

Assessment of biophysical and ecological services provided by urban nature-based solutions: a review



KEY POINTS

- Local climate regulation and recreation are the most commonly assessed ecosystem services in cities.
- Ecosystem service provisioning by urban NBS has mostly been assessed in China, USA and Europe.
- Most studies were conducted in parks and urban forests.
- Climate change was the most frequently mentioned challenge, followed by human health and wellbeing.

ABOUT THE PROJECT

NATure-based URban innoVATION is a 4-year project involving 14 institutions across Europe in the fields of urban development, geography, innovation studies and economics. We are creating a step-change in how we understand and use nature-based solutions for sustainable urbanisation.





Reviewing the evidence base

The aim of the review was to synthesize current literature which assessed ecosystem services (ES) provided by urban nature-based solutions (NBS). The focus was on seven ecosystem services (ES) considered particularly relevant in an urban context: local climate regulation, storm water regulation, waste treatment (incl. water purification and soil remediation) air quality regulation, pollination, recreation and aesthetic benefits. The search resulted in 2629 articles in total. Of these, 526 peer-reviewed publications met the following criteria:

1) presence of the ES searched for in terms of ecological indicators, 2) studying green or blue infrastructure, 3) being specific to the urban context, and 4) being either a review, empirical (field experimental study) or modelling study (incl. mapping studies); and were included in the following analysis.

Increase of publications on NBS and ES

The earliest publication on ES provided by urban NBS as identified in the review is from 1991, reporting on plants in ponds used for cleaning effluents of urban origin. Since 2010, published research on ES provided by urban NBS has increased exponentially (Figure 1).

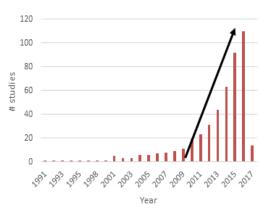


Figure 1: Year of publication of empirical and modelling studies covering ES delivered by urban NBS.

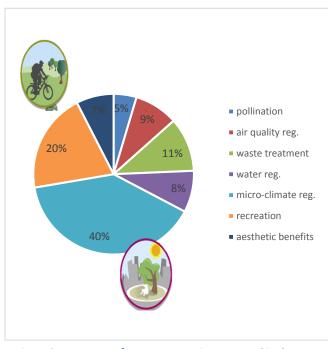


Figure 2: Frequency of ecosystem services assessed in the reviewed publications.

Majority of studies assess local climate regulation with evidence from around the world

The majority of the studies focused on local climate regulation (40%) and recreation (20%) (Figure 2). The positive contribution of urban green to reduce the so-called urban heat island effect was a common study topic in the identified publications. Pollination, air quality regulation, storm water regulation and aesthetic benefits were less studied (< 10% of the studies each). A low number of studies addressed multiple ES simultaneously. Among those studies, recreation and aesthetic benefits was the most common combination.



Geographical bias

When looking at the locations where urban ES were assessed, a geographical biased was observed. The USA had the highest numbers of studies (88), followed by China (84). European countries had 177 studies in total. Only few studies have been conducted in South America and Africa (Figure 3). Local climate regulation has been studied in the highest number of countries across the world (39 countries in total). Recreation has mainly been studied in Europe, USA, China and Australia, while waste treatment studies were about one third from China, and nearly half of the studies about water management came from USA.

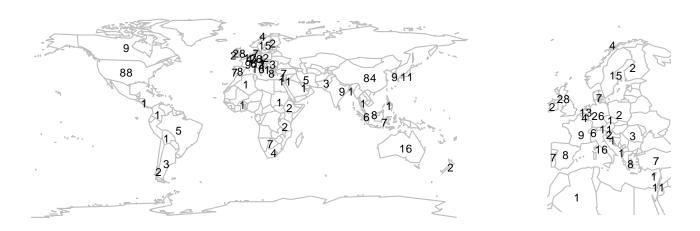


Figure 3: Geographical distribution of NBS studies on country level

Multiple ES indicators

Each ecosystem service is typically assessed by a variety of indicators. For example, water regulation includes a number of different processes such as water losses from evaporation by trees to storm-water runoff retention by ponds and wetlands. Waste treatment includes both soil remediation and waste water treatment activities, reflected by a high variety of indicators, such as concentration of pollutants in the soil, and removal rate of pollutants (e.g. organic matter, metals, pharmaceuticals) based on the concentration of pollutants in the in- and effluent.

Pollination was quantified by indicators reflecting the abundance or diversity of pollinators or their effect in terms of fruit or seed set. For recreation and aesthetic benefits, the largest set of indicators was found, ranging from more quantitative indicators such as the total surface and accessibility of green space, to more qualitative indicators such as people's perception/appreciation of green space.



Parks and urban forest mostly studied

'Parks and urban forest' was the most frequently studied ecological domain, covering 27% of the reviewed publications. Other commonly studied domains were 'green space' (22%) and 'urban green space connected to grey infrastructure' (20%). The least studied domains were 'natural and semi-natural green and blue space' (1%), 'derelicts and industrial land' (2%) and 'allotment and community gardens' (3%) (Figure 4). The frequency of ecological domains studied differed depending on the ES. For example, recreation was primarily assessed in 'parks and urban forest' and waste treatment in 'blue space'. Local climate regulation was studied all ecological domains.

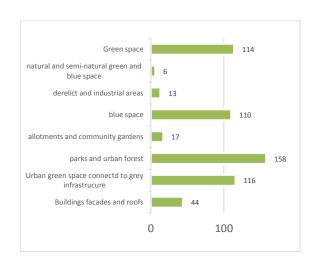


Figure 4: Distribution of ES studies (#) over the different ecological domains

NBS for climate adaptation, resilience and mitigation

A wide range of goals was addressed by the publications. 'Climate action for adaptation, resilience and mitigation was the most frequently mentioned goal (32%), especially linked to the service local climate regulation. 'Improving health and well-being' was also a common goal of the publications (24%), which was linked to all ES. Publications on air quality, waste treatment and water management primarily addressed 'environmental quality' challenges, while publications on pollination addressed 'biodiversity conservation'.

The knowledge gaps



We conclude that the evidence base for ecosystem service provisioning by urban NBS is biased towards a few ecosystem services and ecological domains, which highlights the need for 1) studying a wider range of services and ecological domains, and 2) developing quantitative assessment models that can be used not only locally but across ecological domains and locations.