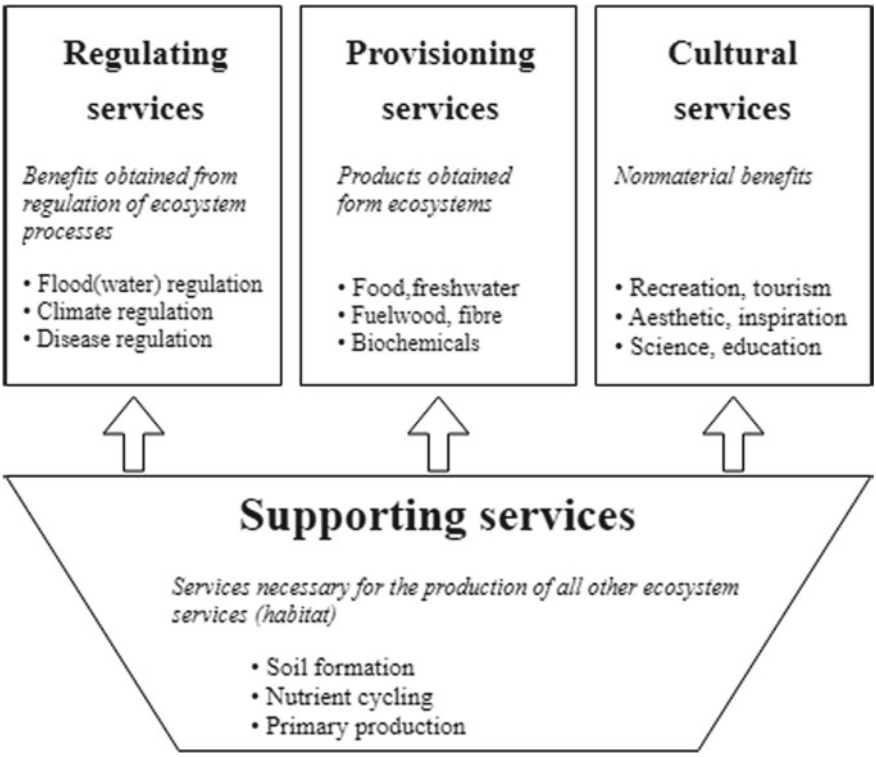

Fig. 12.5 Ecosystem services connected with NBS (based on Millennium Ecosystem Assessment 2005)

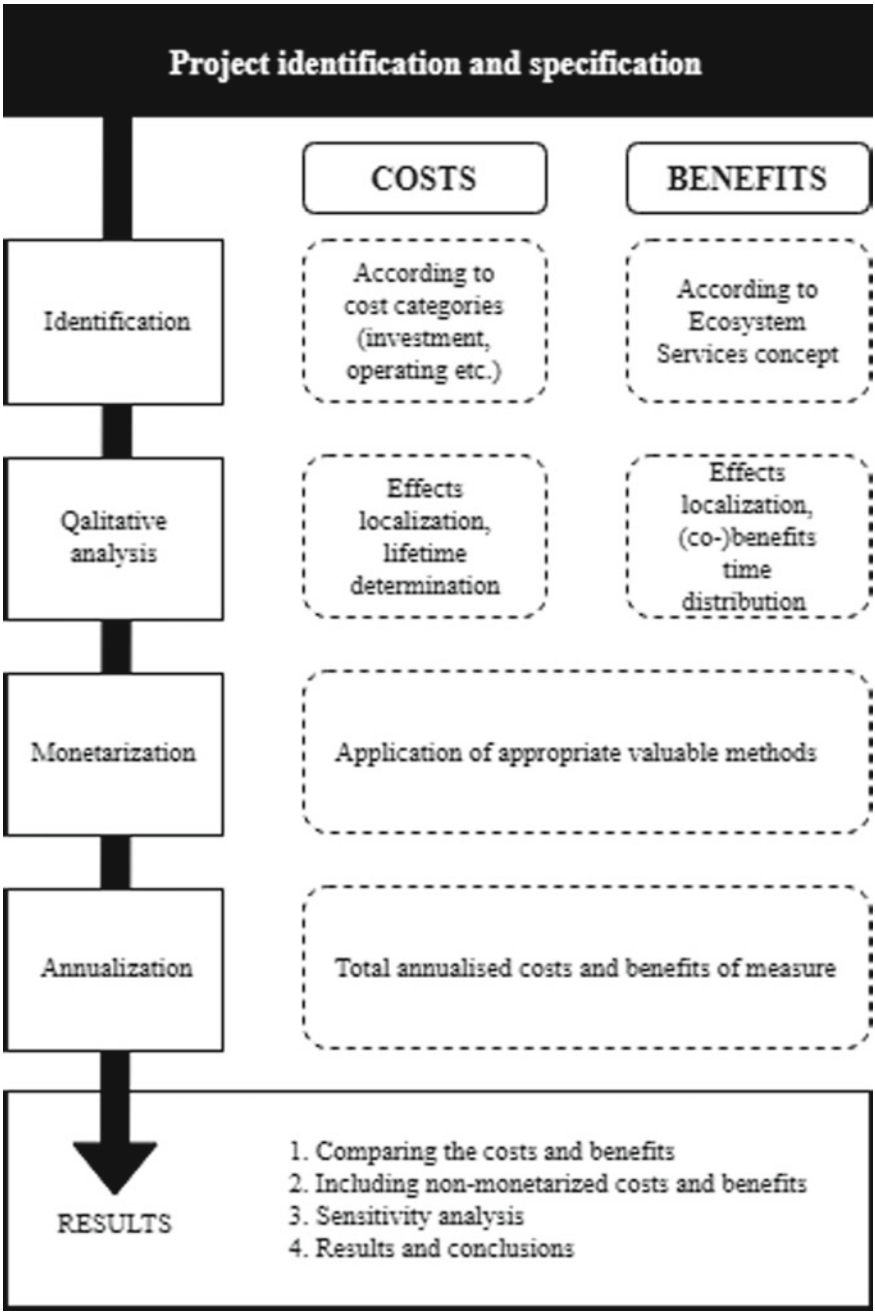

Fig. 12.6 Cost-benefit analysis step by step (based on Slavíková et al. 2015)

Due to the wide range of ecosystem services provided by NBS and the lack of primary data, the benefit assessment used the benefit transfer method in the form of a meta-analysis, which makes it possible to use secondary data from similar sites and transfer them to the area being assessed while involving local conditions in the assessment (Brouwer et al. 1999).

In addition to flood protection benefits, applications of urban wetlands provide a number of co-benefits in terms of ecosystem services. The assessment led to identification of 14 major services/benefits, but not all of them were valuated in monetary terms (see Table 12.2). Regulating services are the most numerous. Benefit transfer was used for valuation of 8 services to quantify the annual benefit of both the wetlands themselves (EFTEC 2010) and the adjacent park greenery (Patrick and Randall 2013). The data transfer takes into account the primary analysis methods, GDP in the area, population count, distance from the centre, number of similar wetlands in the surrounding area, etc.

After consideration of local aspects, the ex-post CBA of the first phase of the urban wetland restoration showed that the annual benefits of this measure amount to EUR 1.47 million. The adjacent greenery contributes significantly to the total amount of benefits. In addition to direct impacts on water retention and reduction to flood damage, it has a noticeable influence on the recreational function and water and air quality. Only part of the services provided was quantified in monetary units by the benefit transfer application.

The cost valuation was based primarily on the investment costs of implementation of the wetlands themselves, as well as the operating costs of periodic maintenance and other irregular costs of management of the area. The total annual costs are about EUR 0.06 million. The annual costs include investment costs (EUR 0.526 million according to City of Pilsen data), operating costs of park greenery maintenance (EUR

Table 12.2 Identified ecosystem services provided by "Lobezská louka" wetlands

Type of benefit	Monetary valuation	Type of benefit	Monetary valuation
Reduced risk of flooding	Yes	Erosion reduction	Yes
Supply of surface water and groundwater	Yes	Real estate value	No
Improved water quality	Yes	Recreational benefits	Yes
Regulation of micro-climate/city heat island	No	Increase in aesthetic value	Yes
Noise reduction	No	Biomass production	No
CO_2 reduction	No	Crop production (urban agriculture)	No
Air quality improvement	Yes	Habitat creation	Yes

0.41/m^2/year) and other costs connected with the wetlands (periodic maintenance and the less periodic costs of desilting the wetlands).

When comparing the total annual benefits and costs, we can see that the benefits exceed the costs nearly 25 times. The annualised costs are only 4% of the total annual benefits. The total annual benefits have to be perceived as a monetary expression of the ecosystem services mentioned above. Thus, they are not benefits that could be followed in the form of cash flows for citizens or municipality. On the other hand, not all the environmental and social benefits were included in the monetary valuation; therefore, the final figure of benefits has to be regarded as underestimated. The significant excess of the social benefits over the costs is confirmed by the results of the sensitivity analysis, which tested the effect of the most important factors on the study results. The effect of the discount rate was tested above all.

Searching for a Way to Support Implementation of Nature-Based Solution in Cities

Solving the flood problem at the city level requires a comprehensive approach. Although large-scale technical measures such as dams often theoretically seem to be appropriate for preventing flood damage, it is seldom within the city's powers to implement such measures (dams, dikes and polders have to be built outside the city's cadastral area upstream the river, negotiations with other municipalities, catchment area administrator, etc., are necessary, and moreover they are very costly measures that cities refuse to fund outside their territories). Besides such large-scale measures, cities have the additional opportunity to focus on more local measures, which (compared to large-scale measures such as dams) are relatively fast to implement directly inside the city. In this respect, Czech cities often resort to the application of single-purpose "grey" measures, such as mobile flood dams. There is also a third option—small-scale nature-based flood protection measures, which can be (from the technical point of view) relatively easily implemented directly in city centres. Although the NBS bring multiple social and environmental co-benefits, their real-world implementation (at least in Pilsen, but we assume other cities as well) often comes up against numerous obstacles that are frequently related to lacking information about their society-wide benefits and to private ownership of land needed for NBS implementation. The stakeholders (and mainly municipal politicians) are very cautious about spending public money on measures with doubtful benefits (from their point of view).

In order to boost the awareness of the importance of such measures, it is not necessary to carry out a detailed economic analysis for each planned measure. The importance of measures can also be documented with successful examples from other cities or countries. The costs and the benefits expressed in monetary terms can be compared easily without having to understand the numerous direct and indirect benefits, which may lead to better awareness about the NBS and, subsequently,

significantly help to implement them. This factor is also of considerable significance when implementing measures on land not owned by the municipality. The case study presented above can be used for that purpose.

In the "Lobezská louka" area in Pilsen, apart from previously implemented measures (Phase 1) paid largely with EU funds, many additional measures of this urban wetland system (Phase 2 and 3) are ready to be implemented (from the urban planning point of view). The land needed for their implementation is mostly owned by private entities. The knowledge of all the benefits that the measure will bring for the society may increase the city's willingness to negotiate on buying out the land and then use it for NBS implementation. Alternatively, application of some form of payment for ecosystem services may be considered (Kumar et al. 2014; Cerra 2017; Reed et al. 2017). In that case, the city would not buy out the land but only pay its owner a certain fee for providing the water retention service (such as in the form of lease or subsidy).

The outputs of ex-post CBA for the first phase of the "Lobezská louka" project proved that the social and environmental benefits of this measure are at least 25 times higher than the costs. This information may be used as a crucial argument for the social debate and decision-making process about implementing further phases of the urban wetlands in Pilsen (and especially in thinking about buyouts or other type of payments for the private land).

In general, we conclude that even though small-scale NBS in urban areas are not able to solve the whole problem of regular flooding, they can complement large-scale measures. NBS can bring significant environmental and social co-benefits compared to small-scale single-purpose technical measures. Social acceptability of the measures and their implementation depends on public awareness. That is why we argue that the co-benefits (environmental and socioeconomic) should also be considered when deciding. We assert that a key factor for supporting NBS implementation at the city level is improving, in a simple and transparent manner, information among stakeholders, particularly decision makers, about all the benefits that this type of measures provides for the society (and, if possible, about their monetary value).

The CBA results can be utilised not only in argumentation in favor of implementing the two remaining phases of the "Lobezská louka" project, where complex property relations will have to be resolved, but also in the case of implementing other nature-based measures in general. Application of the CBA method leads to the aggregation of all the benefits in a single figure. On the one hand, this blurs the importance of the different ecosystem services; on the other hand, it simplifies communication of the net benefits to the general public as it expresses everything with a single figure. In other words, it enables comparison of the financial costs of implementation and maintenance of measures with the benefits, which mostly lack direct financial impact but make a significant contribution to quality of life.

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