

## Nature-based solutions – what is the new concept about?

*The idea of using nature to solve environmental problems is not new – it is the concept nature-based solutions (NBS) that is new. Since long, solutions related to flooding, pollution of soil, water and air, and human health and wellbeing have been developed and implemented. These solutions usually have their dedicated scientific discipline, exploring how the solutions can be improved, and implemented. Many of the solutions also have their own practice, filled with knowledge on the practical implementation. Occasionally this science/practice area even has dedicated concepts, such as ecosystem-based adaptation and green infrastructure.*

*The aim of this focus paper is to inform policy and decision makers about what the NBS concept is, how it is used and interpreted in science and practice, as well as its relation to other ecosystem-based green concepts. We ground the focus paper on a scientific literature review of peer-reviewed publications and a stakeholder analysis of Swedish actors at different societal levels and with different roles (see appendix A for details on the methodological approach).*

*The focus paper consists of three sections and a final reflection. In the first section, we give an overview of how the NBS concept has evolved and how it is defined. In section two and three, we describe the uptake and use of the NBS concept in science, respectively in practice. In the section focussing on science, we have a global perspective, and in the section focussing on practice, we have a Swedish perspective. For both sections, we ask questions such as, who use the concept, what solutions is conceptualised as NBS and how does it relate to other concepts? The final reflection aims to lift the perspectives and discuss advantages as well as disadvantages with the concept using the information presented in earlier sections.*

### The historical development of the nature-based solution concept

The term NBS was first mentioned in 2008 by the World Bank (World Bank, 2008). However, many of the large international organisations have mentioned the concept in different reports (see Figure 1 for a timeline of seminal NBS works). In 2009, the International Union for Conservation of Nature (IUCN) promoted the use of NBS to adapt to climate change in its position paper on the United Nations Framework

Convention on Climate Change COP 15 (IUCN, 2009). Some years later the organization adopted NBS as a part of its 2013–2016 Programme (IUCN, 2012). The IUCN conceptualize NBS as an umbrella term for ecosystem-related approaches, such as green infrastructure, ecosystem-based adaptation and ecosystem-based disaster risk reduction (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016). In 2015, NBS was launched as a major research area within the EU research and innovation program, Horizon 2020 (European Commission, 2015), which

was the entrance point for the concept on a larger scale both in the research community as well as policy and practice.

In 2018, the Intergovernmental Panel on Climate Change mentioned NBS in their 1.5° C report, in the context of flooding and climate adaptation (IPCC, 2018). In the same year, UNESCO published the United Nations World Water Development report on Nature-based Solutions for Water (WWAP, 2018). In 2019, The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services published a global assessment mentioning NBS in relation to the idea that nature can be conserved, restored and used sustainably, while simultaneously meeting other global societal goals (IPBES, 2019). In 2020, the IUCN published a 'Global Standard for Nature-based Solutions'.

## How is the nature-based concept defined?

There are different definitions of the NBS concept, but the most commonly used, and often referred to in the scientific literature, are the definitions proposed by the IUCN and the European Commission. The two definitions share common grounds, but do also have divergences (see Table 1 for an overview). The common grounds relate to the definition of NBS as actions based in nature that can address societal challenges. Both organizations also emphasize stakeholder involvements as important in the work with NBS (Cohen-Shacham et al., 2016; European Commission, 2015).



**Figure 1. Timeline of the publications of seminal works focussing entirely or partly on the nature-based solution concept.**

ions' aiming to facilitate the use and uptake of the NBS concept among a diversity of stakeholders (IUCN, 2020). In 2021, the European Environment Agency published a report about NBS in Europe, focusing on policy, knowledge and practice for climate adaptation and disaster risk reduction (EEA, 2021). The World Bank has since their first mentioning of the concept developed information and examples of implemented NBS on their webpage.

There is a strong focus on the multifunctional character of the solutions; nevertheless, most NBS suggests one major benefit and a series of co-benefits. For example, the main purpose of a wetland could be to buffer high floods (water regulation) and the co-benefits could be water purification, increased biodiversity as well as improved recreational values.

**Table 1. Overview of similarities and differences between the definitions proposed by the European Commission and the IUCN (Cohen-Shacham et al., 2016; European Commission, 2015).**

	IUCN	European Commission
Common ground		
	Actions based in nature to meet societal challenges	
	Stakeholder involvement important	
	Multifunctionality and co-benefits	
Differences		
Targeted part of nature	Protection, sustainable management, and restoration of <b>natural and modified ecosystems</b>	Development of <b>solutions “inspired by nature”</b>
Multiple benefits/co benefits linked to	Human well-being and biodiversity	Three dimensions (domains/pillars) of sustainable development (social, environmental, and economic)
Scale of solution	Large scale solutions	No defined scale of solution

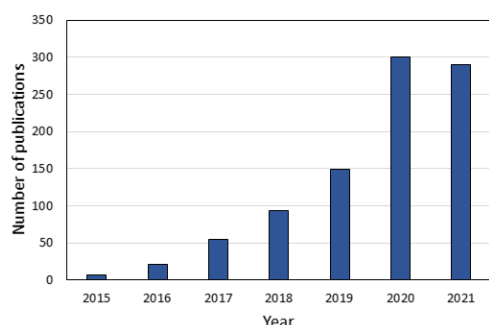
However, the definitions also have some major differences, which can result in different interpretations of which solutions that should be categorised as NBS and not. While the IUCN more strongly stress the protection, sustainable management, and restoration of existing natural and modified large-scale ecosystems (Cohen-Shacham et al., 2016), the European Commission includes solutions that are “inspired by nature”; more artificial solutions, such as green walls, green roofs, aquaponics and seawalls (European Commission, 2015). Both IUCN, and the European Commission relate to the idea that a NBS can provide multiple benefits or be multifunctional (Cohen-Shacham et al., 2016; European Commission, 2015), but they link the benefits to different ends. While the European Commission link to the three dimensions (social, environmental, and economic) of sustainable development, the IUCN link to human well-being and biodiversity.

## The uptake and use of the nature-based solution concept in scientific publications

There has been an exponential increase in the scientific interest in the NBS concept over the last years, where two-third of the 914 included publications were published January 2020 to June 2021 (Figure 2).

There is a large diversity of NBS publications. We discern four overlapping categories of publications. The first category includes publications focussing on explaining and defining the concept as well as its links to other concepts. The second category includes publications focussing on operationalizing the concept into practice by proposing different types of typologies and frameworks. The third category includes publications that report results from empirical and modelling studies covering different types of solutions, which they tag as NBS. The fourth category includes publications that have

synthesized (reviewed) knowledge within different research fields. Most of the NBS publications report on results from empirical and modelling studies.



**Figure 2. The uptake of the NBS concept in scientific publications over time. Note that the review is based on publications available at the Scopus and WOS databases in June 2021, e.g. the number of publications for 2021 is higher than shown in the figure.**

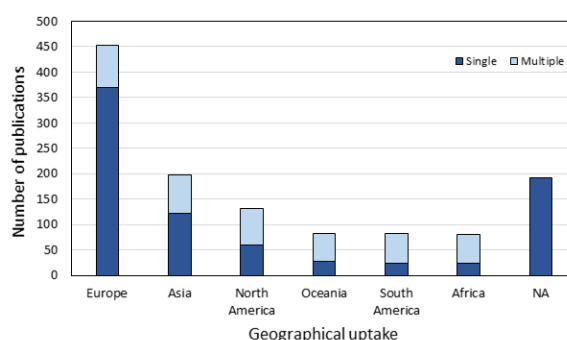
## Geographical uptake of the nature-based solution concept

About half of the 914 publications, report on research that covers the European context (Figure 3). A substantial part of the reviewed publications cover research performed in Asia, followed by a North American context. The African, Oceanian, or South American geographical contexts are the least covered contexts in the NBS publications. In total, 94 publications report on research that covers more than one continent. These studies concerned both empirical and modelling studies with case study sites in different parts of the world, as well as review studies that covered research performed in different parts of the world.

Almost two hundred of the 914 publications did not report or focus on any specific geographical context (categorised as NA). These publications did instead discuss/reflect on e.g., the definition

of the concept, how it relates to other concepts, its use within specific research areas/practice (e.g., disaster risk reduction, storm water management, water purification) etc. (see discussion on types of publication in previous section).

The Nordic countries are covered by 66 publications. These publications, mainly report results from empirical and modelling studies, but do also include some review studies that cover the countries. Most of the publications cover research from Sweden (36 publications), followed by Denmark (21), Norway (14), Finland (11) and Iceland (2). About half of the publications cover research solely focusing on a single Nordic country, while the rest includes research from other countries (mainly other Nordic or European countries).

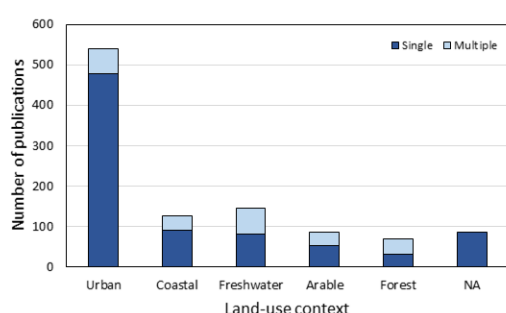


**Figure 3. The geographical uptake of the NBS concept in the scientific publications. A publication can report on research from one, or several continents. Publications that cover research from only one continent is marked as 'Single' and publications that report on research from two or more contents are marked as 'Multiple'. The NA publications are not included in the figure.**

## Which land-use contexts are covered in the publications?

Most of the publications reported on research that covered an urban land use context (59%),

while only 8% and 10% concerned a forested respectively an arable context (Figure 4). About 26% of the publications included multiple land-use contexts. About 9% of the publications did not cover any specific land-use context. Those papers were mainly reflection or conceptual papers aiming at describing how NBS should be understood, conceptualized, operationalized, mainstreamed etc. Commonly such publications included some sort of framework aiming to facilitate the work with the concept.



**Figure 4. The land-use context covered by the publications. A publication can report on research from one, or several land-use contexts. Publications that cover research from only one land-use context is marked as 'Single' and publications that report on research from two or more land-use contexts are marked as 'Multiple'. The NA publications are not included in the figure.**

The 66 Nordic publications show a similar pattern as the total number of publications in relation to land-use context. The urban context is the dominant land-use context covered in 79% of the publications. Thereafter follows freshwater (18% of the publications), arable (8%), forest (8%) and coastal/marine (6%).

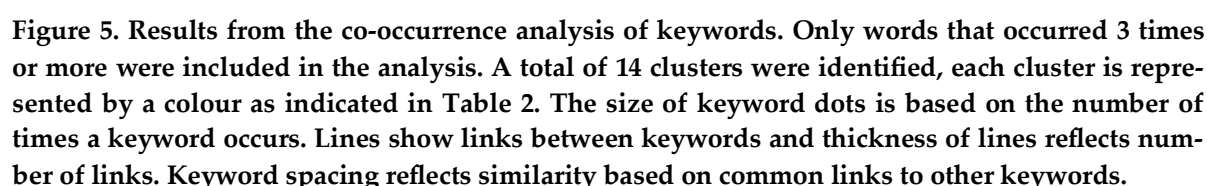
This shows us that so far, the concept has mainly come to use in the urban context and indeed the European Commission's definition can be interpreted as targeting more man-made solutions as well as smaller solutions than what the IUCN definition is referring to.

## The scope and disciplinary focus of research using the nature-based solution concept

As a way to understand the relation between NBS and other related concepts, as well as the uptake of the concept across different research fields, we performed a keyword analysis in VOSviewer. The analysis shows that the NBS research area is very broad, including many interrelated concepts. The analysis identified 14 clusters of keywords that give some indication of the different research fields that are focusing on NBS (see Figure 5).

Several of the clusters are overlapping but generally, we can identify five broader groups dealing with environmental or sustainability problems. These relate to i) freshwater, ii) climate adaptation, iii) coastal zones, iv) urban areas (mainly focusing on planning, and health and wellbeing related issues) and v) environmental pollution. On top of the groups, the five most frequently mentioned key words are nature-based solutions, ecosystem services, green infrastructure, climate, and resilience (see Table 2 for the most occurring keywords). The keywords cover three different content themes: concepts, challenges and solutions. Most of the keywords relate to more than one theme.

Using the sustainable development goals as a framework to interpret the keywords in relation to their intent to solve societal challenges it is clear that NBS research relate to some goals more than they do to others. Many keywords relate to research focussing on climate adaptation, and especially water management and hence, links to goal 13 (Climate actions). There is also a large focus on biodiversity and ecosystem management (including green infrastructure and ecosystem services), which link to goal 15 (Life on land) and goal 14 (Life below water).



## What kind of solutions are conceptualised as nature-based solutions?

related approaches (e.g., re-foresting riparian areas for disaster risk reduction) to small-scale NBS (e.g., biological infiltration beds for runoff water purification). Most of the studies assess the NBS functions in relation to bio-geophysical qualities, e.g., water retention capacity, flood risk reduction, health benefits, biodiversity contribution, but there are also studies looking at potential economic benefits by NBS. Some of the studies are comparing different NBS with each other, and others are comparing NBS with grey (green) engineered infrastructure such as water and wastewater treatment plants, pipelines, and reservoirs. There are also studies comparing similar types of NBS across different land-use contexts. There are also multitudes of 'conceptual' papers that discuss/reflect on the

**Table 2. Keywords occurring 10 times or more, where the occurrence gives the number of times a keyword was used. The content of the keywords cover three different themes: ‘concepts’, ‘challenges’ and/or ‘solutions’. Blue cells indicate that the keyword cover that theme.**

Keywords	Occurrence	Keyword content theme		
		Concepts	Challenges	Solutions
nature-based solutions	407			
ecosystem services	105			
green infrastructure	81			
climate change	47			
resilience	25			
biodiversity	25			
climate change adaptation	23			
constructed wetland	21			
urban planning	21			
sustainability	21			
urban resilience	18			
cities	18			
adaptation	17			
green roofs	16			
green space	15			
ecosystem-based adaptation	14			
social-ecological systems	13			
disaster risk reduction	12			
flood	12			
blue-green infrastructure	12			
well-being	11			
urban agriculture	11			
urban forests	11			
storm water management	10			
circular economy	10			
urban sustainability	10			
sustainable development	10			
urban heat island	10			

role of ‘NBS’ to solve societal challenges, and/or develop frameworks and suggest policy recommendations.

Below, we give a brief overview of what types of solutions that have been in focus in the reviewed publications across the different land-use contexts: arable, coastal/marine, forest,

freshwater, urban. We do not cover the ‘conceptual’ papers. The aim of the overview is to give examples of solutions labelled as NBS within the different land-use contexts. This means that the overview does not provide an extensive list of NBS, nor data on the effectiveness of the different solutions. Many of the mentioned solutions are surrounded by ex-

tensive research fields that provide more knowledge about the environmental, economic, and social aspects of the solution.

### Arable

The reviewed 'arable' publications cover a wide diversity of solutions aiming to mitigate different types of societal challenges within the arable landscape. The most frequently mentioned challenge relates to pollution of waterways caused by nutrient leakage and soil erosion. Publications include studies focusing on cover crops and crop rotation schemes to reduce nutrient leakage from arable land and those looking at constructed wetland's capacity to store and purify farmland run-off water. One study focuses on aquaponics that combine fish and vegetable productions in a circular nutrient reuse system reuse. There are also studies that focus on greenhouse gas emissions and/or carbon sequestration. One study focuses on the potential benefits provided by grasslands for climate change adaptation and mitigation, and another on agroforestry and its potential to increase the soil organic carbon pools and improve biodiversity. Another study looks at the potential of soil-carbon trading system to support landowners that manage their property to promote healthy soils and soil carbon storage. Several publications are also focusing on how to support biodiversity and restore farmland ecosystem services, ranging from narrow studies focusing on the yield increasing benefits provided by landscapes rich in pollinators, to studies focusing on large-scale interventions such as rewilding. Most studies relate to suitable food production systems, but only a few papers explicitly cover food security. An African study focus on the role of perennial grains for a sustainable and resilient food production by smallholder farmers of marginal lands.

### Coastal/marine

The main topic of the reviewed 'coastal/marine' publications was not surprisingly flood mitigation. The variety of covered solutions is broad, ranging from large-scale ecosystem-based approaches to eco-engineered solutions. The ecosystem-based approaches include mangrove, salt marshes, coastal wetlands, eelgrass, dunes, seagrass, coral reefs, oyster beds, etc. that is protected, restored, or managed to defend urban areas, infrastructure and other land-uses from erosion and coastal flood events. Eco-engineered approaches include designs to enhance biodiversity and ecosystem functioning and services of coastal artificial structures, such as breakwaters, seawalls, piers, and tidal river walls. Most publications, report on empirical or modelling results related to the effectiveness of the solutions to flood risk protection, but there are also studies that have studied other aspects such as the effectiveness of NBS to regulate the inflow of fresh water in bay areas, or its contribution to biodiversity and green infrastructure. While most studies cover environmental aspects, some do also cover economic aspects, as well as social aspects, such as the perception by local communities/stakeholders, or the willingness to implement coastal NBS. Some of the studies are comparing NBS with conventional engineered infrastructure used for flood protection. Some of the studies are also considering planning and governance issues.

### Forest

The reviewed forested publications cover a wide diversity of societal challenges and solutions. The most common focus is on improving biodiversity and support the delivery of ecosystem services. These studies focus on reforestation, the use of different types of protection status, green infrastructure, and landscape planning. There are also studies highlighting the genetic diversity as a NBS to adapt to climate change, and a couple of studies are

looking at the concept of rewilding. Several studies focus on the potential of forested areas for erosion control and disaster risk reduction (landslides) due to severe weather events, as well as for improving water quality issues. Some studies are also focusing on carbon sequestration, and hence the potential of forested areas for climate mitigation. Most of the studies cover environmental aspects, and only a few cover social-economical aspects. Many studies use modelling approaches, relying on either large-scale satellite data, or data collected in the field or from publications. However, there are also studies that make empirical studies, or analyse strategies and policy.

### Freshwater

The reviewed forested publications cover three main societal challenges: water quality, flooding and biodiversity, and the general provision of ecosystem services. Many studies focus on these challenges in combination. About the same NBS are targeted independent on the societal challenge in focus. The most targeted freshwater NBS is different types of wetlands, followed by rivers and their next surroundings (e.g., riverbanks). The different studies cover both empirical and modelling approaches. The scope of the studies ranges from modelling studies focusing on ecohydrological processes at the landscape level (e.g., connectivity, uptake of pollutions by vegetation, retention capacity) to case studies measuring the phytoremediation effect by single plant species, and the re-introduction of beavers to build dams in rivers. Most studies focus on biogeophysical aspects, but there are also studies including economic valuation as well as the benefits provided by the different stakeholders.

### Urban

As most studies cover the urban land-use context, this category is the richest and most diverse in relation to the covered solutions. The most frequently covered societal challenges are

urban flood risks and human health and wellbeing, but there are also multiple publications covering other societal challenges, including heat stress, air quality regulation and carbon sequestration. Several studies are also focusing on NBS governance in urban development. A number of studies present results from empirical and modelling studies focusing on either climate change adaptation, water purification or these two in combination. There is a large variety of NBS covered by the different studies. Studied NBS includes constructed wetlands, bioretention basins, biological infiltration beds, sludge treatment reed beds, sedimentation ponds, green roofs, daylighting piped streams and associated implemented NBS, urban farming combined with closed loop systems for sustainable water, nutrient, and waste management. Other studies provide results from empirical and modelling studies focusing on the benefits provided by different types of NBS for human health, wellbeing and/or food supply. Studied NBS includes communal urban gardening, urban and peri-urban agriculture, parks, nature rehabilitation gardens, greening of rooftops, edible green infrastructure, urban green (blue) infrastructure/space and greening initiatives/case studies to promote health benefits, through recreation, stress reduction, physical activity etc. There are also studies focusing on governance structures for implementing NBS for urban societal challenges, including research topics as collaborative planning, mainstreaming, flood management approaches, and practical NBS implementation. Many of the studies contextualise NBS as green infrastructure or ecosystem-based adaptation measures. The scope of the studies ranges from empirical studies based on interviews or document analysis to reflection and conceptual publications, developing frameworks and guiding principles to support the planning, implementation, and management of urban NBS.

**Table 3. The number of documents published by the different stakeholder groups that include the NBS concept across the different land-use contexts.**

Stakeholders	# Included documents	Land-use context					
		Arable	Coastal	Forest	Fresh-water	Urban	NA
Public authorities	21	6	12	7	10	10	0
Regional & municipal public actors	22	0	8	0	3	11	1
Private actors	6	0	1	1	1	4	2
Non-profit organisations	3	0	0	1	0	2	0
Universities & research institutes	11	1	1	1	1	7	4

### The uptake and use of the nature-based solution concept by Swedish stakeholders

The stakeholder analysis shows that Swedish stakeholders are using the NBS concept. In total, we identified 49 stakeholders separated across five groups: national public authorities, regional and municipal actors, private actors, non-profit organisations and universities and research institutes, which mention NBS in one or several documents (total 62 documents) (Table 3). The stakeholders have different roles, where some provide policy documents, others knowledge and information and yet others implement NBS. It is important to stress that this report gives an overview, and it can be expected that more stakeholders, than what is shown here, are engaging with the concept.

The NBS concept has been used in different land-use contexts. The most covered land-use context was the urban (34 documents), followed by coastal/marine (22), freshwater (15), forest (10) and arable (7) (see Table 3). Some documents focus on only one land-use context, while others include several. A few actors write about NBS in more general terms and the land-use context could then not be distinguished.

### National public authorities

Several national public authorities have published material about NBS, including guidelines and information to facilitate the implementation of NBS, examples of implemented NBS cases/projects, as well as results from research projects and case studies. In total, the study identified nine public authorities that have published material where NBS is included:

- The Swedish Environmental Protection Agency (EPA)
- The National Board of Housing, Building and Planning
- The Swedish Transport Administration
- The Swedish Geotechnical Institute
- Swedish Meteorological and Hydrological Institute (SMHI).
- The Swedish Civil Contingencies Agency
- The Swedish Forest Agency
- County Administrative Boards
- Different parts from government and parliament

The Swedish Environmental Protection Agency (EPA) published a report in 2020 with guidelines and examples of implemented NBS. In the report, they define NBS as “multifunctional and cost-effective measures to address various societal challenges by protecting, developing or creating

*ecosystems while promoting biodiversity and human well-being.*" (s.11) (Naturvårdsverket, 2021). According to the Swedish EPA, the purpose of the report is to spread knowledge and information about NBS and guide actors in how different NBS can be planned and implemented. The Swedish EPA also has information about green infrastructure plans on their website, where NBS is mentioned as one approach to achieve viable and multifunctional green infrastructure (Naturvårdsverket, 2022a). They also have a webpage explaining the NBS concept, its benefits, as well as examples from different land-use contexts (e.g., urban, arable, forest and coastal) (Naturvårdsverket, 2022b).

The National Board of Housing, Building and Planning provide guidelines, examples, tools and information about NBS on their website to aid planning and implementation of NBS (Boverket, 2019). They also give examples of implemented NBS projects in relation to flooding, water purification, local climate regulation, erosion, and noise regulation (Boverket, 2021).

Another public authority that has published material about NBS is The Swedish Transport Administration that has put together a portfolio of different research projects, one of which is called "natural adapted erosion protection in fairways" (Trafikverket, 2020). The Swedish Geotechnical Institute has a research project about "NBS-fairways" together with Lund University, studying erosion from ship traffic, amongst other things (Statens Geotekniska Institut, 2022). The Swedish Meteorological and Hydrological Institute (SMHI) has, together with Stockholm municipality, published a report about climate adaptation through green infrastructure in Nordic cities (Persson, Wikberger, & Amorim, 2018). The Swedish Civil Contingencies Agency has published a risk management plan for flooding mentioning NBS as a measure (MSB,

2020). The County Administrative Board in Västra Götaland has published a handbook about NBS and flooding (Länsstyrelsen Västra Götalands län, 2018), and the County Administrative Board in Skåne has developed a regional action program (not yet assumed) for the regional, national, and global environmental/sustainability goals, suggesting NBS in the regional work with sustainable land and water use (Länsstyrelsen Skåne, 2021). The measure is called "An increased use of NBS for climate adaptation" and they write: *"Nature-based solutions are used as measures to increase nature's own resilience to climate change and create conditions for the society to adapt to the effects of a changing climate and can at the same time create better conditions for the conservation of biological diversity"* (s.35).

In addition to the individual work performed by the above-mentioned public authorities, the Council for Sustainable Cities (initiated by the government) has published material about NBS. The Council aims to support the municipal work with goal 11 in Agenda 2030 concerning sustainable cities and communities, and consists of eleven public authorities, the County Administrative Board and SKR (Swedish Association of Local Authorities and Regions). On their webpage, they write: *"Nature-based solutions are multifunctional and cost-effective measures to address various societal challenges by protecting, developing or creating ecosystems while promoting biodiversity and human well-being."* (Hållbar stad, 2022). The government and the parliament have also published material on the subject. The Ministry of the Environment has written a memo about the new EU-strategy for climate adaptation where NBS are mentioned as measures that the EU commission wants to promote (Miljödepartementet, 2021). The Committee on Civil affairs has written a report about the economic administration of land and water areas stating that investments in NBS is needed to restore and construct wetlands to ba-

lance water flows and refill groundwater reserves (Civilutskottets betänkande 2020/21:CU14).

### **Regional and municipal public actors**

This category is diverse, covering 21 regions and 290 municipalities, which means that only a few actors have been possible to include in the analyses (see method for the selection in Appendix A). There is a large variation in the type of published materials, but the focus is generally on planning and implementation (including research projects). The Region Västra Götaland have together with PE Teknik & Arkitektur and Lund University published a report from a research project studying financial instruments for NBS to reduce flood and drought risks (Ternell et al., 2019). Region Skåne is part of an EU-project called Life Coast Adapt where six municipalities in Skåne are testing methods (nature-based) to stop the negative effects of coastal erosion (Region Skåne, 2022). The six municipalities are Båstad, Helsingborg, Kristianstad, Lomma, Trelleborg and Ystad.

Among the 19 studied municipalities, eight have produced policy documents (mainly water related) that mention NBS. Göteborg municipality mentions NBS in their Action plan for good water status (not yet assumed) (Göteborgs Stad, 2021), Linköping municipality includes NBS in their Guidelines for ecosystem services (Linköpings kommun, 2020), Västerås municipality mentions NBS in their Action plan for climate adaptation (Västerås Stad, 2020) and Norrköping municipality mentions NBS in their Guidelines for climate adaptation (Norrköpings kommun, 2020). Lund municipality mentions NBS both in a programme for Ecological sustainable development (Lunds kommun, 2021) and a Plan for storm water management (Lunds kommun, 2018). Huddinge municipality mentions NBS in a technical handbook for exploitation and development (Huddinge kommun, 2021) and Eskilstuna municipality in their

Green plan (Eskilstuna kommun, 2021). The other municipalities, have engaged with NBS in other ways.. For example, Malmö municipality is part of an EU Horizon 2020 project called Clever cities with the aim to "...promote and enable the use of NBS in Malmö's urban planning." (Malmö stad, 2021). Umeå municipality has developed an ecosystem services analysis for a local plan where NBS is included (Grellmann D, 2019), and Nacka municipality has published a news article about the municipal work with NBS in relation to the "The World Water Day" in 2018 (Nacka kommun, 2018).

### **Private actors**

Many private actors have integrated NBS in their business' activities. Several consultancy firms focusing on urban development are engaging with the concept and provide general information (and marketing of their services), as well as information about implementation of NBS projects. One of these companies is Ekologigruppen that together with Morf landskapsarkitektur and Tyréns are running a project called Urban layers (Ekologigruppen, n.d.). They describe Urban Layers as a NBS that meets three challenges in the dense city: 1) the requirement to take care of storm water in a space-efficient way, 2) the need to increase the city's conditions for biodiversity and 3) to provide space and values for citizens. Ecogain, another consultancy firm has included NBS in their Biodiversity index used to rank companies' work with biodiversity in their sustainability accounting. They contextualise NBS as solutions to both climate change and the loss of biodiversity, and they write: "Those who strengthens biodiversity will also absorb carbon dioxide and thus slow down and at last reverse climate change. These are nature-based solutions!" (s.12) (Ecogain, 2020). EcoBio is another actor that provides information about what NBS is, as well as marketing of their NBS businesses on their web page (EcoBio,

2020). Urbio is a landscape architect's office that together with Örebro municipality, the Swedish University of Agricultural Sciences, KTH Royal Institute of Technology, Uppsala University and Nordic Parks run a Vinnova funded research project focusing on sustainable playgrounds in the city (Urbio, n.d.). They call them "lekotop" and base their design on NBS, where natural elements are used to create rooms and stones, twigs, and branches to play with.

### Non-profit organisations

Different types of non-profit organisations are involved in the work with NBS. One example is the Nature conservation association who has published a national report called *The forest, the climate and the biological diversity*, where NBS is mentioned throughout the report as solutions to both the climate crisis and the loss of biodiversity, especially in forested ecosystems, both in Sweden and globally (Naturskyddsföreningen, 2021). There are also local Nature conservation associations engaging with NBS, such as Gothenburg's local Nature conservation association that frame NBS as one measure to make Gothenburg a greener city (Naturskyddsföreningen i Göteborg, n.d.). Another non-profit association is C/O City who focuses on questions related to urban ecosystem services. They are partly financed by Vinnova and develop tools, methods, and guidelines, and offers education, seminars, conferences, and networking in relation to urban ecosystem services. In their report "Green solutions provide living cities", NBS is mentioned in the context of Grönytefaktorn (GYF) which is an Excel-based calculation tool for ecosystem services that contribute to multifunctional NBS and a green urban environment (c/o city, 2017).

### University and research institutes

Both universities and research institutes are involved in different research projects about NBS. Lund University was involved in the Horizon

2020 project Naturvation that was one of the first larger EU financed projects about NBS. The aim of the project was to understand what NBS can achieve in cities, foster innovations, and realise the potential of NBS (Naturvation, n.d.-a). One contribution from the project was the Urban Nature Atlas that provides 1000 examples of implemented NBS across Europe, including several examples from Sweden (Naturvation, n.d.-b). Researchers from Gothenburg University have written a report about "State of the World's Plants and Fungi" together with the Royal Botanic Gardens KEW to provide knowledge about NBS that can manage the so called triple threats: climate change, biodiversity loss and future food shortages for a growing population (Antonelli et al., 2020). Stockholm Resilience Centre at Stockholm University has through their program SwedBio, funded an app called THRIVE that offers 60 NBS that can help improve people's lives at a local scale in sub-Saharan Africa countries, by either individuals or community (Stockholm Resilience Centre, 2016). The app focus on NBS within six themes: restoring soil, saving water, rehabilitating green spaces, producing food gardens, sustainable cooking and energy, and preventing disease and disaster.

The Swedish Environmental Institute has studied Swedish municipalities' progress with climate adaptation, and mention examples of NBS in their report (Matschke Ekholm H, Nilsson Å, & Isaksson Lantto F, 2021). They also provide information about NBS on their webpage (IVL Svenska Miljöinstitutet, 2021). Another actor that works with NBS is the Nordic Co-operation that involves Denmark, Finland, Iceland, Norway, and Sweden as well as the Faroe Islands, Greenland and the Åland Islands (Nordiska samarbetet, n.d.). They have an ongoing programme on NBS funded by the Nordic Council of Ministers where different projects will contribute to: knowledge synthesis of NBS science

and practice, policy development, guidelines and best practices focusing on NBS in a Nordic perspective. The national research council Formas has brought up NBS on the research funding agenda by including NBS under the key theme "Sustainable consumption and production" within their research programme. In the document, they state that there is a need for more knowledge about and solutions to, among others, "Integration of NBS and ecosystem services in planning and management" (s.46) (Formas, 2021).

## Reflection

From this overview, it is clear that the NBS concept is not inventing new research areas nor solutions. However, the concept seems to connect research areas and practices (e.g., coastal flood risk management, urban water management, biodiversity conservation, urban green space governance, etc.) that previously worked with nature, as a solution to environmental problems within their specific fields. These bounding activities may potentially open up for knowledge sharing and learning across disciplines. In the following sections, we will reflect on different angles of the use and content of the NBS concept to get a better picture of what future that lies ahead of the NBS concept and what the practical implications of having NBS as an umbrella concept may lead to.

### ***Does everybody mean the same thing with the nature-based solution concept?***

From the analysis of the NBS definition, we can discern of two different understandings of the concept. One where NBS is perceived as larger ecosystems and more natural solutions, and another where NBS can be of different sizes but usually are smaller man-made solutions. This is also confirmed in the key word analysis. The key word analysis also shows that the NBS con-

cept is integrating into already established research fields, both in relation to its conceptual ideas as well as to the concrete solutions. Three concepts stand out as closely related concepts; ecosystem services (MEA, 2005), green infrastructure (Benedict & McMahon, 2006) and ecosystem-based adaptation (CBD, 2009).

Since the United Nations (UN) Conference on Environment and Development in Rio 1992 (UN, 1993) we have seen a steady stream of 'green' concepts, aiming to operationalise the idea of sustainable development into concrete action targeting different aspects of nature. These 'green' concepts have different origins. Some have been developed and promoted through an international science-policy body, others as a response to the need of embracing a specific problem in an international environmental regime. What these concepts have in common is that they are not scientific concepts, rather bridge builders between policy and science. Their aim is to improve the relationship between man and nature and the latest addition to the list is NBS.

In this review, we have not studied how different researchers use the NBS concept in publications. However, in another review about the NBS concept (Hanson, Wickenberg, & Alkan Olsson, 2020) we show that the integration of the NBS concept varies substantially. According to Hanson et al. (2020) many researchers use the NBS term as a buzzword, and the main concepts are usually ecosystem services and/or green infrastructure. This pattern makes it difficult to discern what the NBS concept is doing for science. Does it create new scientific findings, does it force them out of their disciplinary boxes, or is it just a way to fund old research under a new name? From the practical perspective, these developments within science may not be a direct interest, but in the long run the pathways taken by science may influence

the use of the concepts, as well as which solutions that are brought to the fore, and hence also which benefits will be the main ones, and which will be the co-benefits?

### **The uptake of the nature-based solution concept**

From the scoping exercise of the scientific literature, it is clear that the NBS concept is gaining increasing interest. A considerable amount of the papers is reflecting on the concepts, which is expected when a new concept enters science. The interest from practice is also increasing and there are especially more and more examples of implemented solutions from municipalities.

#### **Strong urban focus**

The uptake of the NBS concept is biased towards the urban context, which was also shown by Hanson et al. (2020). The influence of EU funding, especially the Horizon 2020 calls in 2015, is probably one explanation of the strong research focus on urban areas, but also the strong focus on Europe as the geographical target area of the research. The stakeholder analysis, which provide an insight into how the concept is spreading among Swedish stakeholders also indicate that the concept is somewhat stuck within the urban area. EU funding is probably also influencing this pattern, as several stakeholders, such as municipalities and consultancy companies have been partners or stakeholders in different EU funded projects.

However, there is an accumulating uptake of the concept in the other land-use contexts. In relation to the arable context, the concept was early recognized as a useful tool to promote sustainable agriculture (Peter, Mungai, Messina, & Snapp, 2017), and it has recently been highlighted as a potentially valuable concept to contextualise the benefits that nature contribute with to humanity (Iseman & Miralles-Wilhelm,

2021). From that perspective, the increasing attention is promising. It is also clear that the arable NBS publications include 'solutions', such as, intercropping, agroforestry and cover crops that link to already established 'arable' concepts and practices, such as, organic farming, ecological intensification and agroecology that relies on nature's potential to solve societal challenges, which indicate that there is an uptake of the concept within the arable research community. The Swedish National Board of Agriculture has so far not adopted the NBS concept in any online available policy documents, but from a European perspective, there has been an increasing interest from policy to include NBS in the Common Agricultural Policy, which indicate that the concept might gain interest to the arable sector in Sweden during the coming years.

#### **Flood management - a societal challenge in focus**

There is a strong focus on using NBS in research on flood management and other climate adaptation actions, especially in urban and coastal areas. This is not surprising as the IUCN introduced the concept in their position paper to COP15. The analysis of the uptake among Swedish stakeholders also suggests that climate adaptation is an important focus area for NBS implementation, with a strong emphasis on storm water management and flood reduction.

#### **It covers a diversity of solutions**

It is also clear from the review that solutions tagged as NBS can be many different things, ranging from green infrastructure networks to phytoremediation activities by bacteria in stormwater ponds. Depending on the NBS in focus, their potential to provide co-benefits varies. Larger and more structurally diverse NBS, such as urban parks will generally have a higher

potential to provide multiple benefits, as compared to smaller and species poor solutions, such as green roofs. In the study by Hanson et al. (2020), we showed that only a few empirical NBS studies cover more than one benefit; mainly focusing on the environmental aspects (e.g., local temperature regulation, water retention potential, etc.) and less on social and economic aspects. Instead, most studies mention potential co-benefits in the discussion section. This 'single-focus' pattern is not something new, but is previously known from e.g., the ecosystem service and the green infrastructure research areas (Crossman et al., 2013; Olander et al., 2017). A lack of interdisciplinary research projects – mixing different research areas and methodological approaches, is one possible explanation for this pattern. The practical implication of this finding is that multifunctionality is still more of an idea, or a wish in the definitions of the concept, than an evidence-based fact. However, this does not mean that NBS cannot be multifunctional, we just do not know if they are.

### ***Are nature-based solutions solving the problems?***

The efficiency of NBS in relation to grey alternatives is a recurring issue. We did not cover this in the scoping exercise, but multiple studies have covered this topic before. A review study covering multiple urban ecosystem services demonstrates that only a few empirical and/or modelling studies compare the benefits provided by different types of green infrastructure with those provided by grey solutions (Veerkamp et al., 2021). For review studies covering the effectiveness of specific NBS, such as green roofs and constructed wetlands, the conclusions are mixed. How efficient a NBS is in relation to a grey solution depends on what is included in the efficiency, i.e., what the study is measuring. Does the study only focus on e.g., the water retention capacity provided by a constructed wetland, or does it also include the provision of

other benefits, such as the water purification capacity, space for biodiversity and opportunities for recreational activities? Other important questions are if the study includes costs, lifecycle assessments, and risk assessments related to the solutions. Another aspect to bear in mind is how the NBS will influence future urban development. This is especially important in densely built urban areas, where large NBS might compete with other land-uses.

NBS might also be a potential source of dis-services, i.e., unwanted side effects provided by the solution. Typical examples from an urban perspective are allergens provided by urban trees and grasslands, as well as problems with mosquitos thriving in wet areas. Other dis-services might be that greening activities can spur gentrification processes, leading to segregated urban areas. Within other land-use contexts, the creation of wetlands or partly flooded areas may influence the productivity of the surrounding land, e.g., the arable sector.

### ***What future lies ahead for the nature-based solution concept?***

So, the question to ask, what future lies ahead for the NBS concept? There is no clear answer to such a question. If referring to the history of green concepts it should be noted that each new concept creates a state of hope and enthusiasm within the organisations/scientific disciplines that have created them. However, new concepts may also lead to bewilderment and confusion when trying to situate them in relation to similar already established concepts.

The NBS concept is new, but its core ideas are old, strongly linking to concepts and research areas that have been with us for a long time, such as sustainable development, nature's contribution to people, multi-functionality, and stakeholder collaboration. If we acknowledge its origin and limitations, the NBS concept might

help the bounding work between different disciplines and actors to foster collaboration and knowledge sharing, and hence supports new pathways to sustainable development. Such a pathway will only work with good organizational and economic support from policy makers. On the other hand, if the concept is recognized as a silver bullet to solving environmental problems by itself, the society might face disappointment. While such a view might be easier to include in policy documents, it may probably not lead the promises that the concept is aspiring for in the real world. Its future will also depend on how we are able to address one of the concepts core ideas, multifunctionality but also which main benefits and co-benefits that are considered in science as well as in practice.

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## Appendix A - Methodology

We ground the focus paper on a scientific literature review of peer-reviewed publications and a stakeholder analysis of Swedish actors at different societal levels and with different roles.

### *Scientific literature review*

In the scientific literature review, we used the search string 'nature-based solution\*' in the Web of Science and Scopus database in June 2021. After removing duplicates, we included 914 English peer-reviewed publications in the structured literature review covering articles reporting on empirical and modelling studies, and review studies synthesizing results of others. Book chapters and conference proceedings were excluded. We analysed the publications using a pre-developed excel sheet where we coded: 1) the geographical location (Africa, Asia, Europe, Oceania, North America, South America) and 2) the land-use context (arable, coastal/marine, forest, fresh water or urban) covered by the publications. For both categories, multiple entries were possible. We also extracted 3) the type of solution (e.g., constructed wetlands, green roofs, etc.) covered by the publications. The data were analysed both quantitatively and qualitatively. To analyse the research landscape that links to the NBS concept, we analysed author's key words in the software tool VOSviewer that builds and visualizes co-occurrence networks of important terms. We only used data from Web of Science (the number of included publication is thus a bit lower than 914) and only included keywords that occurred at least three times.

### *Stakeholder analysis*

In the stakeholder analysis, we used documents and webpages developed by different stakeholders that covered the topic of nature-based solutions. We used Google to find the data and finished the search in December 2021. We in-

cluded five stakeholder groups within the study: National authorities, Regional and municipal public actors, Private actors, Non-profit organisations and Universities and research institutes. The analysis was made in a pre-developed excel sheet where we coded: 1) the type of document (guidelines, policy, examples of implemented NBS, research project, EU-project, or information), 2) the land-use context (arable, coastal/marine, forest, fresh water or urban) and 3) how the stakeholders defined NBS. We searched for NBS in the different texts and read selected parts to answer our research questions.

We did not include all potential stakeholders within each group. For the national authorities we included all authorities that work with land-use questions. For the regional actors we covered the three largest actors (Stockholm, Västra Götaland and Skåne), and for the municipal actors we covered municipalities who have more than 100 000 inhabitants (19 municipalities) according to SCB. For the other three categories, we used a snowball methodology to find data, without any specific search criteria.

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**What is AgriFood Economics Centre?**

The AgriFood Economics Centre provides economic expertise in the fields of food, agriculture, fishing and rural development. The Centre, which consists of the Swedish University of Agricultural Sciences (SLU) and Lund University, is a platform for applied research. The aim is to supply government bodies with a solid foundation supporting strategic and long-term policy choices

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