EkoMiasto#Środowisko

Zrównoważony, inteligentny i partycypacyjny rozwój miasta

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NATURE-BASED SOLUTIONS

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11.1. Origin of the concept

Our dependence on nature is not questioned (or at least should not ever be). It is clear that we rely on nature for our well-being and quality of life, but primarily for the elementary living conditions that it ensures (such as clean air and water). Yet, nature has become an increasingly scarce resource in Polish cities, as well as in cities in many other countries. To counteract this trend – and to make our dependence on nature even more evident and appealing – researchers and forward-looking decision makers proposed a renewed focus on "nature-based solutions", which are meant to address the most important challenges that urban areas now face, such as pollution, climate change, water and energy scarcities, and deteriorating health.

This chapter provides a review the origin of this concept, linking to the most important European policy actions in this area. This chapter partly serves as a wrap-up for previous chapters, highlighting the importance of urban nature in the broad context of an eco-city. The reason it is in English is that most discussions on urban environment and urban environmental management are carried out in this language and everyone working in this area should know the basic English language terminology to be able to follow international discussions and read the original official documents of the European Union (EU). Indeed, even the official translations of EU documents often pose interpretation problems and reflect the translators' insufficient specific knowledge and understanding. One more reason for not translating the chapter on nature-based solutions is that this term does not have an established Polish equivalent. Difficulties with translating other common terms, such as sustainable development (*zrównoważony rozwój* vs. *trwały rozwój*) or ecosystem services (*usługi ekosystemów* and *usługi ekosystemowe* vs. *świadczenia ekosystemów*) illustrate how demanding it is to create a term that would comprehensively and unequivocally reflect the original term in another language. Perhaps then the best option is not to translate it at all?

This chapter features several practical examples of nature-based solutions used to solve specific problems that cities now face, indicating how nature-based solutions address the challenges already indicated in the previous chapters. Nevertheless, the concept of nature-based solutions and the present emphasis put on nature-based solutions in European policies also pose some new challenges, which need to be discussed in this context.

History of life on Earth is a history of changing environmental conditions and of how various organisms (eventually including humans) adapted to those conditions and thrived. Like other organisms, people rely on nature for their survival and for their very existence (air to breath, water to drink, food to eat, resources for shelter etc.). Even though a modern society seems detached from nature, we still need natural resources for survival and we depend on specific natural conditions within which our life is possible. Clearly, no economic nor social activity would be possible without the environment.

Apart from the above essential dependence, nature has always served as a source of inspiration and ideas which were then used by people for their benefit. Examples range from an airplane inspired by the observation of flying animals, various synthetic substances equivalent to those that can be found in nature, shapes of buildings and building components mimicking shapes already tested in nature (albeit often at different scales), as well as organisational solutions that mimic ecological processes and functions. The former – replicating design found in nature – is best known as biomimicry; the latter – replicating broader ecological solutions – has been called ecomimicry. As explained by Michael Pawlyn, a British architect who works

on projects that take inspiration from nature, "You could look at nature as being like a catalogue of products, and all of those have benefited from a 3.8-billion-year research and development period. And given that level of investment, it kind of makes sense to use it" [Pawlyn, 2010].

Eden Project as an example of biomimicry

photo: J. Kronenberg

Eden Project in Cornwall (see photo) is supposedly the largest greenhouse in the world and one of the most visited tourist attractions in the UK. As explained by an architect involved in this project [Pawlyn, 2010], the buildings and their components are inspired by nature. Soap bubbles, pollen grains, radiolaria and carbon molecules helped to devise the most efficient structural solution (hexagons and pentagons) and other examples from nature helped to design specific technical solutions, such as pressurised membranes, thanks to which the structure of the building is actually lighter than the air that it holds. Clearly, these and other nature-based solutions used in Eden Project helped to increase its resource and energy efficiency, and to make it better adapted to the natural conditions within which it is located (rehabilitated quarry).

Source: the author, based on Pawlyn, 2010.

Replicating ecosystem functioning in social and economic systems has been termed industrial ecology and aimed at creating a more sustainable industrial system by using our knowledge of ecosystem structure and behaviour [Kronenberg, 2007]. Indeed, within industrial ecology, industrial systems are called industrial ecosystems and they are meant to optimise energy and materials use in an attempt to follow the more efficient energy and materials use in nature. Industrial ecology is perhaps most often associated with waste minimisation and using wastes (also called residues and joint or by-products) as resources for other processes (often referred to as "closing the loop"). This is based on an observation that in nature there is no waste (in terms of material that would be generated and not useful for any organism in the system) – everything is used. In this context, industrial ecology is used to study and design the interactions between industrial and natural systems, keeping in mind that the industrial (economic) system is embedded in the larger natural system and needs to obey the Earth's carrying capacity.

Industrial ecology helps to understand the flows of materials and energy between the industrial (economic) system and nature, i.e. the so-called industrial metabolism. Similar studies can be performed at the level of individual products and product chains, with the use of tools such as life-cycle assessment. In terms of designing industrial systems and product chains, industrial ecology puts emphasis on mimicking the principles of ecosystem functioning, such as resilience and efficiency, diversity, interconnectedness and cooperation (Tab. 11.1). Hence, it emphasises

#industrial ecology #industrial metabolism

economy based on functionality, one of the manifestations of which may be planning of products that considers environmental impacts throughout their life-cycles thus emphasising features such as durability, reuse and recyclability.

Table 11.1. Key principles of industrial ecology

Coevolution	Economies, society and nature coevolve
Nested systems	Economies (and other social systems) are embedded in a larger natural system, the carrying capacity of which has to be obeyed
Natural laws	Material and energy flows in industry form part of material and energy cycles in nature and, as such, are governed by the same biophysical laws
Resilience	Due to their internal "immune system", resilient ecosystems are less likely to be affected by disturbances and more easily adapt to new conditions
Efficiency	The overall efficiency of natural systems exceeds that of the economy, principally because they function as an integrated whole, while the components of man-made systems often function as if they were separate (thanks to these there is no waste in nature)
Diversity	The diversity of organisms and species (biodiversity) constitutes one of the most important sources of nature's resilience and stability and so an analogous diversity of "industrial organisms" does, or at least should do, in industry
Interconnectedness	There are more interactions among organisms in nature than there are among organisms in industry and these linkages also increase ecosystems' resilience (implying a need for increased collaboration between the different actors in socio-economic systems)

Source: Kronenberg, 2007.

Industrial ecology is highly relevant in the context of cities. It serves to design eco-industrial parks within which companies exchange their by-products to minimise waste streams and it also supports various sustainable consumption patterns, all of which is again meant to replicate the efficient use of materials and energy in nature. It also serves to study urban metabolism, i.e. the flows of materials and energy between a city and its surrounding environment. Identifying the relevant flows and inventing ways of managing the relevant "waste" streams (which indeed within industrial ecology are no longer called "waste" streams but rather the streams of unused resources) helps to turn one of the most serious urban environmental problems into an opportunity. This is also aided by urban mining which indicates that cities contain large deposits of unused resources embodied in unused infrastructure, and that these resources could be used effectively for new purposes.

Similar to biomimicry and ecomimicry, including industrial ecology, many other concepts have emphasised the important role of nature as a model to replicate in our socio-economic systems. Several others went beyond replicating nature and indicated that people can actually consciously incorporate nature into the systems that they design. Such approaches can be associated with applied ecology and ecological engineering, and – most recently – with the increasingly popular nature-based solutions.

Similar to industrial ecology, applied ecology uses ecological knowledge to solve environmental problems. In this case, the focus is on broad environmental management and on practical application of knowledge developed within theoretical ecology. Hence, applied ecology is used to design ecosystems by altering some of their properties – to enhance the desired effects, e.g. in biological control or bioremediation but also in the case of preventing and mitigating global environmental changes [Bertelsmeier et al., 2012].

Ecological engineering has been defined as "the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" [Mitsch, Jørgensen, 2003, p. 363]. This includes both the restoration of degraded ecosystems and the development of new ecosystems or ecosystem components that are meant to serve human needs. In many countries, including the USA, large scale engineering projects carried out in the 1970s and 1980s (such as channelling rivers or drying floodplains) are now being reversed. Riverbeds are restored to their natural state and floodplains flooded, often at an enormous cost. These new ecological engineering projects are meant to bring back the ecosystem services lost due to previous interventions. The reason for undertaking them is that those interventions (or more explicitly the environmental degradation that they caused) brought problems and costs rather than the promised benefits. Clearly, the previous engineering projects reflected human hubris, unjustified belief in technology and neglect of the key role that a healthy functioning environment plays in maintaining and regulating our living conditions. Unfortunately, such hubris still persists in many other countries, where so far similar mistakes have not yet been made – or at least not on the same scale – including Poland.

Ecosystem restoration is also performed in cities. A recent study based on data from 25 urban areas in the USA, Canada, and China indicated that restoration and rehabilitation of urban woodlands (but also other ecosystems, such as rivers, lakes etc.) pays in economic sense, even using the most traditional economic approaches and only some of the multiple services provided by these ecosystems. Taking into consideration the minimum benefit and maximum cost combination the estimated benefit–cost ratio was 1.21, while the maximum benefit and minimum cost combination yielded a benefit–cost ratio of 6.57 [Elmqvist et al., 2015]. These results support the relevant commitments made within international agreements, such as by the parties to the Convention on Biological Diversity that agreed to restore at least 15% of degraded ecosystems by 2020. Clearly, they also support the general commitment to use nature-based solutions more broadly in cities.

Building on experience gained in the areas of biomimicry and ecomimicry, applied ecology, ecological engineering and ecosystem restoration, modern discussions on nature-based solutions try to fit into the logic of natural capital (see chapter *Miasto jako system ekologiczny*), whereby ecosystems are seen as a production factor similar to labour and human-made capital. Indeed nature-based solutions go beyond ecosystem restoration and beyond ecological concepts highlighted so far. They focus on the socio-economic context of nature, again – like in the case of ecosystem services (see chapter *Usługi ekosystemów – nowe spojrzenie na wartość środowiska przyrodniczego*) – trying to fit nature conservation in narrower socio-economic considerations to make it understandable for the broader public.

Such a renewed understanding is embraced by the recent policies of the EU but also in activities of some important conservation organisations, such as the International Union for Conservation of Nature (IUCN). The EU defines nature-based solutions in the following way [European Commission, 2015, p. 5]:

#applied ecology #ecological engineering #ecosystem restoration

"Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions which are inspired by, supported by or copied from nature. Some involve using and enhancing existing natural solutions to challenges, while others are exploring more novel solutions, for example mimicking how non-human organisms and communities cope with environmental extremes. Nature-based solutions use the features and complex system processes of nature, such as its ability to store carbon and regulate water flow, in order to achieve desired outcomes, such as reduced disaster risk, improved human well-being and socially inclusive green growth. Maintaining and enhancing natural capital, therefore, is of crucial importance, as it forms the basis for implementing solutions. These nature-based solutions ideally are energy and resource-efficient, and resilient to change, but to be successful they must be adapted to local conditions".

The socio-economic context is also evident in the EU's justification for why promoting the concept of nature-based solutions is particularly relevant in this particular moment [European Commission, 2015, pp. 5–6]:

- the focus on nature-based solutions fits well into the dominant discourse on "sustainable and green growth";
- there is a growing awareness of the value of nature (see chapter *Usługi ekosystemów – nowe spojrzenie na wartość środowiska przyrodniczego*) which is underlined as a "business opportunity";
- nature-based solutions are cost-effective which is a critical advantage in the present period of financial austerity;
- nature-based solutions offer Europe to maintain its position in international markets of the relevant knowledge, expertise, skills and technologies.

If the EU sees nature-based solutions as a window of opportunity not only to protect the environment, but also – or perhaps principally – to improve business opportunities and the position of the EU in international markets, then obviously we can expect that this approach will be further reflected in national policies and on-the-ground management.

11.2. Living with nature: Nature for the city

11.2.1. Practical applications of nature-based solutions

The concept of nature-based solutions reflects a paradigm change – from trying to isolate human beings from nature in our human-made and capital-intensive systems – to a society that co-exists with nature and wisely uses ecosystem services. Similar transformations have already occurred in many locations throughout the world. For example, in the Tisza river valley in Hungary, a traditional paradigm of "protecting the landscape from the river" has been gradually replaced by a sustainable systems approach of "living in harmony with the river", acknowledging that the restoration of traditional floodplains would increase profitability of extensive agricultural practices, which would bring about additional benefits, such as increased soil quality and biodiversity, and increased quality of life for local communities [Magnuszewski, Sendzimir, 2010].

The Hungarian case illustrates a large-scale complex adaptive management perspective on the whole river floodplain, but many other smaller-scale examples are available to illustrate how nature-based solutions contribute to broader key objectives of an eco-city mentioned so far in this book. This section will link to some examples of how nature-based solutions are meant to contribute to sustainable urban

development, restoration of urban ecosystems, mitigating and adapting to climate change, and risk management whereas healthy ecosystems are seen as ultimate insurance against external disturbances.

However, it is always important to keep in mind the broader context of our "living with nature" – a complex dependence which cannot be limited to market-oriented relationships, quantifiable and judiciously valued by "rational economic agents" [Turnhout et al., 2013]. To maintain a balanced view, the second part of this section presents outstanding challenges and limitations related to the concept of nature -based solutions.

According to the expert group appointed by the European Commission [2015], nature-based solutions offer four major groups of applications, which also translate into specific research and development needs:

1) Enhancing sustainable urbanisation (ensuring high quality of life for urban inhabitants and at the same time reducing their environmental impacts).
2) Improving the restoration of degraded ecosystems (renewed understanding of the importance of nature, and of the cost-effective solutions that it offers, highlights new opportunities for ecosystem restoration).
3) Developing climate change adaptation and mitigation (adaptation refers to reducing negative impacts, while mitigation involves limiting emissions of greenhouse gases – as climate change is an over-arching and cross-cutting challenge, integrated nature-based solutions need to address both adaptation and mitigation).
4) Improving risk management and resilience (nature-based solutions can help mitigate extreme events such as drought, extreme temperatures, floods, industrial and transport accidents, landslides and avalanches, storms etc.; i.e. they improve the ecological safety of a city).

The following paragraphs present and illustrate nature-based solutions fitting into each of the above categories. However, note that each nature-based solution actually provides many other benefits, on top of those for which it has been implemented. These benefits are far broader and complex, and there are many non-linear interactions between the use of nature-based solutions and human well-being in urban areas (as already discussed in chapter: *Usługi ekosystemów – nowe spojrzenie na wartość środowiska przyrodniczego* on ecosystem services and their value to urban inhabitants).

Quality of life for urban inhabitants. One of the most important issues related to sustainable urbanisation is that nature in the city (urban green space in particular) contributes to improved health of urban residents. Cleaner air, higher humidity and lower temperatures translate into improved microclimate, thus directly and indirectly also to human health. Contrary to common belief, urban greenery – especially when it is diverse and combined with the presence of water in the city – lowers the incidence of allergy and asthma. This is so because of higher humidity (recall that urban greenery retains water) and improved air quality, as allergies and asthma are reinforced in dry and polluted settings [Kupryś-Lipińska et al., 2014]. Furthermore, urban green space contributes to increased physical activity, as well as to physical and mental regeneration and stress reduction [Shanahan et al., 2015]. Many cities have been consciously using urban green spaces to ensure better health of their residents, paying particular attention to proper green space around hospitals and other medical facilities. Interestingly, urban greenery was consciously used for such purposes in Poland during socialism, and this has been much less emphasised since the beginning of the transition period. There have been particularly interesting cases of using nature-based solutions for the benefit of human health, such as restorative

gardens or horticultural therapy centres. Indeed, the use of nature-based solutions in restorative environments indicates that greener surroundings would in general improve the well-being and in particular mental health of urban residents.

Horticultural therapy as an example of how nature-based solutions improve quality of life for urban inhabitants

photo: T. Klarskov

The Danish Healing Forest Garden Nacadia is run by the Nature, Health and Design Laboratory (University of Copenhagen) in Hørsholm Arboretum in the north of Copenhagen, the most prominent arboretum in Denmark. Nacadia offers nature-based therapy which is combined with conventional treatment and research [Corazon et al., 2012]. The main focus is on treatment for people affected by stress-related illnesses. Therapy starts with a passive stage within which patients regenerate their low resources by simply lying on grass or having a rest in the garden. Once they feel stronger, they undertake gardening activities which strengthen their physical and mental relationship with the environment. Gardening activities follow the rules of permaculture, i.e. farming that imitates the patterns and features observed in nature. This is adjusted to the needs of people with stress problems, who have been found to prefer a wild and diverse environment. The patient's experiences and activities are guided by the therapist. The standard treatment is expected to last 10 weeks and the first patients were soldiers suffering from post-traumatic stress. Nacadia is designed to accommodate eight-person groups at a time on an area of 9700 m^2 of open spaces, forest, water and other habitats (and two buildings). The different habitats and settings are used to create the different "rooms" for different types of activities. Although the idea of horticultural therapy is not new and dates back to gardens in ancient Greece and then medieval monastery gardens, the activity of Nacadia is highly innovative and influential. Indeed, governments in several countries, including Denmark and Sweden formally count horticultural therapy among official stress treatment methods and reimburse the relevant rehabilitation expenses within social insurance.

Source: the author, based on Corazon et al., 2012.

Restoration of degraded ecosystems. Specific nature-based solutions involve ecosystem restoration (e.g. restoration of rivers, natural floodplains, wetlands), introducing new components of nature (e.g. individual trees, green roofs or patches of forest), introducing new habitats to attract specific, desired groups of organisms (e.g. flower gardens and meadows to provide ecological corridors for pollinators), and designing ecosystems in a way to maximise the delivery of selected services (the specific solutions needed in a particular setting). Efforts to restore degraded ecosystems are meant to ensure their best performance in terms of delivery of ecosystem services (as in the abovementioned examples of the related areas of ecosystem restoration, applied ecology and ecological engineering). Indeed, efforts to introduce new ecosystem components or new habitats are also usually related to broader ecosystem restoration objectives. The new components/habitats are meant to recreate ecosystem connectivity that once existed but became affected by

the development of urban grey infrastructure or simply by urban growth. One of the side effects of developing grey infrastructure is sealing of urban surfaces, which affects microclimate and especially temperatures, leading to the so-called urban heat island effect.

Green roofs and green walls complement existing green infrastructure in cities

photo: J. Kronenberg

Introducing nature to where it would not naturally occur, such as on roofs and walls of buildings, is one of the commonly advocated ideas for filling gaps in green infrastructure in dense urban settings [Dunnett and Kingsbury, 2004]. Thanks to these "patches", the green infrastructure maintains its connectivity, hence also multiple services. One of the most important local effects of introducing green roofs and walls is that they improve microclimate and in particular help reduce the urban heat island effect. The authors of a study based on a model that incorporated climatic characteristics of nine cities, different urban canyon geometries and orientations, as well as different wind directions concluded that "the hotter and drier a climate is, the greater the effect of vegetation on urban temperatures" although the positive effect also occurs in all other conditions [Alexandri, Jones, 2008, p. 493]. Similar conclusions have been drawn by other studies [Susca et al., 2011]. Clearly, green roofs and walls also provide many other benefits to urban population – or, in other words, they provide solutions to multiple other problems that affect urban quality of life. Notably, they reduce pollution and runoff, help insulate and reduce the maintenance needs of buildings, contribute to biodiversity, and provide habitats for wildlife. In addition to the above, they are attractive to look at (such as the green wall in Marseille, France, featured in the picture) and enhance the quality of life of residents.

Source: the author.

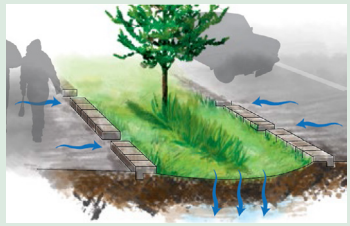
Climate change adaptation and mitigation. Climate change adaptation and mitigation is one of the most highlighted issues in the context of nature-based solutions in cities and urban green and blue infrastructure (as already noted in chapter: *Adaptacja do zmian klimatu terenów zurbanizowanych*). The role of nature-based solutions is underlined in all kinds of climate change adaptation strategies, indicating that to be successful any climate change adaptation strategy "needs to more fully integrate biodiversity, ecosystem services and natural resources at the start of, and throughout the planning and implementation (…). This will help scale up (…) adaptation strategies to ensure they are effective for as long as possible in the face of climate change by safeguarding ecosystem functioning and better understanding changes that will affect it" [Jeans et al., 2014, p. 254]. It is essential to understand that ecosystems

are also affected by climate change, which undermines the underlying ecological processes and translates into their reduced ability to provide us with services.

Nature-based solutions can also mitigate other environmental problems such as water, energy and food shortages, caused by excessive use and global environmental changes [Marton-Lefèvre, 2012]. More nature in the city translates into less stormwater runoff and better circulation of water, which reduces the need for plant irrigation and for cooling purposes. Likewise, energy savings can be achieved thanks to the use of trees and other green infrastructure components for shade, and green roofs and walls for better thermal insulation of buildings. Finally, urban green spaces can also be used for urban agriculture, as can increasingly be seen also in the developed countries (with leading examples from the USA). This does not only increase urban resilience by reducing the dependence on external sources of food, but it also reduces pollution by reducing the number of food trucks that enter the city to deliver food. Indeed, this also helps to keep the money within the city, ensuring additional job opportunities. Using nature-based solutions for all of these needs further improves urban ecosystem functioning (e.g. providing habitat and ecological connectivity), which translates into a host of other ecosystem services that provide benefits to urban inhabitants.

The role of nature based solutions in urban stormwater management and water retention is one of the most highlighted aspects of urban climate change adaptation and mitigation strategies.

Keeping stormwater in the city through nature-based solutions



Source: The Sendzimir Foundation

Water (or blue infrastructure) in the city is a particularly important asset which contributes to climate change mitigation and adaptation. This does not only refer to rivers and lakes but also to many other small components of urban green and blue infrastructure, such as small retention reservoirs, all of which help to retain stormwater and snowmelt close to where it falls. Water retention is important because it reduces the pressure on the urban sewage system and prevents local floods and inundations that accompany extreme rainfall. Thus, it also reduces the costs of developing and maintaining a sewage system large enough to process stormwater in the case of extreme events which would be idle and generate extra costs in normal weather conditions. Furthermore, water retention prevents drought and the heat island effect (see the previous box), typical to sealed surfaces in city centres. Many cities throughout the world consciously use green and blue infrastructure for the above purposes, acknowledging the importance of water as the basis of a fully functioning natural system that provides urban residents with a wide range of ecosystem services. Such solutions include various types of plant buffer strips (see picture), stormwater infiltration facilities (e.g. detention ponds), and various biological stormwater treatment systems (constructed wetlands). Clearly, such solutions aim at reducing the proportion of sealed surfaces which increase runoff and they are part of integrated management of blue-green infrastructure. Altogether they serve as a solution to stormwater management which is increasingly important in the face of climate change. Such solutions are often supported with the use of various fees for stormwater and snowmelt collection which provide incentives to introduce green infrastructure as a nature-based solution to increased

stormwater runoff. For an overview of multiple solutions falling into these categories, see a recent guide on water in the city prepared for local decision makers in Poland [Bergier et al., 2014].

Source: the author, based on Bergier et al., 2014.

Risk management and resilience. Chapter *Bezpieczeństwo ekologiczne miasta* addressed the issue of "environmental safety" in a city, listing a number of the related threats and potential mitigation options. Clearly, proper environmental management is one of the most important and currently most highlighted avenues for action in this area. Ecosystems are analysed from the perspective of insurance value that they offer, notably in terms of preventing health problems (reducing the risks of their occurrence), preventing urban heat island and many other nuisances related to urban life, mitigating the effects of climate change (such as floods or droughts) as we have seen above. Ecosystems can also insure urban inhabitants against socio-economic disturbances, such as economic crises. For example, in the face of long-lasting economic problems, urban gardens provide 50% of food supply in Havana, Cuba.

Many cities implement various large-scale ecosystem restoration or design projects, either focusing on ecosystems in a city or in an urban periphery, to "insure" their inhabitants against the various threats already listed above. In this way, ecosystems are treated as ultimate insurance and such solutions are meant to ensure urban resilience. Examples include preventing logging or tourism development in areas from which cities derive important ecosystem services (e.g. the delivery of clean drinking water, such as in New York or Vancouver), restoring wetlands and buffer zones that are meant to protect a city against the effects of natural disasters (e.g. in New Orleans after Hurricane Katrina or in North East Japan after the 2011 tsunami). Similar examples include large scale tree-planting projects undertaken in several cities in the USA and recently proposed in Warsaw.

Million Trees for Warsaw as a prospective example of a large-scale tree planting campaign

Million Trees for Warsaw is a new initiative of the Capital City of Warsaw Municipal Office, launched in 2015. It is based on similar programmes carried out since the mid-2000s in several US cities, such as New York, Los Angeles, Houston, Denver, Salt Lake City and Sacramento (the last of which actually committed to planting 5 million trees and not 1 million as the other five). All of these initiatives are meant to use urban trees for multiple reasons, including climate change mitigation and adaptation, air quality and microclimate regulation, stormwater retention, as well as numerous cultural services. To achieve such a multitude of benefits, these programmes are supported by broad coalitions of local stakeholders, and they rely on public participation [Young and McPherson, 2013]. Such initiatives were also proposed in other cities, including Lodz [Kronenberg, 2012], but they did not always attract much attention. The new initiative in Warsaw is meant to provide a framework for sustainable management of Warsaw's urban forest and to educate the public on the benefits that it provides. Like in its US

photo: Aisog, Wikimedia Commons [access 24.08.2015]

counterparts, broad public involvement is also expected in the Million Trees for Warsaw initiative. However, the experience from recent years has demonstrated that the preservation of urban trees in Warsaw poses a number of challenges, and the inhabitants have organised a number of large-scale protests against the removal of trees and what they considered poor urban forest management undertaken by the authorities. It is still to be seen whether the new initiative will involve a real change or remain an empty political declaration. Hopefully, the city will go for real trees and not plastic ones, such as the famous palm tree planted by Joanna Rajkowska (see photo).

Source: the author.

11.2.2. Implementation limitations

Nature-based solutions and ecosystem services are often presented as cost-effective alternatives to human-made solutions to various problems. Several case studies are available and widely repeated of nature-based solutions that have successfully outcompeted the human-made alternatives, or that might have done so, had they been implemented. Likewise, as noted above, the EU experts also suggest that nature-based solutions offer cost-effective alternatives to traditional human-made solutions. One of the best-known examples is the preservation of water filtration capabilities of Catskill Mountains from which New York City sources drinking water (the city considered an alternative – construction of a filtration plant that would clean the water once the Catskill Mountains ecosystem is degraded and unable to ensure proper water quality, and this alternative turned out to be twice as expensive as ecosystem preservation). However, there is also evidence that this approach might turn out excessively naïve, especially when the dynamic nature of human ingenuity is taken into consideration [Sagoff, 2002; McCauley, 2006].

The historical concept of economic ornithology is a particularly useful case study which should serve as an important warning [Kronenberg, 2014]. Economic ornithology was an area of research developed at the turn of the 20th century to motivate bird conservation. In hundreds of publications, and with official support from prominent government institutions, especially the US Department of Agriculture, economic ornithology emphasised the role of birds as a perfect nature-based solution for the problem of pest control in agriculture and forestry. Economic ornithologists underlined the utilitarian character of nature to raise political support

for conservation. Already over 100 years ago, they argued for the use of nature-based solutions, indicating that birds provided important services to people.

However, economic ornithology remained relatively narrow and focused on its core task of demonstrating the cost-effectiveness of using birds for biological control in agriculture and forestry. Such an anthropocentric approach, prioritising narrow and measurable human economic interests, undermined the standing of economic ornithology. Probably most importantly, new developments in the area of industrial pest control made the most highlighted of the birds' services obsolete. Meanwhile, not enough attention was paid to the external effects (and costs) of the use of pesticides as an alternative solution, which soon turned out to be very significant (in terms of negative effects on human and ecosystem health).

This cautionary story highlights the need for a broader, more rational and careful approach to how the new concepts are presented to the general public. Indeed, with their focus on the individual benefits that people derive from nature, or even bundles of such benefits, the concepts of ecosystem services, valuation of ecosystem services and nature-based solutions expose nature conservation to similar risks, of which we may not yet be aware. Another key problem with economic ornithology – and to some extent now with nature-based solutions – is that highlighting specific benefits related to a given nature-based solution (or its cost-effectiveness) invites people to think about how the same solution might be delivered even more cost-effectively. This brings about the risk of considering nature-based solutions and human-made solutions as substitutes, which in reality they are not. We should be aware of the limitations to such substitution and always understand that any nature-based solution is in reality entangled in a myriad of interactions with other ecosystem components and hence responsible for the delivery of multiple other ecosystem services. In short, a reductionist view that the concept of nature-based solutions seems to invite (being able to distinguish one specific solution and focus on it as if it were separate from other ecosystem components) emerges as the most important problem, implying that it can be considered as competing with any other way of satisfying the same need.

In addition to the above, in chapter *Usługi ekosystemów – nowe spojrzenie na wartość środowiska przyrodniczego* we have already observed several problems inherent in the concept of ecosystem services and in ecosystem services valuation, such as trying to fit nature conservation into the dominant economic paradigm with its own failures and inadequacies [Norgaard, 2013]. Indeed, some commentators suggest that the concept of nature-based solutions gains so much policy and business support because it detracts attention from many unresolved problems that have been discussed in the context of environmental protection so far (such as curbing emissions from industry and eliminating other pollution sources). The optimistic focus on opportunities, especially business opportunities and green growth, may be seen as reflecting some hidden agendas, such as to patent and sell specific nature-based solutions or the related consulting services. Had this been the case, the problem of potential ecosystem commodification would become particularly relevant.

11.3. Recommendations for Polish cities

The concept of nature-based solutions is increasingly popular in policy discussions, especially with regard to environmental management in cities. It has been embraced by both political circles (especially the European Commission), and large conservation organisations (such as IUCN), and also attracts positive responses from the international business community. It highlights key benefits that people

obtain from nature, and our ability to restore ecosystems and improve their functioning to be able to maximise those benefits. Hence it is close to the well-established areas, such as ecosystem restoration, applied ecology and ecological engineering.

Nevertheless, we need to be careful in how we interpret nature that provides us with solutions. We need to keep in mind the broad reliance of human societies on nature and resist temptation for reductionism. Nature-based solutions should not be viewed as substitutes for human-made solutions as this may start a risky competition that might eventually indicate that people can provide some solutions more cost-effectively, seemingly eliminating our reliance on nature. This is a game of deception, though, as demonstrated by the historical example of economic ornithology. We still rely on nature for a multitude of other reasons, and finding cost-effective substitutes for all of them – for ecosystem functioning in general – is impossible. Also, we cannot let the new focus on nature-based solutions detract attention from outstanding, unresolved environmental problems.

Still, there are important implications from the current discussion on ecosystem services for environmental management in Polish cities. The most important one is that we do need nature because it addresses many crucial needs of urban inhabitants. Second, we still have relatively abundant but continuously threatened nature in our cities and we need to protect it against degradation related to the development of grey infrastructure and urban growth in general. In particular, this refers to how we protect and manage existing resources, such as trees and green spaces. In particular, we still have quite a lot of unsealed land in cities and a rapid trend of sealing it. When decision makers from one Polish city went on a study visit to a city in Germany, they saw how the authorities in that city supported unsealing of land – at quite a significant cost. The Polish guests realised that this was beneficial (in terms of water retention, improving microclimate etc.) and sighed that unfortunately they would not be able to do the same because of limited financial resources. However, the point is that they would not need to spend these resources just because less land has been sealed in Polish cities so far. Essentially, what is needed in Poland is better preservation of existing resources – so that they serve as nature-based solutions. Unfortunately, this has not been implemented yet, neither in the city in question, nor in other cities in Poland, and we keep witnessing further sealing and degradation of green space. Lack of proper care for urban trees, especially at construction sites and in investment planning provides yet another example of an appalling neglect, even though many methods for effective tree preservation exist (see below) and prevention is much cheaper than restoration.

Preventing ecosystem degradation is much cheaper than ecosystem restoration – example of urban trees in Poland

The easiest and the cheapest way of ensuring that urban nature provides us with services is preventing its loss and degradation. Meanwhile, urban nature is under constant pressure from development of grey infrastructure and its preservation is overshadowed by other, seemingly more pressing needs (Kronenberg, 2015). Simple measures might help to significantly improve living conditions for trees in cities and thus ensure the delivery of the simplest of all nature-based solutions, i.e. those that are already available and do not need to be regenerated or created from scratch. Meanwhile, in practice preventing urban nature degradation receives relatively little political priority in Poland and the traditionally recommended procedures (such as covering tree trunks in construction sites with wooden boards) are largely ineffective because they do not protect

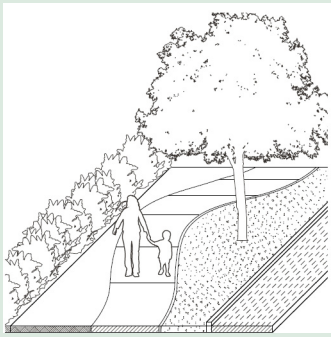


illustration: The Sendzimir Foundation.

the crown nor the root system. Clearly defined responsibilities and monitoring, appropriate timing of construction works, proper tree protection design and the use of less damaging construction technologies as well as inevitability of penalty are the most important recommendations concerning effective tree protection at the construction site. Further simple solutions can be used to facilitate tree growth in difficult urban conditions, such as structural soils, underground building blocks that leave space for root development, permeable pavements, rerouted or bridged sidewalks, alternative curbs, and fences with supporting posts. All of these help to effectively protect urban trees and the related nature-based solutions, often at a low cost. Many specific recommendations that can be used to protect urban trees and ensure that they have proper development conditions are described in a guide for local authorities prepared by professionals involved in the management of urban green spaces [Bergier et al., 2013], from which the attached picture also comes.

Source: the author, based on Bergier et al., 2013.

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