Developing metrics and instruments to evaluate citizen science impacts on the environment and society

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Abstract (for dissemination)	Deliverable 5.4 outlines the context for the creation of four NBS policy briefs. These policy briefs are aimed at decision makers to encourage the uptake and application of NBS and contain key recommendations for their implementation. The content and recommendations of the briefs were derived from a review of the literature and the results of a survey disseminated to practitioners of NBS. The purpose of this survey was to gather evidence regarding the perceptions of NBS practitioners on working within the policy framework for implementing NBS, as well as different factors affecting the uptake and lack thereof of NBS in practice, and recommendations for how these could be overcome. These NBS policy briefs should be considered 'active' documents and will be updated throughout 2021 in light of planned consultations with key stakeholders engaged with delivery NBS.			
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Contents

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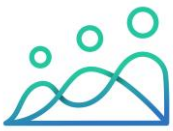

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Executive Summary

The MICS project is developing an integrated platform of metrics and instruments to measure the impacts of citizen science across five domains: society, environment, economy, science & technology, and governance. The MICS project will test and validate these metrics and instruments in hands-on citizen science activities in four case studies to evaluate the impact of Nature-based Solution(s) (NBS) in Western Europe: (UK); Southern Europe (Italy); and in Central and Eastern Europe (Hungary & Romania). Deliverable 5.4 presents a first draft of NBS-science recommendations aimed at decision makers. These will take the form of four briefs focusing on: (1) general recommendations; (2) Western Europe specific recommendations; (3) Southern Europe specific recommendations; and (4) Central and Eastern Europe specific recommendations. This represents the first stage of Task 5.5 which looks to produce recommendations related to NBS and forms the basis for Deliverable 5.6 which will provide an updated version of recommendations in 2021.

The project, as indicated in the MICS DoA, adopts the definition of NBS proposed by the International Union for Conservation of Nature (IUCN): NBS are "…actions to protect, sustainably manage, and restore natural or modified ecosystems, which address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits". NBS are multifunctional, having the capacity to deliver simultaneous benefits for society, the economy and the environment. NBS can be considered as an umbrella term incorporating a wide range of ecosystem-related solutions which address societal challenges.

The EU has been quick to integrate NBS within policy and planning strategies, but multiple knowledge gaps have hindered their implementation and acceptance: natural systems behave differently depending on ecosystem type, climate, location, condition and management, and therefore generalised assumptions about the functioning and impact of NBS can be made only with caution. Consequently, NBS are seen to be less well 'tried and tested' in comparison with conventional grey infrastructure. This is despite the growing evidence regarding their benefits and cost-effectiveness. NBS necessitate and actively encourage transdisciplinary approaches, including involving citizen scientists and identifying innovative ways to unite different stakeholders in order to align their goals, maximise resources and deliver and implement NBS.

This report aims to assess the current application of NBS for tackling water related issues within the EU in order to derive general recommendations regarding the application of NBS aimed at decision makers. A brief review of NBS science in relation to freshwater environments is provided to contextualise recommendations and give examples of key domains within freshwater management that can benefit through the application of NBS. The review identifies barriers to the uptake of NBS in policy and practice. To define recommendations, the report engages with technical experts and practitioners of NBS across Europe via a survey which was designed to clarify regional commonalities and differences in NBS knowledge, support and implementation. The information gathered from the

literature review and survey results is used to produce four short NBS briefing documents (2 pages) aimed at decision makers. These policy briefs should be considered as 'active' documents and will be updated as a final deliverable in light of planned consultations with key stakeholders engaged in the delivery of NBS.

NBS are effective means of managing a range of freshwater issues such as meeting Water Framework Directive (WFD) requirements for water quality and ecosystem resilience, avoiding and mitigating flood damage, and ensuring water security through changing climatic conditions. However, overcoming the barriers that currently limit their application requires working with a range of stakeholders at local, regional and national scales. Citizen science can offer opportunities for addressing knowledge and resource gaps as a part of this engaged approach.

1 Introduction

1.1 Background to MICS

The MICS project is developing approaches and tools to assess citizen science impacts. These approaches and tools can help to plan and implement projects in ways that lead to more robust results. The MICS project specifically aims to:

- provide comprehensive, participatory and inclusive metrics and instruments to evaluate citizen science impacts;
- implement an impact assessment knowledge-base through toolboxes for methods application, information visualisation, and delivery to decision makers, citizens and researchers;
- improve the effectiveness of nature-based solutions through test-site development and citizen science tool validation;
- generate new approaches that strengthen the role of citizen science in supporting research and development;
- foster a citizen science approach to increase the extent to which scientific evidence is taken up by decision makers through recommendations and guidelines.

The result is an integrated platform where these metrics and instruments are available for use by anyone involved in a citizen science project wanting to understand its impact, whether at the planning stage or several years after the project's conclusion. This platform is validated by pilot testing in test and validation sites across Europe. The test and validation sites are in the UK, Italy, Hungary and Romania. These sites explore the applicability of MICS impact-assessment tools in regions with differing needs, contexts, and approaches to nature-based solutions, and with various levels of citizen science application. For example, in Western Europe, river restoration is increasingly carried out within an ecosystem-based management framework at river or catchment scale; in Southern Europe, river restoration tends to be issue-specific with some ecosystem relevance; in Central and Eastern Europe, river restoration is about ecosystem protection and related to existing infrastructure.

1.2 Purpose and Scope

This report on *"NBS science briefs"* is a deliverable of Task 5.5 and contributes to the ongoing activities associated with WP5 – *Dissemination and outreach*.

The policy briefs are aimed at decision makers to encourage the application and use of NBS for managing water. To develop these briefs, a review of NBS science was carried out to identify gaps in our understanding of the effectiveness of NBS and the barriers that inhibit their uptake. This was used to guide the preparation of a survey to gather feedback from practitioners and experts on the application of NBS. The outcomes from the literature review and the survey were used to produce four NBS briefs.

1.3 Structure of the Report

The first part of this document provides a brief review of NBS science, including the definitions used to define NBS and issues of freshwater management that NBS can benefit. It then proceeds to discuss the barriers and limitations that currently impact NBS uptake. A description of the benefits of NBS to society and the importance of citizen science in designing and implementing NBS is also provided. Key findings from this review helped guide the formulation of the online survey that was circulated to NBS practitioners.

The second part of this document provides details regarding the construction and results of the survey produced to gather evidence regarding the perceptions of NBS practitioners of working within the policy framework for implementing NBS, as well as different factors affecting the uptake of NBS in practice, and recommendations for how these could be overcome. The results from this survey and key findings from the literature review were used to formulate the recommendations presented in the NBS policy briefs, which are presented in the final part of the document.

2 Context for Application of NBS in Europe

2.1 What are Nature-Based Solutions? Historical Context and Definition

Figure 1. Diagrammatic representation of the NBS umbrella and the five ecosystem-based approaches it encompasses. Source: IUCN (2020).

Over the past decade, the idea of 'working with nature' has gained traction across Europe and has become increasingly integrated within European Union (EU) policy (Calliari et al., 2019; Mendes et al., 2020). This shift towards ecosystem-based approaches has been driven by the increasing need to mitigate against pressures resulting from rapid urbanization, biodiversity loss and the current climate crisis, in addition to resolving the apparent disconnect between society and nature (Faivre et al., 2017). More recently, the need to not only 'work with' but also 'innovate with' nature has been promoted by the EU's Research and Innovation (R & I) 2015 policy agenda, which places NBS at the core of addressing societal and environmental challenges (EC, 2015).

Nature-based solutions (NBS) are inspired and supported by nature and use or mimic natural processes (WWAP, 2018). NBS are multifunctional, having the capacity to deliver simultaneous benefits for society, the economy and the environment. Despite increasing popularity, the concept of NBS has not been clearly defined (Nesshöver et al., 2017; Cohen-Shacham et al., 2019), and competing definitions are present in the literature (Table 1; Sarabi et al., 2019). Broadly speaking, NBS definitions fall into two categories: those that are *focused on nature and conservation* in line with the definition outlined by the International Union for the Conservation of Nature (IUCN) (Cohen-Shacham et al., 2016), and those that *prioritise society and sustainable development* following the definition proposed by the European Commission (EC, 2017).

Table 1. Definitions proposed for NBS. Modified from Sarabi et al. (2019).

Definition of NBS	Reference	Focus
"Nature-based solutions are actions inspired by, supported by or copied from nature and which aim to help societies address a variety of environmental, social and economic challenges in sustainable ways."	EC (2017)	Sustainable development
"multifunctional green interventions delivering upon the social, economic and environmental pillars of sustainable development."	van der Jagt et al. (2017)	

"any transition to a use of ecosystem services with decreased input of non-renewable natural capital and increased investment in renewable natural processes	Maes & Jacobs (2017)	
"actions that alleviate a well-defined societal challenge (challenge-orientation), employ ecosystem processes of spatial, blue and green infrastructure networks (ecosystem processes utilization), and are embedded within viable governance or business models for implementation (practical viability)."	Albert et al. (2019)	
"conscious use of nature to help urban inhabitants address various environmental, social and economic challenges."	Kronenberg et al. (2017)	
"actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."	Cohen-Shacham et al. (2016)	Nature and conservation
"soft engineering approaches that are aimed at increasing the resilience of territories and societies affected by meteorological events and therefore reducing the economic, functional, cultural, and social damage disruption that such events cause."	Short et al. (2019)	

The concept of NBS builds upon and supports several other established ecosystems-based approaches, e.g. *ecosystem services*, *ecosystem-based adaptation*, *disaster risk reduction* and *green* and *blue infrastructure* (Eggermont et al., 2015). In framing NBS and considering their applications, it is useful to think of NBS as an umbrella concept that covers a whole range of ecosystem-related approaches, all of which address societal challenges. These approaches are placed within five categories as outlined in Table 2 (Cohen-Shacham et al., 2016).

Table 2. Main categories of NBS approaches. Modified from Cohen-Shacham et al. (2016).

Category of NBS approaches	Examples
Ecosystem-restoration approaches	• Ecological restoration • Ecological engineering • Forest-landscape restoration
Issue-specific ecosystem-related approaches	• Ecosystem-based adaptation • Ecosystem-based mitigation • Climate-adaptation services • Ecosystem-based disaster risk reduction
Infrastructure-related approaches	• Natural infrastructure • Green infrastructure
Ecosystem-based management approaches	• Integrated coastal-zone management • Integrated water-resources management
Ecosystem-protection approaches	• Area-based conservation approaches, including protected area management

A set of principles that underpin NBS has been developed by the IUCN (Novoa, 2019). This set of NBS principles, to be considered in conjunction with the NBS definition, is helpful in providing a fuller understanding of NBS, and is as follows:

- Embrace nature conservation norms (and principles);
- Can be implemented alone or in an integrated manner with other solutions to societal challenges (e.g. technological and engineering solutions);
- Are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge;
- Produce societal benefits in a fair and equitable way, in a manner that promotes transparency and broad participation;
- Maintain biological and cultural diversity and the ability of ecosystems to evolve over time;
- Are applied at a landscape scale;
- Recognise and address the trade-offs between the production of a few immediate economic benefits for development, and future options for the production of the full range of ecosystems services; and
- Is an integral part of the overall design of policies, and measures or actions, to address a specific challenge.

2.2 Nature-Based Solutions for Freshwater Management

Water is a vital strategic resource in Europe and under threat from increasing pressures and demand. Because natural processes are dynamic, NBS offer solutions based on ecosystem function for adapting to and mitigating the effects of change such as changing patterns of rainfall and competing pressures over resources for industry and domestic use. By managing and working differently with freshwater, we can address these key challenges. NBS can be implemented at any scale. At the micro-scale NBS may involve citizens willing to take action within their direct environment (EU, 2015) by, for example, installing rain gardens or grey water toilets (van der Jagt et al., 2017; Laforetezza et al., 2018) and increasing the water retention capacity in parkland (Snep et al., 2020). When applied at larger scales, NBS initiatives aim to restore natural ecosystems and/or enhance the built environment to incorporate natural function (WWAP, 2018). This can include landscape-scale projects requiring the cooperation of multiple stakeholders (e.g. wetland creation or channel restoration) (Thorslund et al., 2017; Guerrero et al., 2018).

NBS can be used to address key water challenges, specifically *surface* and *water quality*, *flood risk management* and *water availability*. Table 3 provides details of the types of NBS that can be used to address specific issues. Additionally, all NBS will provide benefits in *habitat restoration and biodiversity* and *human health*.

Table 3. NBS used to address specific issues related to *surface* and *groundwater quality*, flooding and *water availability*. Modified after Trémolet et al. (2019).

	Water Challenges									
	Surface water quality				Ground water quality		Floods	Water availability		
Nature-based solutions	Nutrients	Sediments	Pesticides	Other chemical & emerging pollutants	Nitrates	Pesticides	Upstream watershed	Lower river flows	Lower groundwater levels	Droughts
Reforestation/ afforestation	●	●	●		●	●				
Targeted land protection (including forest protection)	●	●	●		●	●				
Land-use change from farmland to pastureland	●	●	●		●	●	●	●	●	●
Riparian buffer strips/Riparian zone restoration	●	●	●				●	●	●	●
Aquifer recharge	●	●								
Reconnecting rivers to floodplains	●	●								
Establishing flood bypasses							●			
Wetlands restoration/ conservation	●	●						●	●	●
Construction of artificial wetlands	●	●		●			●	●	●	●
Ponds and basins	●	●		●	●		●			
Forestry Best Management Practices (BMP), including forest fuel reduction	●	●			●		●	●	●	●
Improved agricultural practices:										
Catch crops/Cover crops	●	●	●		●		●			
Crop rotation	●	●	●			●	●	●	●	
Conservation tillage	●	●			●					
Reduced fertiliser use	●				●					
Alternative plant protection			●			●				

2.2.1 Nature-Based Solutions for Surface Water Quality

The EU have made progress towards addressing poor water quality through increased waste-water treatment and point source emission controls (Trémolet et al., 2019). However, when considering the wider natural environment, considerable pressures and impacts remain, specifically in the areas of nutrient enrichment, sediment loads and chemical pollution (EU, 2020). Member states have not yet achieved the objectives they set themselves in terms of water quality, with only 40% of surface water bodies reaching Good Ecological Status, and 38% in Good Chemical status as of 2015 (EEA, 2018).

To tackle these issues EU Member States are increasingly applying green infrastructure to support or replace conventional methods such as waste-water treatment, reducing pollution at source and

targets and measures to reduce mineral fertilisers. Larger-scale NBS (such as the restoration/construction of natural/artificial wetlands, river restoration, and changes in land-use and improved land management practices) have been shown to have greater success than conventional methods in tackling diffuse pollution (EEA, 2018). There is clear evidence that NBS are effective in reducing sediment loading and nutrient levels, and solutions may take a variety of forms considering local conditions and concerns. Examples include:

- **Riparian buffer zones of natural vegetation**: Riparian buffer strips and reed fields reduce erosion and intercept nutrient-rich, pesticide- and/or sediment-loaded runoff from agricultural and urban land before it enters watercourses and waterbodies (Hickey & Doran, 2004; Prosser et al, 2020). The effectiveness of vegetated buffer strips for water quality improvement varies widely, depending on the width of the vegetated buffer, ratio of source area to buffer area, soil composition and structure, rainfall and runoff intensity and plant community structure (Stutter et al., 2019). Vegetated buffers have been shown to reduce the movement of pesticides and nutrients from agricultural fields into surface water by 10 to 100% and 12 – 100% respectively (Prosser et al., 2020). Additionally, they provide a broader range of ecological niches and enhance the biodiversity of adjacent rivers and agricultural land.
- **Restoring and conserving wetlands and wet woodlands**: Wetlands and wet woodlands offer a variety of ecosystem services, including carbon sequestration, water quality protection and flood regulation, but despite their potential the total area of wetland in Europe continues to decline (Thorslund et al., 2017; Verhoeven et al., 2006). In relation to water quality, wetlands and wet woodlands intercept runoff and capture and retain nutrients and pollutants (WWAP, 2018). However, prolonged nutrient loading can result in drastic shifts in species composition, resulting in reduced capability to capture and store nutrients (Verhoeven et al., 2006). The restoration of wetlands and woodlands must be implemented alongside efforts to reduce pollution and nutrient runoff at source.
- **Improved agricultural practices and less intensive land use**: a range of measures such as catch/cover crops and conservation tillage are effective in reducing nutrient and soil loss from arable land, contributing both to a reduction in surface water pollution and an improvement in soil health (Holland, 2004; Lībiete et al., 2019). Conservation tillage includes several methods designed to reduce the loss of soil and water compared to conventional methods. It has been demonstrated that conservation tillage can reduce runoff from agricultural land by between 15% and 89%, thus reducing the amount of dissolved pesticides, nutrients and sediments carried in runoff to rivers (Clausen et al., 1996; Holland, 2004). Land use change can also impact water quality. For example, pastureland is highly effective at binding nitrogen, and by turning over arable farmland to pasture, leaching of nitrate through surface runoff can be reduced significantly (Trémolet et al., 2019).
- **Green roofs**: Installing vertical greenery provides more pathways to remove contaminants from urban areas (Bauduceau et al., 2015). Green roofs retain particulates so their infiltration into the water system through surface runoff is reduced, improving local water quality (Berndtsson, 2010). Additionally, green roofs increase water storage, reduce surface run-off and provide thermal benefits (Wong et al., 2003; Zölch et al., 2017). For example, the potential energy savings from green roof installation have been estimated at around 10% to 15% (Bigham 2011).

- **Sustainable urban drainage systems (SuDS)**: SuDS such as bioswales and bioretention filter pollutants out of stormwater and urban runoff (Davis et al., 2017). Additionally, they can mimic natural hydrological response and absorb urban stormwater through soil infiltration, stormwater retention, storage and purification, recharging groundwater and improving water quality of the runoff (EU, 2015).

2.2.2 Nature-Based Solutions for Flood Risk Management

In terms of physical damage and economic losses the impact of flood events in Europe has risen sharply during the 20th century (Linnerooth-Bayer & Amendola, 2003). It is difficult to find reliable estimates for the direct and indirect costs of flood damage in Europe, but recent reports suggest that from 1998 to 2009 flooding represented Europe's costliest natural hazard, with losses from flooding adding up to €52 billion (EEA, 2011). The factors driving this include urbanisation, loss of floodplains to socio-economic activities and historically modified rivers.

The traditional approach to flood risk management – the 'protection paradigm' – views floodplains as something to protect against flooding, relying on engineered structures such as the construction of dykes, channelisation of natural rivers and streams, culverting under roads and bridges and the construction of stormwater detention basins to mitigate flood risk (Kumar et al. 2020; Bark et al., 2021). However, NBS such as natural flood management (NFM) are becoming increasingly popular worldwide (Bark et al., 2021). NFM involves "techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters" (SEPA, 2015). Instead of implementing expensive measures to try to prevent the floodplain being flooded, NFM aims to encourage flooding where suitable, as a means of storing water through periods of high flow. Measures can include:

- **Restoring natural river courses**: Rivers that have been straightened, diverted and/or over-deepened can be re-meandered to reinstate a more natural course and river profile (Kondolf, 2006). This improves habitat diversity and biodiversity, whilst slowing, storing and reducing flows, thus mitigating the effects of flood events (Lorenz et al., 2009).
- **Floodplain reconnection and wetland creation:** To restore connectivity, flood banks can be breached or set back to allow water to spill out onto the floodplain again. Benefits of reconnecting rivers with their floodplains include an increase in flood storage area, recreation of wetland habitat, reintroduction of wetland species and the creation of refuge areas for fish during high flows (Acreman & Holden, 2013; WWAP, 2018). An example is the River Isar, Munich, Germany, where NBS including reconnection with the floodplain were implemented to improve flood control (RRC, 2013). Compared to other areas of Southern Germany the 'big flood' of 2005 did not cause substantial damages in Munich due to the restoration of the Isar river (Climate ADAPT, 2016).
- **In-stream enhancement:** In-stream enhancement involves reinstating some natural processes within confined urban river channels where floodplains have been developed. Several actions can be taken, including introducing some form of roughness in-channel such as woody material, reworking gravels or creating berms to promote flow and habitat diversity (Brown et al., 2018; Gunnell et al., 2019).

- **Urban green infrastructure:** Flood risk is particularly acute in cities where bottlenecks in flow occur and aging infrastructure is unable to accommodate additional stormwater (WWAP, 2018). Several NBS are available that can mitigate these effects, but all aim to increase urban water retention and conveyance of floodwater. The 'green city' scenario includes a combination of measures including green roofs, rain gardens, park depression and infiltration devices (Burek et al., 2012).

Flood risk management can be a highly contentious issue, and it can often be difficult to persuade local communities to make space for water and encourage decision makers to adopt new strategies (Bark et al., 2021). Many NBS employed for flood risk management slow and store floodwater and release it gradually, reducing peak flows so that lower-magnitude flood events may be prevented, and the damage caused by severe events reduced. This approach does not always seek to resist or prevent floods, but instead seeks to mitigate and minimise their impact on society and infrastructure (Bark et al., 2021). This requires a level of 'flood risk acceptance' among citizens that is often difficult to establish (WWAP, 2018; Brillinger et al., 2020). A recent survey of key stakeholders in the UK in the position to enable and/or implement NFM showed that many viewed NFM as a 'no-brainer' given the perceived cost-effectiveness, social and environmental benefits and failure of the traditional protection paradigm to mitigate flood risk (Bark et al., 2021). However, farmers and landowners were typically more cautious and opposed to radical change.

2.2.3 Nature-Based Solutions for Water Availability

Ensuring a steady supply of clean water is essential for our society, the economy and nature. Yet climate change, population growth, rapid urbanisation and economic and agricultural activities put extreme pressure on Europe's water bodies (Trémolet et al., 2019). Worldwide, it is estimated that 3.9 billion people will be living in river basins under severe water stress by 2050 (OECD, 2012). In Europe, droughts accounted for €100 billion in economic damages between 1976 and 2006 and this figure is likely to rise with increasing temperatures and demand (Trémolet et al., 2019).

Promoting resilience to water scarcity is therefore critical and can be achieved through the application of NBS (Eggermont et al., 2015):

- **Natural and artificial aquifer recharge:** Groundwater aquifers offer a unique buffer to overcome fluctuations in natural water supply, storing excess water in wet periods that can subsequently improve freshwater availability during dry periods (WWAP, 2018). Artificial methods include building infrastructure and/or modifying the landscape to increase the conveyance of water into the aquifer, while natural solutions such as wetland creation aim to increase natural infiltration.
- **Urban greenspace:** Urban infrastructure that increases the storage and conveyance of rainwater are cost-efficient solutions for water management that provide cross-cutting benefits in areas such as biodiversity conservation, public health and well-being (van der Bosch & Ode Sang, 2017; Raymond et al., 2017).
- **Conservation agriculture:** Conservation agriculture involves the application of methods that incorporate three principles: minimum soil disturbance, a degree of permanent soil cover, and

crop rotation (WWAP, 2018). This alternative agricultural paradigm can be appealing to farmers, where there is recognition that the approach delivers economic benefits comparable to or greater than intensive farming practices, in addition to off-farm environmental benefits. Studies in the Mediterranean comparing vineyards applying traditional management practices with those adopting improved practices (i.e. cover crops) found that after 5 years a 14% increase in the total organic carbon contained within the soil was observed in those vineyards employing conservation practices (Kirchhoff et al., 2017). Carbon capture, including in soils, will be a key component of measures to mitigate against climate change, one of the primary threats to water availability.

Under climate change, droughts are predicted to become more frequent and intense throughout the 21st century, particularly in Southern, Eastern and Central Europe (Kumar et al., 2020). The factors that trigger droughts are complex and non-linear, influenced by climate (precipitation, evapotranspiration etc.), historical and current land use practices, and landscape context. These factors will change for a given area as climatic conditions shift and NBS must be robust and capable of adapting to these changes to ensure continued efficacy (Calliari et al., 2019).

2.2.4 Nature-Based Solutions for Society

Societies are facing a broad range of challenges, from poor public health and social cohesion, to natural capital depletion and issues of food, water and energy security (Carcus et al., 2017; Vujic et al., 2017). These challenges are intertwined with global processes, such as climate change, and with local drivers such as urbanisation and natural disasters (Faivre et al., 2017). NBS that aim to improve water-related management issues are often cross-cutting into other impact domains as well, resulting in multiple co-benefits for health, the economy, society and the environment, and thus they can represent more efficient and cost-effective solutions compared to more traditional approaches (EU, 2015).

- **Urban gardens**: In many EU countries the popularity of communal urban gardening on allotments and community gardens is on the rise, increasing urban (social) resilience (van der Jagt et al., 2017). In the UK, the effect of urban greenspace on mental and physical health has been estimated to reduce treatment costs by £2.1 billion (UK, 2015). Moreover, urban gardens reduce localised run-off and increase infiltration, mitigating flood risk and recharging groundwater (van der Jagt et al., 2017).
- **Waterway restoration**: NBS focused on the urban waterways provide quality blue space and many associated benefits such as psychological relaxation, stress relief, enhanced opportunities for physical activity, reduced depression and improved mental and physical health (Raymond et al., 2017). NBS also have a disproportionate positive impact in deprived urban areas, helping to tackle social injustice (Bauduceau et al., 2015), while mitigating the economic impact of flood events. Rivers and canals are effective wildlife corridors, connecting habitats, enabling species migration and dispersal, and supporting a rich biological diversity including pollinating insects (EU, 2015).
- **Green walls and roof gardens**: Living (green) walls and roof gardens increase biodiversity at street and roof level and provide urban refugia for species, as well as a place for relaxation

and social activities. Additionally, they can be used to support wastewater treatment and deliver cost savings due to reduced stormwater runoff (WWAP, 2018; EU, 2020).

Active engagement with the planning and implementation of NBS schemes by local communities and individuals additionally serves to embed schemes in the needs of communities and instil a sense of ownership. It can provide a point of applied education about natural processes and the local environment which can serve to increase support for and interest in the wider implications of NBS. Schemes are likely to become a focus of community activity and engender a sense of pride in place. There is widespread consensus that NBS support and require transdisciplinary approaches, including involving citizens and identifying innovative ways to unite different stakeholders in order to align their goals and maximise resources (Eggermont et al., 2015; Nesshöver et al., 2017; Bark et al., 2021). As such, they can be important instruments of social cohesion.

2.3 Citizen Science & Nature-Based Solutions

Citizen science is one of the most effective means of fostering community engagement in NBS. It engages members of the public in collecting and mobilising information for research (Eggermont et al., 2015). There is a mutually beneficial relationship between NBS and citizen science. NBS benefit from increased information and data gathering, and by being embedded in the community with associated greater acceptance and greater likelihood of ongoing maintenance and management by the community. Citizen scientists benefit by having the opportunity to make a meaningful contribution to their community environment, learning new skills, and seeing the impacts of their work in real terms.

Citizen science monitoring can serve as a cost-effective means of gathering large quantities of baseline data beyond the resource and time constraints of government agencies, statutory bodies, and non-governmental organisations (Cross, 2019). In many EU member states policy objectives explicitly support the use of citizen science data in decision making (Nascimento et al., 2018). In the UK, two examples of citizen science initiatives, the data from which have been used to inform decision making, are the Riverfly Partnership's (RP) Anglers Monitoring Initiative (ARMI) and Outfall Safari.

- **Anglers Monitoring Initiative (ARMI):** The RP is hosted by the Freshwater Biological Association and was established in 2004 to monitor key macroinvertebrate species (riverflies) that are indicators of river water quality (The Riverfly Partnership, 2020). The Partnership consists of a network of over 180 organisations, including angling clubs, local conservation groups and wildlife trusts. These organisations act as Riverfly 'hubs', coordinating the activities of local volunteers and liaising with the relevant statutory agencies, such as the Environment Agency in England. ARMI represents the RPs primary citizen science project and offers a simple, standardised monitoring technique that can be conducted by citizen scientists to detect severe perturbations in river water quality. The ARMI method has been applied nationally and has over 3,000 active volunteers. It is used alongside and complements routine monitoring carried out by the statutory agencies in the UK to ensure an increased number of river sites can be monitored and to identify and respond to pollution events more effectively.
- **Outfall Safari:** Outfall Safari is an innovative citizen science method devised to systematically survey outfalls in urban rivers in order to identify, assess the impact of and report polluted

surface water outfalls (PSWOs) (Zoological Society of London, 2019). The initiative was developed in response to concerns regarding poor urban river water quality within Greater London, and the need to address polluting outfalls and 'misconnections' in the sewage system. The objective of Outfall Safari citizen science project is to detect sewer related pollution in rivers from misconnections, cross connections and blocked sewers. The identified polluting surface water outfalls are reported to the regulator (e.g. Environment Agency) and Water Company to resolve the issue as soon as possible.

Beyond data collection, volunteers increasingly participate in all stages of the scientific research process, including data analysis and project or protocol design (Zingra-Hamed et al., 2020). Haklay (2013) defined three forms of citizen science:

- **Contributory**: citizens are only involved in data collection. The project design, aims and objectives and activities are decided by scientists/project coordinators.
- **Collaborative**: citizens contribute data and may help in project design, but the aims and objectives and activities are decided upon by scientists/project coordinators.
- **Co-created/co-design**: citizens are actively engaged in all stages of an NBS project, working alongside scientists/project coordinators to identify the aims and objectives and agree upon activities, in addition to being involved in data collection.

Of these, co-design strategies offer a potentially powerful approach to include stakeholders and citizens on the same footing as professional actors, bringing together real-life experiences, views and skills of many different perspectives to address a specific problem (Basnou et al., 2020). The involvement of local communities in early stage planning of NBS can serve to empower the planning and management processes, since local knowledge can be used to tailor NBS to local conditions, thus increasing the chances of successful implementation (Sarabi et al., 2019).

A co-design approach can develop organically, building on the relationships developed between citizen scientists and project co-ordinators during the lifetime of the project. Increasingly the co-design methodology is also being actively and intentionally adopted and used to guide citizen science activities. The MICS case studies operating in Italy, Romania and Hungary are good examples of projects adopting co-design.

- **The Marzenego River, Italy:** The Marzenego and its tributaries, flowing into the Venice lagoon, have historically been modified (e.g., channelized), which has increased flood risk. In addition, pressures from urban development and agricultural activities have affected water quality and biodiversity. NBS to address these issues have involved restoring and enlarging two wetlands (Oasi Lycaena and Oasi di Noale) to increase flood water retention and improve biodiversity. These NBS are the focus of the citizen science monitoring activities. Opportunities for citizen involvement within Marzenego river catchment have been available since 2012 in the form of "river contracts" but following initial interest engagement declined and the initiative was abandoned. A co-design process involving workshops with citizen scientists and local authority stakeholders is being used to reinvigorate the project and reinvest the local community in the NBS proposals.
- **Creek Rákos, Budapest, Hungary:** The heavily modified urban rivers in Budapest suffer from pollution, loss of biodiversity and lack of space for recreation. Changing attitudes to the environment have led to the desire to create a 'green corridor' along Rákos Creek. The potential restoration of the Creek has been discussed previously but due to lack of resources

and engagement has not progressed. Co-design in this case is about capitalising on existing interest in the restoration of the creek and connecting interested citizens with expertise to allow for the identification of targets for citizen science activities. Based on the outcomes of the co-design workshops these will include mapping naturalness, habitat and indicator species as well as monitoring water quality. This will provide baseline information that will help local communities identify sites for future NBS restoration activities.

- **Carasuhat Wetland, Romania:** The Romanian case study looks to use citizen science to carry out long term monitoring of a wetland restoration project following re-wetting of the wetland area in 2016, as part of the Danube Delta Biosphere Reserve. Local communities are being engaged in the co-design process to help define the activities that will be used to monitor the wetland as it responds to restoration. Using citizen science will extend the legacy of the project and contribute to the evidence base for wetland restoration NBS.

2.4 Challenges

Several knowledge gaps remain that hinder NBS implementation and acceptance: natural systems behave differently depending on ecosystem type, climate, location, condition and management, and therefore generalised assumptions about the functioning and impact of NBS can be made only with caution. This has led to a wide variation in their success and application, even where they are proven to be effective.

Barriers hindering the uptake of NBS can be grouped into six categories:

- **Inadequate financial resources**: Financial support, which includes the costs of implementation, access to sources of funding and long-term funding commitment, can have significant implications for NBS application (WWAP, 2018). Specific funding opportunities to facilitate NBS remain limited, particularly for large-scale projects (Davis et al., 2018). In addition, many of the co-benefits associated with large-scale NBS can only be realised in the long-term whereas funding schemes are predominantly short-term in nature (Sarabi et al., 2019).
- **Path dependency:** Despite an overall policy framework which supports the application of NBS, path dependency, or acquired knowledge, remains one of the most significant barriers impeding NBS application (Cohen-Shacham et al., 2019; Sarabi et al., 2019). NBS can be seen to entail a paradigm shift in approach (Bark et al. 2021), recalibrating the way we manage our freshwater for public goods provision, introducing incentives, rights and responsibilities and new frameworks of governance that support catchment-scale collaboration and networking within and across scales (Paavola & Primmer, 2019). Such shifts are difficult to achieve, since existing ways of thinking, working and governing promote resistance to change (Waylen et al., 2015; Bark et al., 2019). NBS are often seen by stakeholders as a relative unknown compared to traditional grey infrastructure (Santiago Fink, 2016; Brillinger et al., 2020).
- **Institutional fragmentation:** Variations in decision making often occur between regions due to differences in administrative structure, which makes collaboration between regions problematic (Brillinger et al., 2020). This is a particular challenge for large-scale NBS and where issues occurring in one region have impacts in another, i.e. land management practices higher in a catchment impacting water quality downstream.

- **Inadequate regulations:** Regulations, or 'policy instruments' supporting NBS include directives, strategies, programmes and incentives instigated at the EU or Member State level. While EU policies that impact on freshwater management are broadly supportive of an NBS approach few explicitly detail NBS-related concepts or provide measurable targets for their deployment and quality (Davis et al., 2018). This gap is left to be filled at a lower level, i.e. regional or local. This increases the potential for lack of regional cooperation and lack of standards and inhibits the realisation of large-scale projects (Trémolet et al., 2019).
- **Uncertainty regarding implementation process and effectiveness of NBS:** Lack of knowledge supporting the effectiveness of NBS is frequently cited in the literature as being a barrier to NBS application. Since NBS have complex socio-ecological impacts it is indeed difficult to measure their benefits and effectiveness, and the body of literature remains predominantly academic (Sarabi et al., 2019). Important knowledge gaps exist in terms of water quality impacts of catchment scale habitat degradation (EU, 2020).
- **Limited land and time availability:** NBS often require more space than conventional grey infrastructure and time to provide the expected benefits (WWAP, 2018). While this is can be the case for large-scale projects, local-scale interventions can take days to install and have immediate benefits.

3 Survey of NBS Practitioners

3.1 Rationale

In order to assess NBS application across Europe and support the development of the NBS policy briefs, we gathered responses from practitioners of NBS regarding their practical experience of policy instruments and implementing NBS.

An online survey was created as a means of accessing expertise from as wide a pool as possible. It was designed to gather information regarding perceptions of working within the policy framework for implementing NBS, as well as different factors affecting the uptake and lack of NBS in practice, and recommendations for how these could be overcome.

3.2 Description of Survey

The survey was hosted on SurveyMonkey®, an online platform for administering and analysing questionnaires. It was advertised throughout the contact networks of the MICS team, MICS partners and associated networks. A full list of the survey questions is provided in Annex 1.

Information from section one (respondent background and country of residence) provided context for understanding responses, as well as allowing for regional analysis of the survey results. The second section focused on gathering information on the respondents' knowledge of and involvement with NBS, assessing whether practitioners prioritise certain aspects of NBS impact over others (e.g. environment compared to society). The literature review identified that overarching EU policies are broadly supportive of an NBS approach, and yet practitioners operate in regional, national and local policy frameworks that can vastly impact on their abilities to plan, fund and deliver NBS. Section three thus asks questions regarding policy framework and funding sources to determine whether NBS

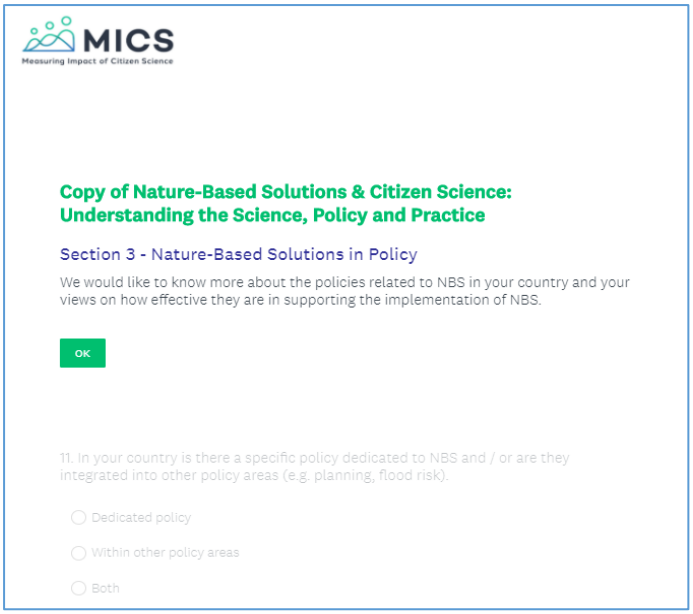

Figure 2. A screenshot of the online survey, Section 3 – Nature-Based Solutions in Policy.

implementation is being driven at a local, national or European scale, in the respondents' experience. The literature review also identified a series of barriers to NBS implementation. Section four seeks to understand which of these barriers were the most significant in impeding NBS implementation and to solicit feedback as to what measures could be taken to tackle these barriers. Section five of the survey determines whether citizen science activities are incorporated into the NBS schemes with which respondents are familiar and assesses perceptions among NBS practitioners regarding the incorporation of citizen science.

3.3 Survey Results

The following section provides a high-level overview of the survey results. A full list of the survey responses is given in Annex 2. The survey received 44 respondents in total, of which 64% were based in Western Europe (n=27), 21% were from Southern Europe (n=9) and 14% were from countries within Central and Eastern Europe (n=6) (Figure 3a). Most of the survey respondents worked within the Environmental sector (68%), as environmental consultants or managers / officers at environmental NGOS, while 20% work as Scientists within research institutes (Education sector) (Figure 3b).

Asked to define NBS, a small majority of participants (45%) agreed with the definition as outlined by the European Commission (EC, 2017) that places Society and Sustainable Development at the centre of the NBS as opposed to the definition that prioritises nature and conservation (Table 4). This is in line with findings of Sarabi et al. (2019), who, based on a review of the scientific literature found Society and Sustainable Development to be the most widely cited definition for NBS. Those respondents who selected 'Other' either suggested a combination of the two definitions or stated there was little difference between the two.

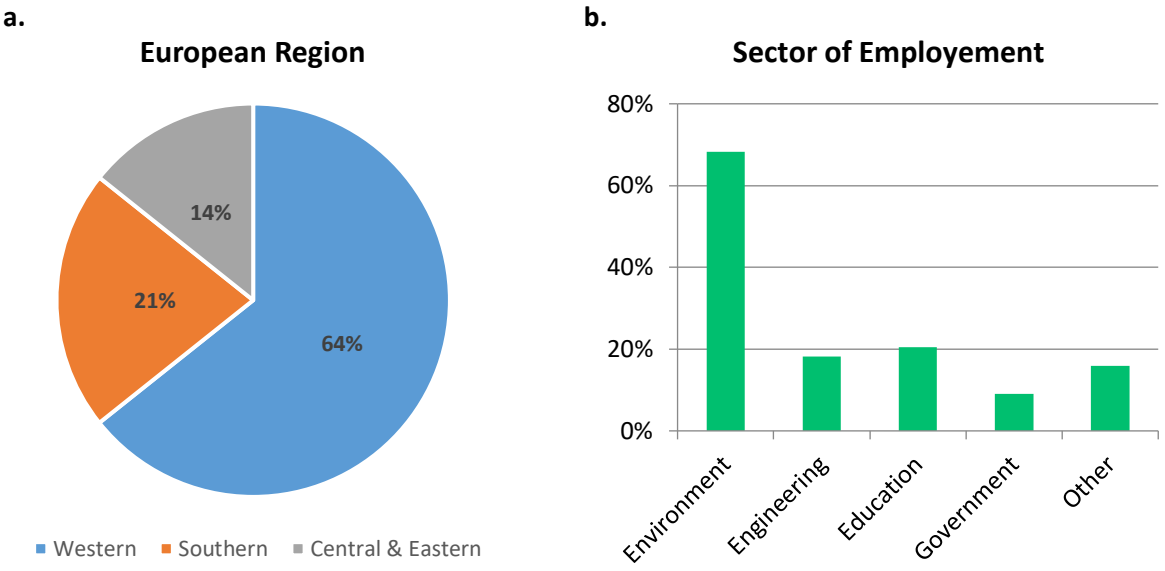

Figure 3. (a) Percentage of survey respondents from Western, Southern and Eastern & Central Europe. (b) Survey respondents' sector of employment.

Table 4. Respondents preferred definition of NBS. Note the figures are given as a percentage of the number of respondents who answered the question. Total number of responses to question n=38, number of respondents that skipped question n=6.

Answer Choices	Responses
Focused on nature and conservation Solutions to major societal challenges while improving natural capital and biodiversity	42% (n=16)
Focused on society and sustainable development Solutions which meet environmental, economic and social objectives simultaneously	45% (n=17)
Other	13% (n=5)

The perceived importance of NBS on the five MICS impact domains (society, governance, the economy, science and the environment) was broadly consistent between the three European regions (Figure 4). 83% of respondents ranked the *Environment* as very important (Rank 1) or important (Rank 2), with *Society* following as the next most significant domain of impact. Of the five categories *Science and Technology* ranked the lowest with 70% of respondents choosing Rank 4 or 5 (not very important or not important). *Economy* also ranked lowly with only 8% of respondents ranking it as very important (Rank 1) and over half of respondents ranking it as 4 or 5 (not very important or not important).

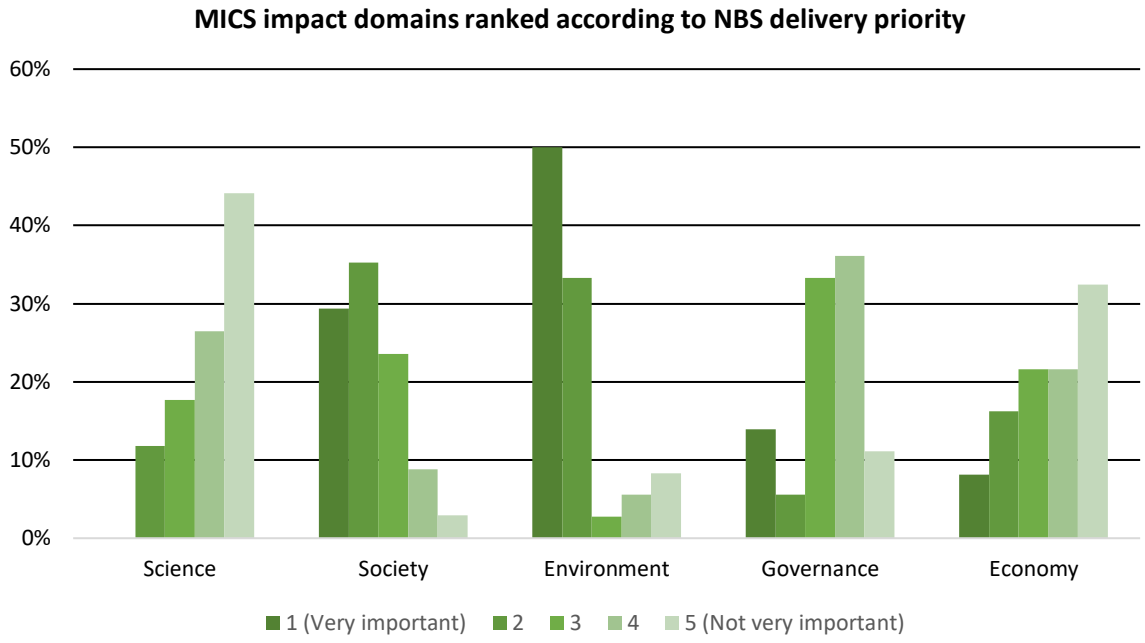

Figure 4. MICS impact domains ranked in the order of importance that NBS should deliver, where a score of 1 = very important, and a score of 5 = not very important. Note the figures are given as a percentage of the number of respondents who answered the question. Total number of responses to question n=38, number of respondents that skipped question n=6.

Over 70% of the survey participants were either working on or aware of projects incorporating water management related NBS, though a higher proportion of the respondents (57%) from Southern Europe were not involved in or aware of NBS projects. The most common aims of these NBS projects were *flood management*, *water quality*, *climate resilience* and *wetland creation, restoration or conservation* (Figure 5). However, in Central and Eastern Europe a higher proportion of projects had a focus on delivering improved *river habitat quality* and were conducted with *public engagement* in mind. Fewer respondents in Southern Europe responded to this question, however, all consider *climate* to be a factor in the NBS projects they were involved in or aware of. 50% of the NBS projects participants were involved with were medium term (2 – 5 years) in timescale.

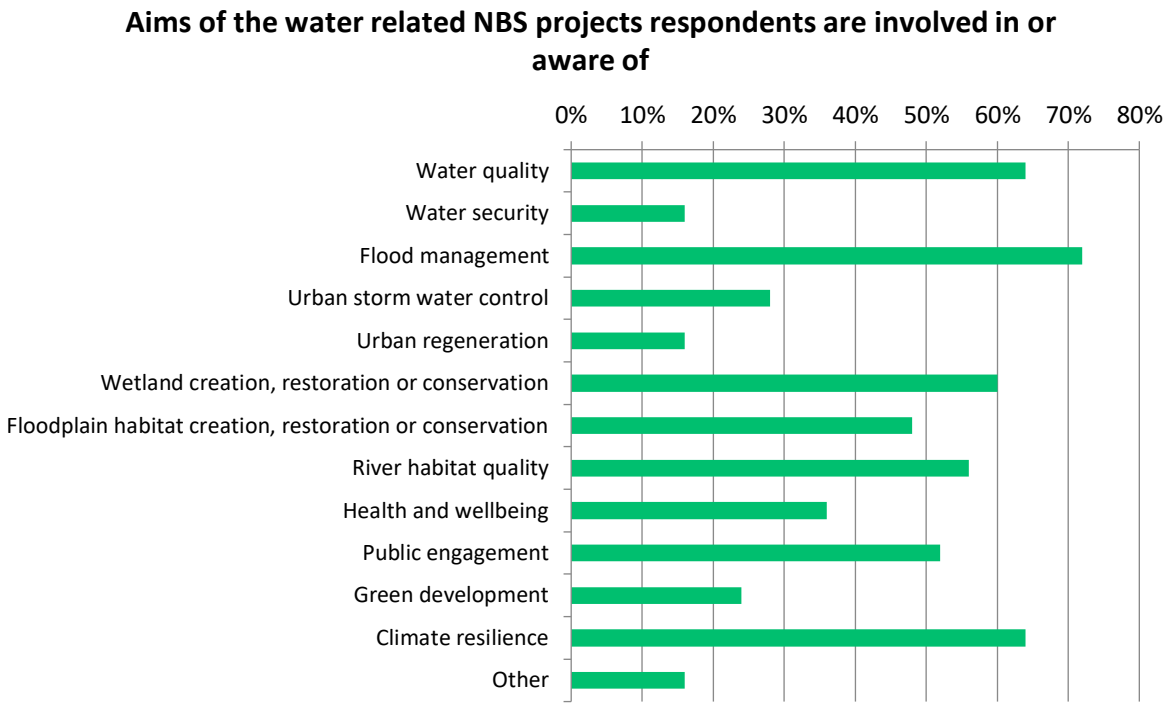

Figure 5. The aims of the water related NBS projects survey respondents were aware of or involved in. The survey question was multiple choice giving respondents the option to select multiple aims for a single project. Note the figures are given as a percentage of the number of respondents who answered the question. Total number of responses to question n=25, number of respondents that skipped question n=19.

The majority of respondents believe that NBS are not adequately supported in policy (77%) or were unsure (17%) (Table 5). This figure is higher in Southern and Central and Eastern Europe compared to Western Europe. *Lack of long-term funding commitment*, *inadequate policies supporting NBS*, and a *lack of willingness from policy makers to adopt new approaches* were believed to be the primary barriers to NBS application across Europe. In Southern and Central and Eastern Europe *poor communications between ministries / governmental departments* and *space limitations* were also perceived to be significant barriers. When asked what more can be done to address the perceived lack of support for NBS within policy at a national level, suggestions included: mainstreaming and awareness-raising among local stakeholders and actors, including decision makers, regarding the benefits of NBS; integrating NBS within more and a wider range of policies; incentivising NBS over conventional grey infrastructure; and integration of a regulatory framework capable of enforcing policy.

Table 5. Respondents perceived belief as to whether NBS are adequately supported in current policy. Note the figures are given as a percentage of the number of respondents who answered the question. Total number of responses to question n=30, number of respondents that skipped question n=14.

Answer Choices	Responses
Yes	6% (n=2)
No	77% (n=23)
Not sure	17% (n=5)

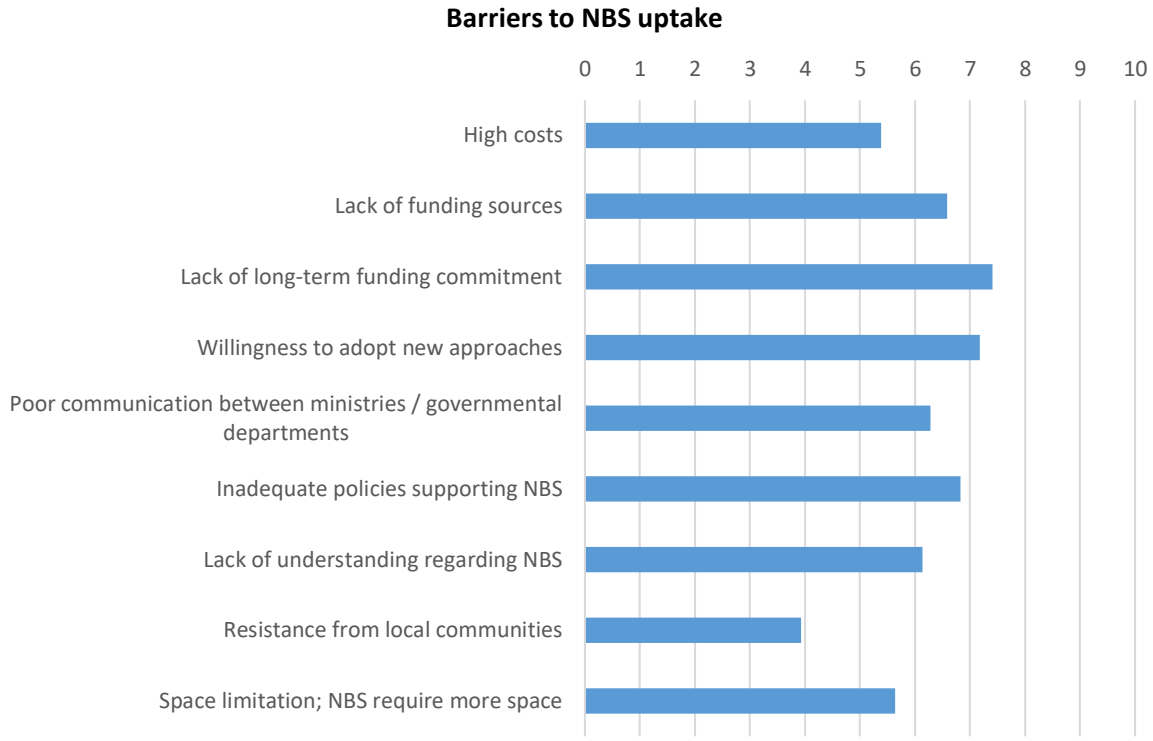

Figure 6. Barriers to NBS uptake ranked by according to their perceived impact on NBS implementation. A score of 0 = Not an issue, while a score of 10 = Major issue. Total number of responses to question n=29, number of respondents that skipped question n=15.

A large proportion of respondents were involved in 1-3 NBS projects that had a citizen science element (54%). Most participants believed that the involvement of citizens in NBS projects through citizen science was *important*, although some respondents believed citizen involvement was helpful but not critical. When asked to expand upon their reasoning, respondents identified several areas where citizen science was considered to be of particular significance: ensuring project continuity/legacy and long-term engagement; engendering interest among citizens generates interest from decision makers and increases the potential to incite change; moving towards ameliorating the disconnect between society and the environment; educating and garnering support of local residents (particularly important in urban settings given small spaces and complicated planning and design). The primary citizen science activity was data collection/monitoring, although in Western Europe a large proportion of projects also involved volunteers in the design of NBS. A large proportion of participants believed that projects involving citizen scientists should be co-created, although this belief was higher in Western Europe (82% of respondents) than Southern and Central and Eastern Regions (60% and 75% respectively).

3.4 Summary

The survey helped to identify some regional commonalities regarding the application of NBS across Europe and the factors perceived by practitioners of NBS to affect the uptake and lack thereof of NBS in practice.

Across all regions the impact of NBS on the *environment* and *society* was ranked highly by survey respondents while the NBS impact on the *economy* was considered a lower priority. This result is unsurprising given most survey participants worked within the environmental sector (68%) and the management of environmental issues is likely to be a primary focus. However, this could also be an indication that the economic benefits of NBS are not fully understood among practitioners.

Some of the barriers identified in the literature were highlighted by the practitioners who participated in the survey. Inadequate support in policy, lack funding and willingness from policy makers to adopt new approaches were identified by survey respondents in all regions as the primary challenges to the uptake of NBS. Indeed, the majority of survey respondents believed NBS were not adequately supported in policy (77%). Regional differences were also identified. For example, respondents in Southern and Central and Eastern Europe indicated *poor communications between ministries / governmental departments* and *space limitations* were also believed to be significant barriers to the application of NBS.

Citizen science is recognised as an important mechanism for delivering NBS in practice and there was widespread support among practitioners for a co-design approach to citizen science. In Eastern and Central Europe a primary objective of the NBS projects survey participants were involved in or aware was public engagement, and citizen science was identified in the individual responses as a means of ensuring project continuity/legacy and long-term engagement and as a means of educating and garnering support of local residents.

4 Development of the Nature-Based Solutions Science Briefs

The NBS policy briefs are aimed at decision makers to encourage the uptake and application of NBS and contain key recommendations for NBS implementation. The content of the NBS policy briefs was developed using information obtained from the literature (see Section 2) and the results of the survey (see Section 3). The literature review was used to establish the usefulness and the breadth of influence of NBS and the survey helped to identify some regional commonalities and differences that were translated into the briefs. The finalised policy brief for Europe is shown in Figure 6 while the regional briefs for Western, Southern and Central and Eastern Europe are shown in Annex 3.

The briefs were designed to clearly demonstrate the value of NBS to freshwater management in order to appeal to a non-expert decision maker audience. They included:

1) **General background to NBS**: This included a description of NBS concepts and the rationale for their application as a means of tackling climate change and societal challenges. The primary source of this information was the literature review. Within the briefs the definition developed by the IUCN was used to define NBS, which focuses on *Nature and Conservation*.

While a small majority of respondents indicated a preference for the definition of NBS as defined by the European Commission (EC, 2017), which places *Society and Sustainable Development* at the centre of the NBS, the MICS project adopts the definition proposed by the IUCN as indicated in the MICS DoA. Despite this, the briefs still emphasize the co-benefits of NBS for economy and society.

2) **Role of decision makers in mainstreaming NBS:** This section is included in order to highlight avenues available to decision makers where they can influence the wider uptake of NBS. This information was prompted by the survey results where only 7% of respondents felt that NBS were adequately supported by policy. The suggestions provided are based on survey responses and the literature.
3) **Case study of NBS for freshwater management:** 89% of survey respondents believed the inclusion of studies was useful for providing real world examples of NBS successfully applied to tackle issues related to freshwater management. For the general European brief, the 'Isar Plan' implemented on the Isar River, Munich, Germany, was used as a best practice example for river restoration and flood management (RRC, 2013) (see Section 2.2.2). For the regional briefs, examples of NBS projects involving citizen-science activities were selected. Case studies were chosen from the region of interest to increase the relevance of the briefs to regional policy makers. The MICS project case studies described elsewhere in this report were used (see Section 2.3), as examples of citizen science for monitoring water quality, urban regeneration and flood managements and wetland restoration.
4) **Barriers to NBS uptake:** Barriers to the uptake and application of NBS identified in the literature and highlighted by the practitioners who participated in the survey were placed in 'text bubbles' as a means of emphasising their importance to decision makers as specific issues to tackle. The perceived lack of adequate support for NBS within policy was highlighted in both the general European and regional briefs. Different barriers were identified in the survey to have a greater impact in certain regions compared to others and this was translated to the regional briefs. For example, in the Southern European brief the lack of evidence and incentives to convince private landowners of NBS benefits was identified by practitioners of NBS as key issue for decision makers to tackle and was consequently included in a text bubble.
5) **NBS for tackling issues related to freshwater management:** Examples of NBS were presented according to the issues of freshwater management that they can address, specifically *surface water quality*, *flood risk management* and *water availability*. These examples were selected from the literature (see Section 2.2). The intent of these briefs is not to provide technical detail on the science of NBS, but instead to illustrate to policy and decision makers in simple terms the breadth of water management issues that NBS can effectively address.
6) **The value of citizen science to NBS:** The mutually beneficial relationship between NBS and citizen science is well-documented in the literature (see Section 2.3). It was also highlighted by NBS practitioners who responded to the survey, who additionally were strongly supportive (79%) of the co-design approach to citizen science in NBS. This support is likely due to the widespread recognition that local involvement in the planning and design of NBS can have a large impact on the success of the NBS implementation.
7) **Key recommendations:** Recommendations were based primarily on the suggestions provided by survey respondents with regards to the barriers impacting the uptake of NBS (Annex 2,

Q16-24) and actions decision makers can take to help 'mainstream' NBS and address the lack of NBS uptake (see Annex 2, Q25). In order to maximise the cross-cutting benefits of NBS, the involvement of citizen science and the co-design approach is also included as a recommendation. The recommendations are applicable for all regions.

These briefs are 'active' not 'passive' documents: they will be hosted online and updated during 2021 following further planned consultation with NBS practitioners and stakeholders via webinar and video series.

4.1 Images of the General European NBS Policy Brief

Figure 7. NBS brief design for general European audience.

5 Dissemination and Next Steps

The NBS policy briefs will be available on the mics.tools website as a PDF and shared in soft copy with key stakeholders via consortium-wide communication channels. Hard copies will be produced for dissemination by consortium members at events and conferences. As part of the ongoing Task 5.5, which aims to develop recommendations on the science related to NBS, the MICS case study groups will be holding a series of webinars in 2021 to invite people (e.g., practitioners, decision makers etc.) to continue the discussion around NBS and citizen science and to disseminate knowledge gained in the surveys. An aspect of these webinar events will be to canvas participants for their opinions regarding how best to engage more widely with decision makers and bring the policy briefs to their attention.

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Annex 1. Survey Questions – Nature-Based Solutions & Citizen Science: Understanding the Science, Policy & Practice

Introduction

The aim of this survey is to find out about **Nature-Based Solution (NBS)** science, policy and practice in different regions across Europe in order to develop best practice guidance NBS briefs. This work is part of the Measuring Impacts of Citizen Science (MICS) (www.mics.tools) Project focusing on the impacts of citizen science around water themed Nature based solutions.

The survey will take approximately 15 minutes to complete. All answers will be anonymised.

We will share the key results from the survey once collated.

If you have any questions please contact us at rrc@therrc.co.uk.

Thank you for your help.

The MICS Team.

Section 1 - Your Background

Q1 What sector do you work in?

- Environment
- Engineering
- Education
- Government
- Other

Q2 What is your role?

Q3 What country do you work in?

Section 2 - Understanding Nature-Based Solutions

We would like to know your views on NBS, what projects (if any) you are involved in that incorporate NBS, and the issues (environmental, societal or economic) these NBS projects address.

Q4 There are several definitions for NBS that fall within two groups: those that emphasise nature conservation and restoration, and those that prioritise society and sustainable development. Please select which ONE you think best describes NBS. If neither of these definitions adequately describe NBS in your opinion, please explain why and how you define NBS.

- Solutions to major societal challenges while improving natural capital and biodiversity: Focused on nature and conservation
- Solutions which meet environmental, economic and social objectives simultaneously: Focused on society and sustainable development
- Other (please write your definition)

Q5 Rank these in the order of importance that NBS should deliver. 1 = Very important, 5 = Not very important.

- Science
- Society
- Environment
- Governance
- Economy

Q6 Are you involved in or aware of any water related NBS projects?

Q7 Please provide the title and a brief description of the projects you are involved in or are aware of that relate to NBS. If you are not involved in any projects incorporating NBS please proceed to Q11.

Q8 What are the aims of the water related NBS projects you are involved in? (You can select multiple answers)

- Water quality
- Water security
- Flood management
- Urban storm water control
- Urban regeneration
- Wetland creation, restoration or conservation
- Floodplain habitat creation, restoration or conservation
- River habitat quality
- Health and wellbeing
- Public engagement
- Green development
- Climate resilience
- Other (please specify)

Q9 What is the timescale from project inception to application of NBS?

- 0 - 6 months
- 6 months - 2 years
- 2 - 5 years
- 5 years +
- Other (please specify)

Q10 What is the source of funding for your project?

Section 3 - Nature-Based Solutions in Policy

We would like to know more about the policies related to NBS in your country and your views on how effective they are in supporting the implementation of NBS.

Q11 In your country is there a specific policy dedicated to NBS and / or are they integrated into other policy areas (e.g. planning, flood risk).

- Dedicated policy
- Within other policy areas
- Both
- Unsure

Q12 Please give the title(s) of the policies you know of in relation to NBS.

Q13 At what scale are these policies / strategies implemented in your country?

- Local
- Regional
- National
- At all scales
- Unsure

Q14 Do you believe NBS are adequately supported in current policy?

Q15 If you answered No to Q14, what more can be done?

Section 4 - Barriers to Nature-Based Solutions

There are multiple barriers to NBS implementation, listed below in Q16 - 24.

Please use the sliding scale provided in Q16 - 24 to rate the impact of the barriers to NBS implementation in your country. 0 = Not an issue, 5 = Moderate issue, 10 = Major issue.

Q16 High costs

Q17 Lack of funding sources

Q18 Lack of long-term funding commitment

Q19 Willingness to adopt new approaches

Q20 Poor communication between ministries / governmental departments

Q21 Inadequate policies supporting NBS

Q22 Lack of understanding regarding NBS

Q23 Resistance from local communities

Q24 Space limitation; NBS require more space

Q25 Have you encountered or can you think of any other barriers not in our list?

Section 5 - Nature-Based Solutions and Citizen Science

Q26 How important is it to involve citizens in NBS through citizen science? Please use the sliding scale to indicate how important you believe citizen science involvement to be. 0 = Not important, 5 = Reasonably important, 10 = Very important.

Q27 Please explain your answer to Q26.

Q28 Are you involved in any NBS projects? If you are not involved in any projects incorporating NBS please proceed to Q31.

Q29 If you answered Yes to Q28, how many of these NBS projects incorporate citizen science?

- 0
- 1 - 3
- 4 - 6
- 7 - 9
- 10+

Q30 What types of citizen science activities occur in these projects? (You can select multiple answers).

- Data collection / monitoring
- Data analysis
- Installation of NBS
- Co-design of data collection methods
- Design of NBS
- Not applicable

Q31 In your opinion, at which of these stages should citizens be involved in NBS projects?

- Contributory: citizens are only involved in data collection. The project design, aims and objectives and activities are decided by scientists/project coordinators.
- Collaborative: citizens contribute data and may help in project design, but the aims and objectives and activities are decided upon by scientists/project coordinators.
- Co-created: citizens are actively engaged in all stages of a NBS project, working alongside scientists/project coordinators to identify the aims and objectives and agree upon activities, in addition to being involved in data collection.

Q32 Do you have any other comments related to NBS citizen science, policy and practice?

Section 6 - Creating a Nature-Based Solution Brief

We are creating 2 page NBS science summary briefs. We would like to hear what you think should be included in these documents to meet the needs of environmental managers, decision makers and others looking to support and implement NBS.

Q33 In your opinion, who should the NBS briefs be aimed at? (You can select multiple answers).

- Non-experts
- Citizen Scientists
- Project coordinators / scientists
- Decision / policy makers
- Other

Q34 What would you like to see in an NBS brief? (You can select multiple answers).

- Information on different types of NBS
- Barriers to implementation
- Suggestions for successful implementation
- Timescale of delivery
- Case study / examples
- Other (please describe)

Q35 Would you be interested in receiving the NBS briefs?

- No
- Yes, please write your name and email address

Q36 Would you be interested in attending a webinar on NBS science, policy and practice?

- No
- Yes, please write your name and email address

Thank you for answering our questionnaire on NBS

Before you go, you may be interested in learning more about the MICS project?

Q37 Are you interested in in learning more about MICS?

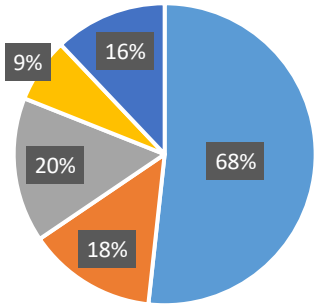
- No
- Yes, please write your name and email address

Annex 2: Results of the Survey Questionnaire

Q1. What sector do you work in?

Answered: 44 Skipped: 0

Sector	*Responses*	
Environment	30	68%
Engineering	8	18%
Education	9	20%
Government	4	9%
Other	7	16%



Q2. What is your role?

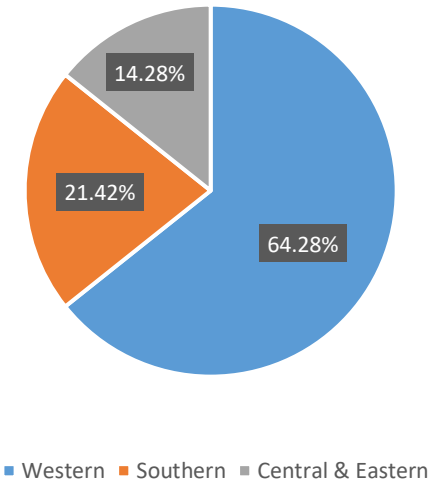
Answered: 41 Skipped: 3

Responses:
Not included to maintain anonymity

Q3. What country do you work in?

Answered: 42 Skipped: 2

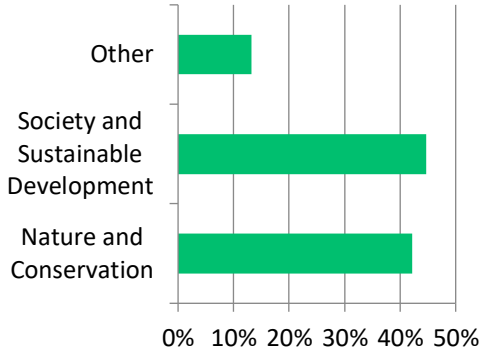
Country	*Responses*		*European Region*
Austria	1	2%	Western
Denmark	1	2%	Western
France	7	17%	Western
Germany	1	2%	Western
Hungary	1	2%	Central & Eastern
Ireland	1	2%	Western
Italy	4	10%	Southern
Netherlands	1	2%	Western
Norway	4	10%	Western
Poland	1	2%	Central & Eastern
Portugal	2	5%	Southern
Romania	4	10%	Central & Eastern
Spain	3	7%	Southern
Sweden	1	2%	Western
United Kingdom	10	24%	Western



Q4. There are several definitions for NBS that fall within two groups: those that emphasise nature conservation and restoration, and those that prioritise society and sustainable development. Please select which ONE you think best describes NBS. If neither of these definitions adequately describe NBS in your opinion, please explain why and how you define NBS.

Answered: 38 Skipped: 6

Answer Choices		*Responses*
Focused on nature and conservation: *Solutions to major societal challenges while improving natural capital and biodiversity*	16	42%
Focused on society and sustainable development: *Solutions which meet environmental, economic and social objectives simultaneously*	17	45%
Other (please write your definition)	5	13%



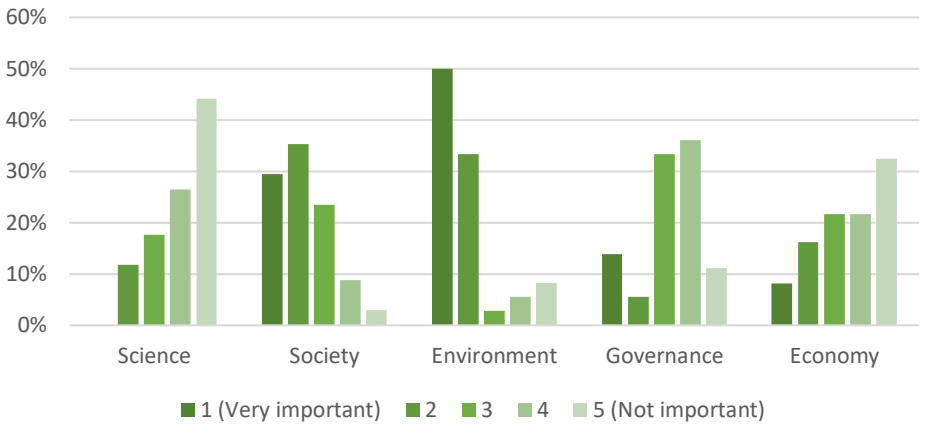
'Other' definitions/comments provided by respondents:

- From those definitions, I do not understand well the difference. I think NBS can be defined by both definitions at the same time.
- Integration of improving nature state and human well-being through actions oriented to a sustainable management.
- Both
- Both, equally. Not very well-defined question.
- It is a false dichotomy to propose one or the other.

Q5. Rank these in the order that NBS should deliver: (1 = Very important, 5 = Not important)

Answered: 38 Skipped: 6

Impact Domain	*Rank 1*		*2*		*3*		*4*		*5*	
Science	0	0%	4	12%	6	18%	9	26%	**15**	44%
Society	10	29%	**12**	35%	8	24%	3	9%	1	3%
Environment	**18**	50%	12	33%	1	3%	2	6%	3	8%
Governance	5	14%	2	6%	12	33%	**13**	36%	4	11%
Economy	3	8%	6	16%	8	22%	8	22%	**12**	32%



Q6. Are you involved in or aware of any water related NBS projects?

Answered: 36 Skipped: 8

Answer Choices	*Responses*	
Yes	27	75%
No	9	25%

Q7. Please provide the title and a brief description of the projects you are involved in or are aware of that relate to NBS. If you are not involved in any projects incorporating NBS please proceed to Q11.

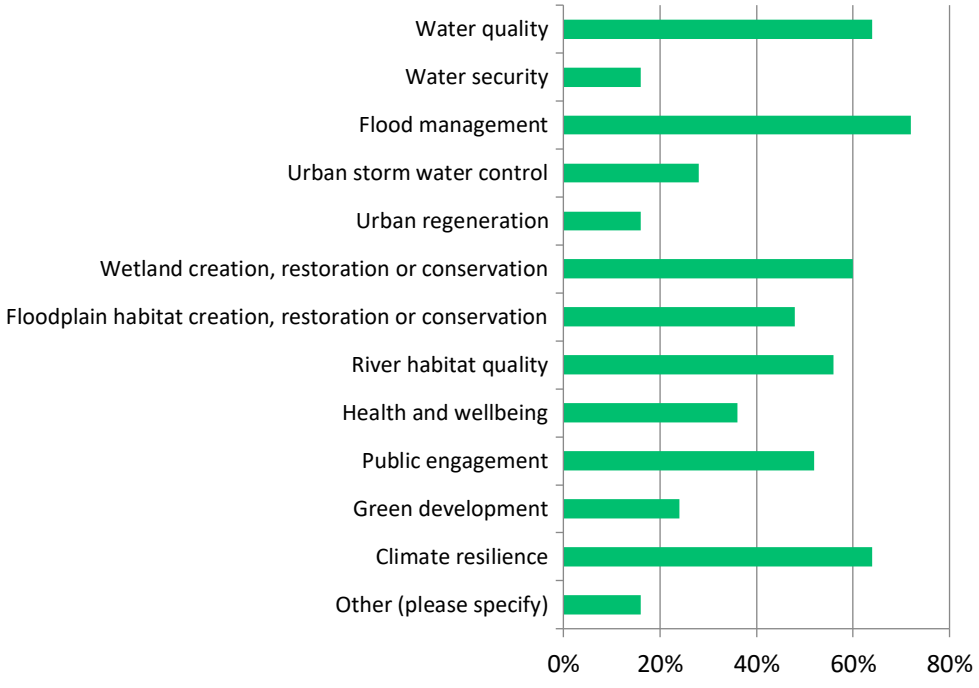
Answered: 22 Skipped: 22

Responses:
Not included to maintain anonymity

Q8. What are the aims of the water related NBS projects you are involved in? (You can select multiple answers)

Answered: 41 Skipped: 3

Answer Choices	*Responses*	
Water quality	16	64%
Water security	4	16%
Flood management	18	72%
Urban storm water control	7	28%
Urban regeneration	4	16%
Wetland creation, restoration or conservation	15	60%
Floodplain habitat creation, restoration or conservation	12	48%
River habitat quality	14	56%
Health and wellbeing	9	36%
Public engagement	13	52%
Green development	6	24%
Climate resilience	16	64%
Other (please specify)	4	16%



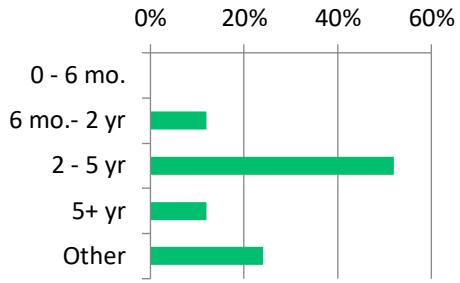
'Other' aims provided by respondents:

- Reduction of fatbergs and water quality issues within sewer system
- Social inclusion
- Erosion control, invasive species control
- Science into Policy Education

Q9. What is the timescale from project inception to application of NBS?

Answered: 25 Skipped: 19

Answer Choices	*Responses*	
0 - 6 months	0	0%
6 months - 2 years	3	12%
2 - 5 years	13	52%
5 years +	3	12%
Other (please specify)	6	24%



'Other' timescales/comments provided by respondents:

- The NBS is already functioning. The study is oriented to a better knowledge of the system.
- We started 2 years ago and hope to deliver gradual change in societies behaviours and a reduction in the use of toxic chemical cleaning products over the next 5 years
- We do not know if NBS shall be applied
- I personally only work on education and engagement rather than application. The rest of the team and project timescales vary.
- 25 years
- NbS were introduced after 2 years, but the first 2 years of the project were spent scoping the works, setting up a network of hydrological and ecological monitoring systems, and then collecting baseline (pre-NbS) data. Only then, 2 years in were the first (of many) NbS implemented

Q10. What is the source of funding for your project?

Answered: 22 Skipped: 22

Summary of Responses:

- EU funds from Horizon 2020 or other (8 responses)
- Private sources (7 responses)
- Public Authorities (local) (3 responses)
- Public Authorities (national) (2 responses)
- Public Authorities (unspecified) (7 responses)
- National research agencies or universities (4 responses)
- Charities (3 responses)
- Water companies/Water Agency (2 responses)
- Various/Diverse (8 responses)

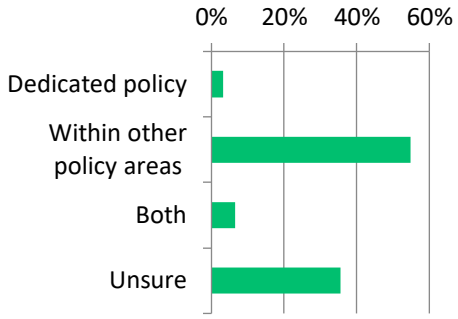
Other notable responses/comments:

- Personal funds
- Structural funds
- Taxes and water fees
- in-kind contributions from landowners

Q11. In your country is there a specific policy dedicated to NBS and / or are they integrated into other policy areas (e.g. planning, flood risk)?

Answered: 31 Skipped: 13

Answer Choices	*Responses*	
Dedicated policy	1	3%
Within other policy areas	17	55%
Both	2	6%
Unsure	11	35%



Q12. Please give the title(s) of the policies you know of in relation to NBS.

Answered: 19 Skipped: 25

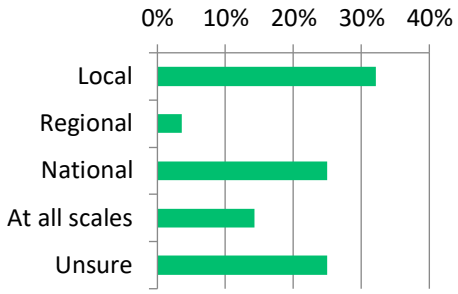
Responses:

- Natural Water Retention Measures (NWRM) Overview and Recommendations for Use in Ireland, September, 2020. Natural Water Retention Measures (NWRM) Evidence and Opportunities for use in Ireland, September 2020.
- The Norwegian Environmental Directorate: 'Veiledning til statlige planretningslinjer for klimatilpasning' (Guidelines for govermental climate adaptation)
- Need to use NBS for climate adaptation projects /Environmental directorate in Norway)
- Green infrastructures plans
- Environment Bill (UK)
- Spanish water law (previous to EU WFD and later adapted to this)
- Climate Adaptation Plan 2011
- there is no policy related to NBS, there are only recommendations of no legal power incorporated into the City Climate Adaptation Plans, "Stop Drought" national strategy, River Basin Management Plans,
- Unsure (2 responses)
- Various local policies. Defra's 25 Year Environment Plan Environment Agency's National Flood Risk Management Strategy.
- Water Framework Directive, Flood Directive, Habitat and Birds Directive
- Water management, flood protection, water security, economic development, renewable energy, nature conservation, transortation, urban development
- Miljöbalken, plan och bygglagen, lag om allmäna vattentjänster
- GEMAPI
- Natural capital approach , Natural flood management Net zero carbon targets Tree planting and nature recovery network policies
- Flood Risk Management (Scotland Act (2009) requires the assessment of the potential contribution to flood risk reduction that could be achieved by management of the 'natural characteristics' of the catchment. This provides a legal basis to NbS in flood schemes.
- framework law on protected areas 349/91, Ramsar, Habitat Directive, WFD,

Q13. At what scale are these policies / strategies implemented in your country?

Answered: 28 Skipped: 16

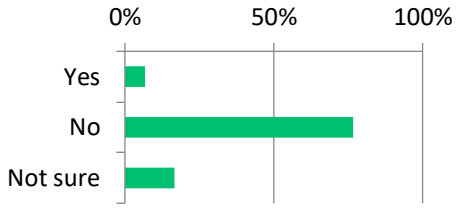
Answer Choices	*Responses*	
Local	9	32%
Regional	1	4%
National	7	25%
At all scales	4	14%
Unsure	7	25%



Q14. Do you believe NBS are adequately supported in current policy?

Answered: 30 Skipped: 14

Answer Choices	*Responses*	
Yes	2	7%
No	23	77%
Not sure	5	16%



Q15. If you answered No to Q14, what more can be done?

Answered: 19 Skipped: 25

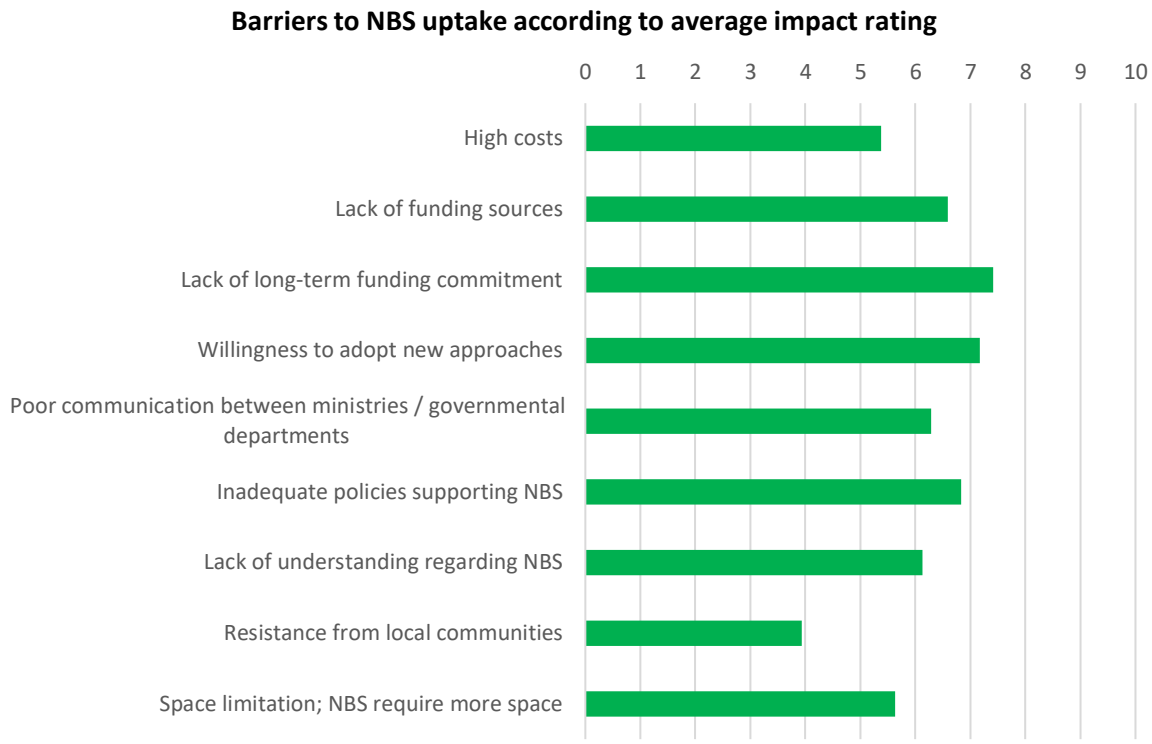
Responses:

- Strengthening of Integrated Catchment Management to include all statutory & non-statutory stakeholders.
- More ambition from authorities side.
- Mainstreaming NBS into sectorial policies
- Educating local, regional and national stakeholders and actors at all levels. Far too little is known, e.g. about NBS co-benefits.
- base it on regional level
- Specific policies promoting NBS, and inclusion of NBS in sectorial policies as efficient and important ways to tackle different problems and needs
- essentially legislation has no real teeth or insentive to encourage development of NBS in the UK. e.g. developers are required to do the bare minimum. Even our legistation doesn't project small water bodies.
- To make mandatory the choice of NBS.
- mainstreaming, awarness raising, more information about it, should be taught in schools as well
- They should be mandatory in all redevelopment commercial, industrial domestic etc.
- NBS should become present in legislation, as obligatory measures complementing grey solutions
- More funding to NBSs and less to grey infrastructure

- More to be done to make it mandatory and a priority over grey development / hard measures
- Research, demonstration, public awareness, stakeholder engagement.
- Reinforce knowledge, regulation and fundings
- Needs to be added to the wider range if policies as a priority approach to problems eg health, agriculture,
- Need to integrate alongside 'normal' methods of Project development and Options appraisal. Need to provide better funding. Need long-term changes in Governance to provide support to land managers to get them engaged.
- link theory to practice more and improve ecological knowledge of NBSs

Q16-24. There are multiple barriers to NBS implementation, listed below in questions 16-24. Please use the sliding scale provided to rate the impact of barriers to NBS implementation in your country (0 = Not an Issue, 5 = Moderate Issue, 10 = Major Issue).

Q	*Barrier*	Answered / Skipped	*Percentage of Respondents for each rating*											***Avg rating***
			0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
16	*High costs*	29 / 15	3	1	1	0	1	**10**	3	5	1	2	2	**5.4**
17	*Lack of funding sources*	29 / 15	1	0	0	1	1	**9**	1	7	1	4	4	**6.6**
18	*Lack of long-term funding commitment*	29 / 15	0	0	1	0	1	7	3	2	2	4	**9**	**7.4**
19	*Unwillingness to adopt new approaches*	29 / 15	0	0	1	3	1	5	3	1	1	5	**9**	**7.2**
20	*Poor communication between ministries/ government departments*	28 / 16	1	0	0	2	2	**7**	4	3	3	2	4	**6.3**
21	*Inadequate policies supporting NBS*	29 / 15	0	0	0	3	2	**7**	2	1	5	3	6	**6.8**
22	*Lack of understanding regarding NBS*	30 / 14	1	1	2	2	1	**6**	3	5	0	4	5	**6.1**
23	*Resistance from local communities*	28 / 16	4	2	**5**	3	3	2	3	2	2	1	1	**3.9**
24	*Space limitation; NBS require more space*	30 / 14	2	2	1	2	1	**8**	1	3	4	4	2	**5.6**



Q25. Have you encountered or can you think of any other barriers not in our list?

Answered: 29 Skipped: 15

Answer Choices	*Responses*	
No	13	45%
Yes (specify)	16	55%

Other barriers provided by respondents:

- Large scale of collaborative working, extensive joined up working and converging of separate budgets all required, making delivery very complex.
- Economic motivation from property owners. Lack of standard technical and design criteria Lack of skills and experience (in NBS) in construction companies - procurement difficulties
- Regulation issues, resistance from area owners.
- lack of general knowledge about NBS and related projects
- Lack of information, lack of involvement of society in the NBS proposals
- Fear of change , our blame culture is stopping innovation. people are no longer brave enough to embrace and drive change. No one gets fired for doing the same old thing. In addition there should be much higher tariffs / taxes on environmentally harmful products especially in the cleaning chemicals market. Companies get all these green certifications for recycled packaging when it is the contents of the package that is killing the environment. I have seen approvals go towards products in recycled bottles that are acutely toxic to aquatic life - we need to see the bigger picture.
- distrust to efficiency of NBS
- Lack of benefits (and cobenefits) evaluation

- Lack of institutional cooperation
- Barriers in communication among stakeholders. Lack of LCA. Lack of impact assessment.
- Private land owners - access to land. Timescales - takes a long time to even implement simple measures Developers - priorities not aligned with NBS
- Confronted to Economy, mainly Agriculture in our case, the barrier is that or the lack of public properties (or no strategy) to implement properly at a lrger scale
- Innovation
- Lack of confidence in long term resistance
- Evidence requirements to meet funders requiremdnts
- Lack of standard methods for assessing effectiveness of NbS Lack of accepted methods for valuing multiple benefits of NbS Lack of Integration in to standard Project Assessment and Options Appraisal process and policies

Q26. How important is it to involve citizens in NBS through citizen science? Please use the sliding scale to indicate how important you believe citizen science involvement to be (0 = Not important, 5 = Reasonably important, 10 = Very important).

Answered: 29 Skipped: 15

Percentage of Respondents for each rating											***Avg rating***
0	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	
0	0	1	2	0	1	2	5	2	6	10	**7.9**

Q27. Please explain your answer to Q26.

Answered: 22 Skipped: 22

Responses:

- Citizen science can increase confidence in NBS and increase public buy-in.
- Many times is about citizens ' properties.
- NbS are designed to solve societal issues, and in this process, the citizens are important from the beginning stages (of defining the problem, identifying the solution and design / accept the design of the solution) until the after implementation stage for a proper engagement into the maintenance and sustainable use.
- Due to lack of knowledge about NBS, stakeholder involvement is crucial to create local enthusiasm and ownership. Particularly the fact that long time is needed to see the effects of co-benefits.
- Need local backing.
- It will be good to increase the knowledge and awareness about the potential of NBS, and it will be always good to involve in a real way citizens. Nevertheless, it is not a total requirement to implement NBS (although it is always recommended).
- Green spaces in cities are often relatively small and used by diverse stakeholders, which complicate the planning and design of urban landscapes. Without understanding of social beliefs, management viewpoints it is difficult to quantify support for development of greenspace as such citizen science can help to bridge these gaps
- Nowadays citizens have the real possibility to induce policy in one or another sense.
- Citizens are the main actors who should understand their role in the Resources Management

- Education of the public is the answer. People watch Attenborough films and say " ooh that's terrible" and then get in their gas guzzling Range Rovers, crank up their A/C and leave all their outside lights on. People point the finger at the big corporations and do nothing expecting the other masses to change their behaviours. We must educate every individual to create the masses at a consumer level not a producer level of environmentally harmful products and practices.
- ownership of the NBS
- I believe that policies that support NBS should first be implemented by government and partly funded by private owners/developers. Any additional help from citizens is helpful but not critical.
- civilians can put a pressure on decision makers to implement either NBS or grey solutions, if they chose the latter any centralized action fails e.g. due to conflicts or vandalism
- Citizen can contribute to implement an NBS and also them should be responsible, in the future, with the management of that specific NBS
- CS offers wider benefits, its not just about the data. Although CS can collect meaningful and visual data which can really fuel the NBS planning, design, implementation and maintenance process.
- Citizen have to endorse those strategies in order to make it possible to implement and change related policies (such as the CAP). Schools must be among the first targets
- The know the local circumstances, their inputs improve quality, awareness raising an public participation, cost effective,
- A way to enhance knowledge and engagement.
- Citizen involvement guarantee the sustainability of the NBS
- If aids understanding and engagement
- People should be aware of the pros and cons of a particular NBS
- It will help, but it is not a barrier nor a prerequisite

Q28. Are you involved in any NBS projects? If you are not involved in any projects incorporating NBS please proceed to Q31.

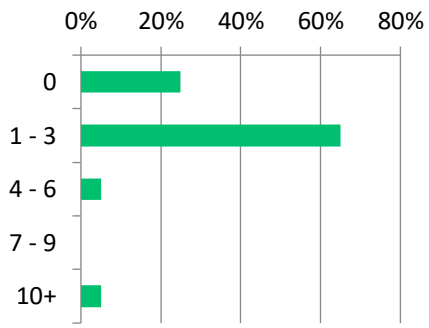
Answered: 26 Skipped: 18

Answer Choices	*Responses*	
Yes	20	77%
No	6	23%

Q29. If you answered Yes to Q28, how many of these NBS projects incorporate citizen science?

Answered: 20 Skipped: 24

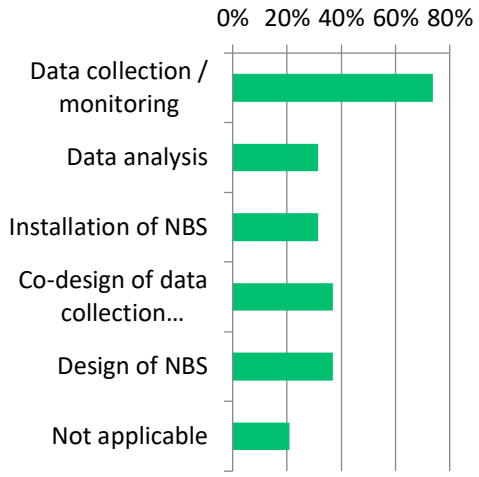
Answer Choices	*Responses*	
0	5	25%
1 - 3	13	65%
4 - 6	1	5%
7 - 9	0	0%
10+	1	5%



Q30. What types of citizen science activities occur in these projects? (You can select multiple answers).

Answered: 19 Skipped: 25

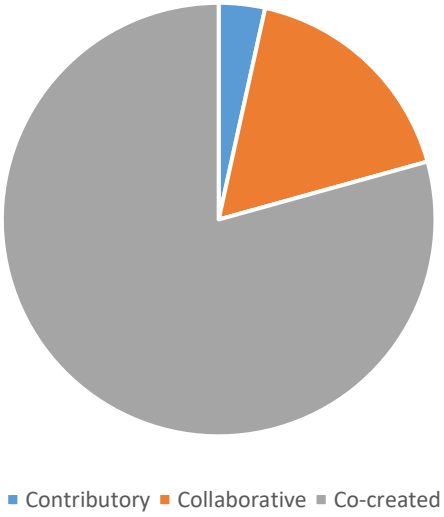
Answer Choices	*Responses*	
Data collection / monitoring	14	74%
Data analysis	6	32%
Installation of NBS	6	32%
Co-design of data collection methods	7	37%
Design of NBS	7	37%
Not applicable	4	21%



Q31. In your opinion, at which of these stages should citizens be involved in NBS projects?

Answered: 29 Skipped: 15

Answer Choices	*Responses*	
***Contributory**: citizens are only involved in data collection. The project design, aims and objectives and activities are decided by scientists/project coordinators.*	1	3%
***Collaborative:** citizens contribute data and may help in project design, but the aims and objectives and activities are decided upon by scientists/project coordinators.*	5	17%
***Co-created:** citizens are actively engaged in all stages of a NBS project, working alongside scientists/project coordinators to identify the aims and objectives and agree upon activities, in addition to being involved in data collection.*	23	79%



Q32. Do you have any other comments related to NBS citizen science, policy and practice?

Answered: 7 Skipped: 37

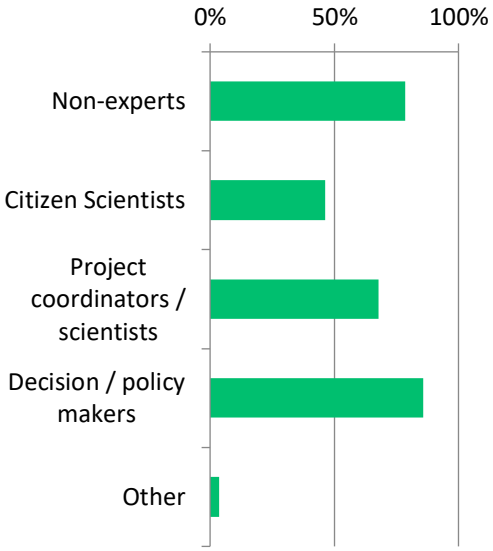
Responses:

- Difficult issue, needs to be raised from academic level (thus avoid social scientist speaking academic)
- I think there is still a blindspot in much NBS research - plants are often overlooked and we lack granularity and naunce in NBS design
- There should be national media advertising especially social media and TV highlighting how bad UK water quality is and what the main contributors are both domestically and industrially and then there should be clear guidance on true green products that will help reduce the chemical contamination of our natural water supplies. This has never been more important than today where we are undertaking needless mass broad spectrum disinfection killing vast amounts of natural bacteria critical for the survival of any health eco system. Triclosan a comment component of anti bacterial gels is already appearing in breast milk - it is carcinogenic. Our needless overuse of these products driven by the chemical manufacturers mass media campaigns driving us all into a sterilization frenzy may lead to the environmental equivalent of DDT in the next 5-10 years
- Barriers to CS in the NBS process - funding pots don't always allow CS to be integrated into the process. Project staff do not always have the skills to implement the full CS process.
- Coordinated data storage for different citizen science data with statutory and industry and academic data needed
- Citizen Science is not a barrier to NbS - any more than it is a barrier to Traditional structural solutions BOTH should engage with stakeholders. It is wrong to think NbS is in any way 'special' in this respect.

Q33. In your opinion, who should the NBS briefs be aimed at? (You can select multiple answers).

Answered: 28 Skipped: 16

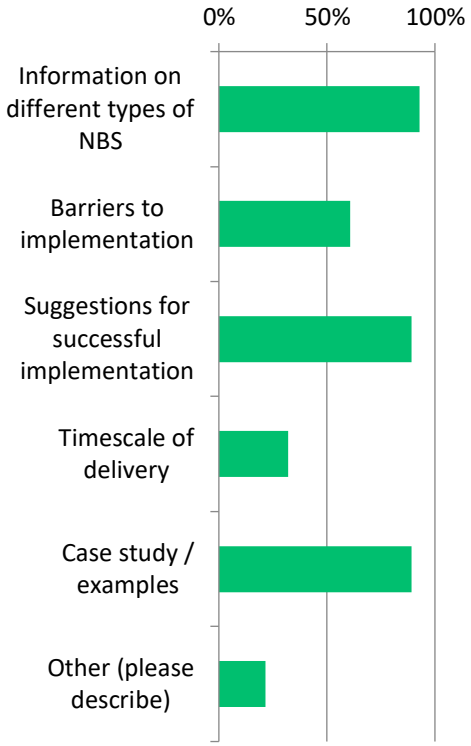
Answer Choices		*Responses*
Non-experts	22	79%
Citizen Scientists	13	46%
Project coordinators / scientists	19	68%
Decision / policy makers	24	86%
Other	1	4%



Q34. What would you like to see in an NBS brief? (You can select multiple answers).

Answered: 28 Skipped: 16

Answer Choices	*Responses*	
Information on different types of NBS	26	93%
Barriers to implementation	17	61%
Suggestions for successful implementation	25	89%
Timescale of delivery	9	32%
Case study / examples	25	89%
Other (please describe)	6	21%



Other topics provided by respondents:

- Efficiency, pros and cos compared with other alternatives, costs
- Information on how the public can become involved and support on Micro and Macro scales
- examples of failures with clear identification of causes
- Comparison to grey infrastructure
- How to monitor; multiple benefits
- Benefits

Q35. Would you be interested in receiving the NBS briefs?

Answered: 27 Skipped: 17

Answer Choices	*Responses*	
No	3	11%
Yes	24	89%

Q36. Would you be interested in attending a webinar on NBS science, policy and practice?

Answered: 27 Skipped: 17

Answer Choices	*Responses*	
No	3	11%
Yes	24	89%

Q37. Are you interested in in learning more about MICS?

Answered: 23 Skipped: 21

Answer Choices	*Responses*	
No	9	39%
Yes	14	61%

Annex 3: Images of Regional NBS Policy Briefs

MICS
Measuring Impact of Citizen Science

Living Nature: Adopting Nature-Based Solutions for Safeguarding Freshwater in Western Europe

What are nature-based solutions?

Nature-based solutions (NBS) are defined by the IUCN as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simulta-neously providing human well-being and biodiversity benefits*".

- NBS are increasingly seen as a **crucial part of the green recovery programme** because they can address the climate, biodiversity, economic inequality and human health crises in a more integrated and therefore cost-effective way;
- **Water is a key strategic resource in Europe**; by managing our land and water differently, using NBS we can better address all of these challenges;
- European countries have made progress towards addressing the loss of aquatic biodiversity, poor water quality and water security, but more work is needed;
- NBS can help us tackle these issues and achieve more sustainable and cost-effective management of freshwater environments;
- NBS are based on inclusive, trans-parent and empowering govern-ance processes involving local citizens in design, reflecting their needs and aspirations leading to long-term ownership and care for the environment.

Case Study - NBS for Improving Water Quality

Anglers' Riverfly Monitoring Initiative (ARMI), UK

Citizen-science plays a vital role in supporting the planning and monitoring of NBS initiatives. In the UK, the Riverfly Partnership aims to protect river water quality and ecology by engaging with local citizens and interest groups such as anglers, providing them with tools and training to monitor indicator species. ARMI has been successfully applied nationally through the commitment of 180 organisations and 3,000 active individuals.

Key highlights are:

- Cost-effective collection of long-term data sets;
- Better alignment between the monitoring efforts of citizens and regulatory bodies;
- Increased detection and reporting of pollution events;
- Increased feeling of stewardship amongst citizens;
- Inspired scientific interest in a new audience.

The initiative has also developed the participants' skills in co-ordinating the planning, initiation and implementation of their own restoration schemes.

Role of decision makers

More work is required to mainstream NBS and policy actors at different levels have a role to play. This includes:

77% of NBS practioners do not believe NBS are adequately supported in policy

- Increasing ambition, setting targets and deadlines;
- Identifying water related issues and the NBS that can address them;
- Encourage large-scale projects to tackle multi-ple issues through incentives.

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Why we should use nature-based solutions

Practitioners perceive commitment to **long term funding** as an important enabler of NBS uptake

NBS can help address some of the most urgent water-related challenges:

- **Surface water quality**: Urban rain gardens, wetlands and connected floodplains intercept run-off before it enters the river, reducing nutrient and sediment loads. These solutions can be much cheaper than conventional water treatment.
- **Natural flood management**: Restored meanders, reconnected floodplains and woody material can slow, store and reduce peak flows, preventing downstream flood risk and damage.
- **Water availability**: River and floodplain restoration promote water retention in soils and encourage groundwater recharge, supporting summer flows in rivers and reducing the severity of drought.
- **Habitat restoration and biodiversity**: All NBS provide more space for wildlife by creating, restoring or maintaining existing habitats, reconnecting people with nature.
- NBS are cross cutting, often providing benefits across multiple challenges, including storing carbon and improving landscape aesthetics and recreational amenity.

Policy is too slow adapting to new approaches

Nature-based solutions for people

Local communities can and should be involved in all stages of designing and implementing NBS from early consultation to collaborative and co-design work and implementation, because this will:

- Increase their knowledge, awareness and involvement;
- Engage with a diverse range of people & interests; provide local employment;
- Empower local citizens and involve them in the democratic process;
- Encourage more diverse partnerships, increased ambition and funding possibilities;
- Encourage ownership and early reporting of problems.

Citizen-science work can help encourage active involvement. From our survey, **79%** of practitioners said that the benefits of co-creating citizen science projects include:

- Shared ownership with the community;
- Regular long-term monitoring and inspection;
- Stronger local voice and champions;
- Reconnects people with nature, improving their health and well-being.

Key recommendations

1. Integrate NBS within existing policies so that they become mainstream;
2. Restore ecosystem functionality and to achieve climate resilience;
3. Co-design and implement NBS with local communities;
4. Ensure NBS are informed by science and use available evidence of effectiveness.

Project information

Project Coordinator: Earthwatch **Website:** mics.tools **Scientific Coordinator:** Luigi Ceccaroni lceccaroni@earthwatch.org.uk **Contact Person:** Katrin Nolland knolland@earthwatch.org.uk

DURATION: 1 JANUARY 2019 - 31 DECEMBER 2021 | TOTAL COST: 1,944,428.00 € (100% EUROPEAN-COMMISSION FUNDING)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824711.

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Living Nature: Adopting Nature-Based Solutions for Safeguarding Freshwater in Southern Europe

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- **Water is a key strategic resource in Europe**; by managing our land and water differently, using NBS we can better address all of these challenges;
- European countries have made progress towards addressing the loss of aquatic biodiversity, poor water quality and water security, but more work is needed;
- NBS can help us tackle these issues and achieve more sustainable and cost-effective management of freshwater environments;
- NBS are based on inclusive, trans-parent and empowering govern-ance processes involving local citizens in design, reflecting their needs and aspirations leading to long-term ownership and care for the environment.

Case Study - NBS for Wetland Restoration

Marzenego River Basin, Veneto Region, Italy

Urban and farming activities have resulted in increased flood risk, poor water quality and low biodiversity in the rivers entering the Venice Lagoon.

Wetland restoration is being used to tackle these problems. Two wetlands on former quarry sites were enlarged, reed beds and trees were planted, channels dug to connect the wetlands to the main river and paths were constructed.

The benefits include:

- Reduced risk of flooding;
- Water purification and pollutant and nutrient retention;
- Increased public access;
- Hotspot of biodiversity in the region;
- Engagement in design and continuing involvement.

The local community is engaged in citizen science monitoring activities to document the ongoing success of the project.

Role of decision makers

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77% of NBS practioners do not believe NBS are adequately supported in policy

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Why we should use nature-based solutions

Evidence and incentives to convince private landowners of NBS benefits

NBS can help address some of the most urgent water-related challenges:

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Lack of long-term funding commitment

Nature-based solutions for people

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Case Study - NBS for Urban Regeneration and Flood Management

Rákos Creek, Budapest, Hungary

The heavily modified urban rivers in Budapest suffer from pollution, loss of biodiversity and lack of space for recreation.

Changing attitudes to the environment have led to the desire to create a 'green corridor' along Rákos Creek by improving connectivity with its wetlands and groundwater, by increasing water retention in the urban areas, and constructing a cycle way.

The benefits include:

- Reduced flood risk;
- Rejuvenation of the urban landscape, providing recreation space;
- Improved water quality.

Local involvement through citizen science activities has increased support and awareness for the project; reconnecting people with their environment and providing cost-effective collection of information about the condition of the Creek.

Role of decision makers

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More resources are required for NBS implementation and operation

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