

TITLE PAGE**Examining the policy needs for implementing nature-based solutions in cities: Findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland)**

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Abstract

To advance the science and practice of implementing nature-based solutions in cities, it is important to examine the obstacles and provide means to overcome them. This paper presents a conceptual framework of *policy needs* for analysing the science of nature-based solutions' implementation and connect it to the practice of their implementation that advances the literature by connecting well-researched gaps to a more innovative action-oriented policy development approach that we argue is required for embedding scaled-up nature-based solutions. We conceptualise and ground the policy needs framework of skills, knowledge and partnerships theoretically in current literature of NBS policy and planning and empirically in three European case study cities: Genk in Belgium, Glasgow in UK and Poznan in Poland. The cross-case study analysis points to the knowledge needs of systems' thinking and solutions-oriented thinking as paramount for implementing nature-based solutions. Our analysis further points to the skills' needs of negotiation and collaboration for administrative silo bridging and for forging multi-sectoral partnerships essential for planning, and co-managing NBS. We conclude with three ways forward to addressing the policy needs for implementation: first, cities can invest in tailored and targeted capacity building programs, second, institutional spaces need to be established that allow for collaborative learning through and for partnerships and third, cities need to chart governance innovations that promote evidence-based policy for nature-based solutions' design and implementation.

Keywords: nature-based solutions; cities; climate change; knowledge; partnerships; collaboration; planning

1. Introduction

Nature-based solutions have emerged as both a challenge and an opportunity to assist urban communities in the transition to greater sustainability and adaptation to climate change. NBS are living solutions inspired and supported by nature that simultaneously provide environmental, social and economic benefits and help to build resilience (European Commission 2015). These solutions bring more nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (Faivre et al. 2017). As systemic solutions, nature-based solutions (NBS) provide multiple benefits such as ecological, economic, social and business (Laforteza et al. 2018), and are advocated and evinced to be the next-generation solutions for cities to deal with climate and social pressures (Frantzeskaki et al 2019).

In practice, NBS represent a complex problem for many urban planners, with barriers still standing in the way of the scale-up and roll-out necessary for city-wide benefits (Connop et al. 2016; Kabisch et al 2016; Krauze and Wagner, 2019). As such, scaling-up NBS requires knowledge and expertise from many different disciplines for being designed, planned, implemented and maintained spanning discipline-specific knowledge from ecology to engineering (Frantzeskaki 2019). To progress the science and practice of implementation of NBS in cities, it is important to understand what hinders their implementation and examine critically the requirements for overcoming these difficulties. Recent literature has pointed to a number of implementation gaps that refer to the substantial gap between what is stated in an urban plan or program and the realisation of NBS on the ground. We differentiate between knowledge gaps, skills gaps and governance gaps for implementing NBS in cities.

First, there are knowledge gaps on the effectiveness of NBS and their simultaneous delivery of multiple benefits (Albert et al 2019; Santoro et al 2019) that is the result of the dispersed knowledge of NBS, linked to the dearth of long-term monitoring and evaluation of outcomes, and the lack of knowledge systematization (Albert et al 2019; Fernandes and Guiomar, 2018; Raymond et al 2017). The knowledge gaps concern not only the design, the operation of NBS but also their delivery of economic benefits (Blau et al 2018) and their potential to generate green businesses and green jobs specifically.

Second, there is a gap about the affinity and skillsets of urban planners and infrastructure professionals in cities in understanding, designing and adapting NBS to their local conditions (Blau et al 2018; Davies and Laforteza, 2019). This knowledge gap applies to tactical planning actions and processes, pointing to the expertise and experience as well as the openness of planners and engineers in cities to learn, and to the knowledge required to trust NBS similarly to grey infrastructure (Fernandes and Guiomar, 2018).

Third, there is a governance gap about collaboration between different urban actors required for the design and implementation of NBS as multifaceted solutions with the potential to deliver across multiple planning and community agendas (Davies and Laforteza, 2019). This gap is recognised also in any type of cross-sectoral solution or approach (Weitz et al 2017) and in interconnected sustainability issues (Bergsten et al 2019, p.30 as 'collaborative misfit').

We contend that these implementation gaps are recognisable in and relevant for urban planning of NBS in European cities but remain rather abstract and difficult to operationalise, or connect to actions for advancing the implementation of NBS in cities. Thus, these well-documented discourses that focus on gaps and barriers remain within the realm of organisational silos and policy disintegrations. Notwithstanding these discourses, a growing number of city-makers are looking to

transform and progress urban agendas, including the scaling-up of NBS, that transcend persistent barriers and shift the discourse towards a policy and action-focused framework. We see this as a gap in the literature to develop an analytical framework to explore this more transformational approach. We therefore propose the use of the conceptual construct of '**NBS policy needs**' to operationalise and connect these gaps to proposed actions and governance processes to progress the science and practice of implementing NBS in cities. By using the concept of policy needs, we plan to systematically investigate what are the requirements for every phase of the NBS planning cycle as mapped by Raymond et al (2017). Responding to the need of a planning cycle that acknowledges and maps complexity of governance processes, Raymond et al. (2017) propose a seven-stage policy process for implementing NBS, considering the multiplicity of stakeholders and the possible feedback loops. The stages are: 1) identify problem or opportunity; 2) select NBS and related actions; 3) design NBS implementation processes; 4) implement NBS; 5) frequently engage stakeholders and communicate co-benefits; 6) transfer and upscale NBS, and the transversal stage of 7) monitor and evaluate co-benefits.

We apply and test this Raymond et al (2017) policy cycle approach as an analytical framework to explore our conceptual construct of NBS policy needs in relation to empirical data collected from our three case study cities, but we do so through the more nuanced conceptual lens of the three types of policy needs of knowledge, skills, and partnerships. In this way, we examine the specific needs for cities to accelerate the uptake and implementation of NBS. Thus, we not only advance the conceptualization of NBS policy needs in urban planning and environmental management literatures but also provide useful insights for urban planners in terms of directions to update and advance their practice for better planning of and with NBS. To do this, the paper explores our conceptual framing of policy needs in the following section. We then outline our methodology (expanded through the supplementary material), followed by data analysis from our three cities. We then discuss the data through our conceptual framework and reflect on limitations and suggestions for further research.

1.1 Policy needs for nature-based solutions in cities

In policy and planning literature, the focus on how to achieve identified (policy) objectives and (policy) goals has been in formulating strategies and mobilising capitals to support the implementation of these strategies (Dunn 2012). We argue that a (policy) objective or goal in order to be achieved requires a governance process to see the mobilization and/or sourcing of capitals and the implementation of solutions. The concept of 'policy need' will help us identifying and examining these complementary governance processes. We conceptualise a policy need as the combination of governance processes and conditions that are required to bridge the gap between a strategy or solution, a policy problem or opportunity (the current situation) and a policy objective (the desired situation).

First, our conceptualization of policy needs extends from the need assessment literature. 'Need' is identified as a gap between current and desired results at the strategic (goals, objectives, strategic policies), tactical (procedures) and operational level (decisions and tasks) (Watkins et al 2012). A more appreciative perspective sees a needs perspective as a process of engaging people and empowering them to reach the desired situation (Watkins et al 1998, 2012); while a more accounting perspective points to the possibility of prioritizing and ranking needs based on the expected costs to meet or ignore them (Kaufman and Guerra-Lopez, 2013).

Second, our conceptualization is informed from the needs' approach proposed from sustainability science researchers by considering the collective processes and conditions. Jolibert et al (2014) argue that a (human) needs based approach to policy making is relevant, because it helps to understand

and deal with the (conflicting) values and practices of planning processes (on both short and long-term) through creating “more dynamic interaction of stakeholders for social change” (p.30).

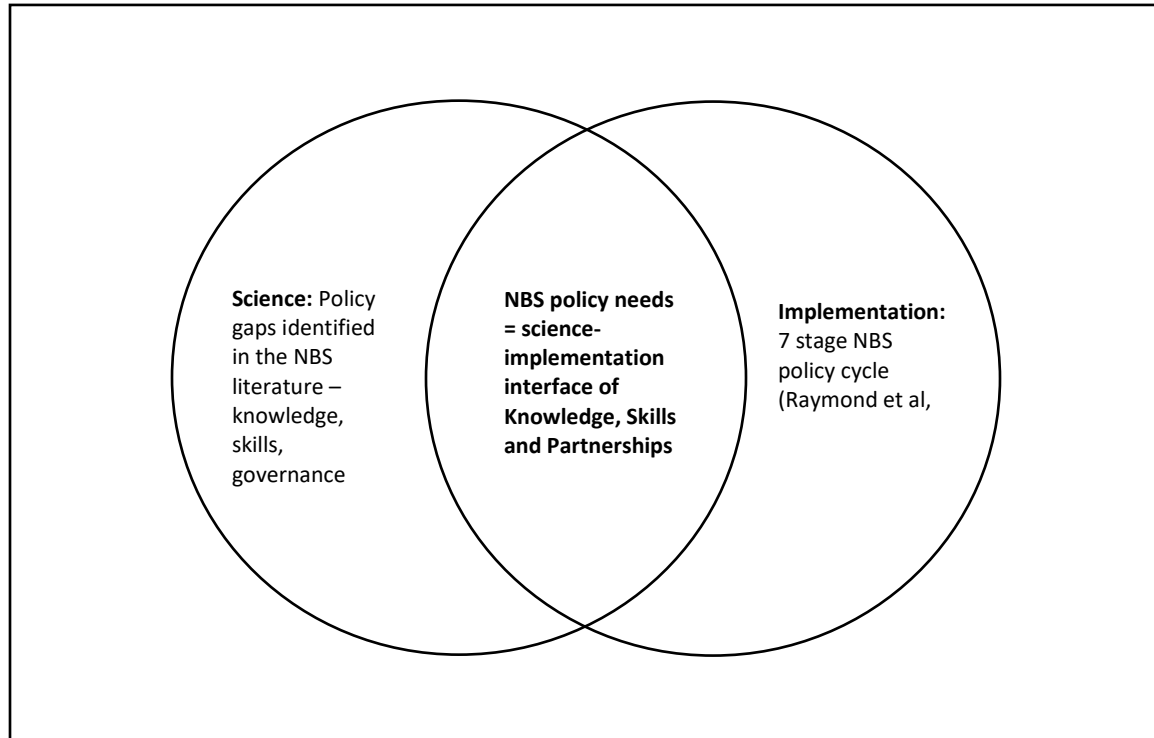
Third, our conceptualization agrees with assemblage thinking in the way of looking beyond policies and into programs, processes and (political) conditions to identify policy needs for achieving strategic objectives (Anderson and McFarlane, 2011; Andersson et al 2012; McFarlane 2011). Our conceptual proposition suggests three types of policy needs as interrelated processes and conditions for successful implementation of NBS in cities: knowledge, skills, and partnerships.

Knowledge needs are often addressed as amongst the fundamental requirements for the planning and implementation of NBS. Urban planning has recently shifted into evidence-based approaches that require different forms of knowledge for the design and implementation of systemic solutions in cities. NBS as systemic innovative solutions that have the potential to deliver on multiple urban agendas require substantive knowledge for their successful implementation. This might be challenging since there is uncertainty in the direct and indirect impacts of NBS implementation (Nesshöver et al. 2017). Recent research on NBS also points to this dimension with Albert et al (2019) suggesting different forms of knowledge. Frantzeskaki and Kabisch (2016) and Frantzeskaki (2019) point to the need for including knowledge from different urban actors as essential for institutional embedding of NBS. An example of knowledge need has been highlighted by recent research by Russo et al 2017 (p.62) who argue on the need for “proper planning guidelines that indicate, when designating an area as suitable for edible green infrastructure, that knowledge of past site history, existing soil properties and distance from possible nearby sources of pollution, especially traffic, should be taken into account in order to prevent crop contamination.” Hence knowledge needs are important to understand in order to equip urban planners to implement NBS.

Acquiring knowledge about NBS and their implementation requires not only receptivity in planning practice but also skilled officers in identifying the appropriate knowledge from the diffuse sources available, embedding it effectively in relation to local context and local needs (Connop et al 2016; Pedersen Zari 2015), and relating it to existing knowledge systems in their practice. Hence, the second type of policy need we identify is the **required skills** for planning NBS. For example, for implementing innovative solutions, skills in leadership also play an important role (Carmeli et al 2006). Critical to this are problem-solving skills and an ability to see the “big picture”. Due to the need for collaboration with different actors, managerial and cooperation skills are also required (O’Leary et al 2012; Zeemering 2008). Additionally, knowledge and skills in organising and realising monitoring and evaluation of NBS due to their multifunctionality are required to assure a fully operational NBS for climate adaptation and resilience in cities.

Introducing systemic NBS often require multiple actors to ensure effective design, implementation, management and maintenance. To coordinate and orchestrate the multitude of urban actors and their involvement, collaborative efforts can take the shape of temporal or longstanding partnerships. **Partnerships** are vital for mobilising and providing resources such as finances, knowledge, institutional backing and social acceptance (Frantzeskaki et al 2014). Collaborations with local stakeholder groups and “close collaboration between scientists and practitioners to establish concepts and share knowledge” are also important for mainstreaming NBS in cities (Wamsler et al 2014, p.193 & 198). Albert et al 2018 (p.17) add to this by pointing out that in the best practice examples of implementing NBS, co-creation and co-implementation of funding, business and governance of NBS has been a collaborative endeavour. Lopez-Rodriguez et al (2017) further argue that through partnerships, scientific knowledge becomes embedded and is introduced in a more effective way in science-policy interfaces for conservation of nature in cities. Figure 1 below summarises our emergent conceptual framework of NBS policy needs.

Figure 1: NBS policy needs conceptual framework for interface between science and implementation.



This paper presents a conceptual framework for not only analysing the science of NBS implementation but also the practice of implementation. It adopts and extends a policy needs approach that we argue helps identify and examine governance processes and conditions that are required to bridge the gap between a strategy or solution, a policy problem (the current situation) and a policy objective (the desired situation). This analytical framework is explored in the rest of this section. Section 2 presents the methodology for collecting our empirical data, outlining our three case study cities. In section 3 we analyse the data from each city using our conceptual framework. Section 4 discusses our findings in the light of the most recent literature and reflects on the conceptual framework and emerging limitations. We conclude in section 5 with a discussion of the research and propose next steps and recommendations.

2. Research methodology

This paper contributes to the emerging NBS policy and governance literature by exploring, and proposing adaptations to, the conceptual frameworks within which NBS policy needs and NBS planning cycles are being developed, as outlined in section 1. We do this through empirical data analysis from three case study cities in Europe. Empirical testing of a conceptual framework is a

critical step in advancing understanding, and, by analyzing empirical data from our three case study cities, this paper presents a substantive contribution to the nascent conceptual literature. We adopt a case study approach because of its strengths in relation to understanding real world contexts. The usefulness of case studies has been noted in relation to new approaches to urban planning (Sevenant and Antrop 2010), and the context-dependent knowledge generated through case study research is argued to be a key contribution to advancing understanding of processes and actors that more generalised research often misses (Flyvbjerg 2006).

The paper addresses the following research question: What are the policy needs for implementing NBS in cities? To explore this, we employ case study research in three European cities with demonstrated experience in NBS that are working on plans for upscaled NBS to deal with climate change challenges: Genk (Belgium), Glasgow (Scotland) and Poznań (Poland). These city authorities are the focus of our research because they are Front Runner City partners in a Horizon 2020 innovation project, Connecting Nature. The ambition of this project being to support the transition of cities from innovating and implementing NBS at a demonstration scale, to widespread roll-out. All three cities have experience in implementing NBS in localised projects, primarily led by the city authorities.

For each case study, we use a replicated suite of methodologies to collate data. Data were gathered through the following techniques: Firstly, semi-structured interviews in each city, primarily with representatives across departments in the city administration, with the aim to explicitly explore the individual experiences and understanding of NBS and the policy and administrative context within which NBS are developed (Glasgow n=13, Genk n=12, Poznan n=10 between September 2017 and December 2017). Interviewees were deliberately selected by city teams based on the following three criteria: their knowledge and experience of implementing existing NBS, and / or their potential role in delivering scaled up NBS in each city; they represent a cross-section of departments and delivery institutions. Secondly, we undertook site visits to existing NBS locations in each city with local experts explaining their development (in total site observations comprised 6 hours in Glasgow, 7 hours in Genk and 5 hours in Poznan). The sites were selected by city teams based on the selection criteria of showcasing interesting and varied aspects and scales of NBS in each city. Thirdly, a series of workshops with city authority employees (and some external delivery partners) to provide feedback on and validate synthesized interviews' findings. The invitees to these workshops were selected by each city team based on their capacity to influence and/or implement scaled up NBS. This included the interviewees and other key actors the city teams wanted to share knowledge with about their NBS exemplar. Every workshop lasted 3 hours and included a facilitated discussion (by an external partner) on the synthesised interviews' findings. These occurred in November 2017 in Glasgow, in October 2017 in Genk and in January 2018 in Poznan. These workshops further resulted in exploring policy needs, introducing governance and partnership reflections. Fourthly, interactive and facilitated exercises for city teams to explore linkages between city policies and NBS frameworks using the Raymond et al 2017 framework with city officers from different departments that were held in January 2018 in Genk (n=17 participants for 2 hours with two facilitators), in March 2018 in Glasgow (n=10 participants for 2 hours with two facilitators), and in April 2018 in Poznan (n=11 participants for 2 hours with two facilitators). The design of the workshops was co-created and tested with two city officers from the Genk city team in a separate workshop.

The data collected were transcribed verbatim. The data were analysed using formal narrative methods to identify policy needs across knowledge, skills and partnerships as well as allowing for additional 'categories' (codes) to emerge from the data. This analysis draws on the work of Saldana (2009), using a data journal method to analyse results manually. Bryman (2012, p.584) asserts

"narrative analysis can be applied to data that have been created through a variety of research methods (...) but it has also become a focus for an interviewing approach in its own right". In our research we used narrative analysis to all collected data from the semi-structured interviews to the focus groups and workshops. Given the confidentiality agreements with all interviewees and participants of the workshops, authors cannot share transcriptions. The analysis of the results is presented in Section 3 of the paper.

We include a Supplementary Material where the following operational material can be found: (a) The Interview Protocol of the semi-structured interviews we conducted in the cities, (b) the lists of interviewees from every city, and, (c) the operational agenda of the workshops that shows the way they were executed. We included the operational agenda of the Glasgow workshop as indicative, since the same format was replicated in the other two cities.

Our three cities are Genk in Belgium (population around 65,000), Glasgow in Scotland (UK) (population around 590,000) and Poznań in Poland (population around 540,000). For this paper, the unit of analysis is the city municipal authority in each city, comprising the executive and political functions. The following sections outline each city's NBS context and exemplar strategy.

3. Results: Policy needs for planning and implementing NBS in cities

In this section, we present the results of our analysis of data gathered from the interviews, workshops and site visits outlined in section 2. We analyse each of the case study city's perceived policy needs (that is, as elicited from the city participants), framed by our conceptual lens of the NBS policy cycle identified by Raymond et al (2017), cross cut by our proposed themes of *knowledge, skills and partnerships* outlined in section 1. Thus, we test this proposed conceptual framework through the empirical data gathered in each city, analysing respondents' experiences with the on-going implementation of the specific scaled-up NBS exemplar outlined in section 3.1.

3.1. Genk city's policy needs for realizing the Stiemer valley NBS exemplar

Genk (population 65,000) is situated in the province of Limburg, Flanders region of Belgium. Genk grew as a city due to its coal mining industry established in the early 20th Century, and its population grew exponentially, drawing workers from across Europe. With the demise of traditional industries, the Genk municipality is actively engaged in identifying and developing its vision, identity and functions fit for the 21st Century. As part of the city vision for the future, Genk works intensively on the NBS exemplar that is a linear multifunctional park in the Stiemerbeek Valley, running for 8km through the city. The Stiemer river is a neglected blue artery, suffering from poor water quality due to combined sewage infrastructure overflow. The Municipality of Genk with identifying the Stiemer Valley as its nature-based solution exemplar has as strategic objectives to transform into a strategic green-blue link, facilitating connections between sites, urban neighbourhoods and reconnecting people with nature through the length of the city. Within these overarching strategic objectives for the exemplar, a suite of projects have been identified as foci for implementation, ranging from redevelopment of a former mill as an arts & information centre and 'gateway' to the Stiemer, to engaging with private landholders to develop rain gardens and other sustainable urban drainage system features to attenuate runoff across the Stiemer catchment (The City of Genk; VLM; Team Vlaams Bouwmeester, 2015).

In Genk, the research participants identified the following policy needs and challenges with regard to the policy cycle. In terms of identifying the NBS challenge or opportunity, respondents indicated a lack of *knowledge* on the potential strategic and economic benefits of NBS, and a lack of

entrepreneurial attitudes within *partnerships*. Some respondents trying to implement NBS felt that effective NBS governance is hindered by power dynamics, due to a lack of synergy between silos within the municipality, which exacerbate apparent trust issues between some departments. This relates to the need for partnerships internal to the local government structure for identifying NBS challenges and opportunities in early planning stages. Additional challenges raised by interviewees include the uncertainty caused by short-term political cycles (and elections) and how to effect change on privately owned land. In this context, *skills* on how to organise project work and navigate political complexity and uncertainty are also identified as important in this stage of NBS planning.

With regards to the selection of NBS type and related actions, *knowledge needs* identified by interviewees first relate to identifying ways of developing business opportunities through NBS actions. Second, knowledge needs associated with technical knowledge to adequately evaluate the risks and threats of the Stiemer exemplar and how to deal with fear of flooding and poor water quality in innovative NBS ways. Identified skills needs are related to technical expertise on NBS-based sustainable drainage systems and the absence of baseline data and skills for targeted multiple benefits. In terms of *partnerships*, sharing responsibility between local authority and community is a relatively new challenge and need for the city. For building partnerships, there is a need for developing collaborative skills, as demonstrated in the recent success story of a civic-public partnership in the Heempark (Gorissen et al 2018).

Designing implementation processes are a *knowledge* challenge for Genk because of the lack of culture in how to govern in a collaborative way for the implementation and maintenance of NBS, including understanding viable NBS business models. A consequent challenge and need is to develop skills on how to *collaborate* with social innovation initiatives given that they have capacities and creativity in connecting urban actors in the city (Frantzeskaki et al 2017). A further challenge is around designing for multiple functions, so that the end result is more than a spatial transformation.

Implementation itself is likely to prove challenging due to the need in establishing lasting *partnerships* with urban actors and the local government. The current practice in the city of Genk is that the majority of infrastructure projects, including small-scale NBS ones, are being municipality-led and city-dependent where collaborative governance models fail to develop and mature. This hinders the effective creation of public-private partnerships to deliver NBS, despite our interviewees indicating a recognition that broader partnerships are required. Looking to the future, replicating, mainstreaming and scaling up NBS may be compromised by a lack of demonstrated impact on communities of previous flagship projects and the fact that scaling up at city level would require changes of governance of water infrastructure at the provincial or regional level.

The city of Genk identified that knowledge needs on specific frameworks and on indicators for monitoring and evaluating the implementation of NBS are required whereas organisational skills for the monitoring and evaluation process are adequate currently.

3.2. Glasgow city's policy needs for realizing nature-based solutions as Open Space Strategy

Glasgow is the largest city in Scotland (UK) (population 590,000). As a result of post-industrial decline and previous housing policies, Glasgow has a large amount of vacant and derelict land within the city boundaries and neighbourhoods with significant levels of deprivation (Glasgow City, 2015). Glasgow has successful examples of NBS and there is a new strategic focus (in the Glasgow City Region) on surface water management through integrating sustainable drainage systems into new developments. Glasgow's approach to developing a scaled up NBS exemplar is underpinned by its strategic Open Space Strategy (OSS), and accompanying Local Context Analyses. The OSS is a cross-

cutting strategic document, intended to offer a coherent vision and co-ordinate the various open space responsibilities to ensure well-managed, well-located and well-connected open spaces that operate as part of a wider green network and deliver multifunctional benefits. So the NBS exemplar in Glasgow is a city-wide network of multifunctional green spaces and sustainable urban drainage system pilots that deliver multiple benefits for climate protection and reconnection to nature. The 15 Local Context Analyses are how these strategic goals will be translated into operational projects within 15 areas of the city, with the aim that local communities will be embedded in developing the projects at this scale. Glasgow's OSS is based on a wealth of data and spatial analysis.

In Glasgow, *knowledge* needs that have been identified through our research related to the challenge or opportunity for NBS, with interviewees pointing to the fragmented nature of knowledge across different departments and related different methods of assessment, and on the erosion of green urban space in the city. In terms of knowledge in the broader city context, there is a historic lack of community experience in socio-innovation. This has highlighted the need to find new ways to form and sustain *partnerships* with communities, especially in flood prone areas. For effective partnerships to develop, interviewees responsible for SuDs design have experienced a challenge that communities do not necessarily understand the benefits of NBS, which has proved counterproductive in aspirations to partner with communities for co-designing NBS to ensure that they deliver social and ecological benefits.

Selecting the NBS type, and associated actions, is hampered by *knowledge* needs in terms of the different approaches and selection processes for NBS. Green/blue space is often seen as a waste of space. Associated *skills* challenges have been identified as a lack of competencies or capacities of the city council to identify key community relationships and build bridges, a lack of easily accessible data enabling assessment of the specific needs of a place to feed into the planning process and a strong focus on traditional SuDS rather than multifunctional SuDS components. There is a lack of capacity in relation to innovation and entrepreneurship around NBS, so the focus on engineering solutions has led to missed opportunities for biodiversity, open space and health. This latter point links to the *partnership* challenge of silo working, and conflict where costs of NBS are borne by one city budget whilst benefits accrue more broadly, for example between green space and health.

On designing NBS implementation processes, analysis of the interviews from Glasgow indicates the following *knowledge* needs for the city council: understanding the informal organization flows during the implementation of NBS, and who does what and when, so that the design of the implementation process can be optimized. There is also a knowledge need in terms of understanding and assessing options identified locally by residents and small-scale organisations, in order to decide who can deliver local scale NBS and balance that with public accessibility to a location. A key *skills* need that impacts effective design and implementation is the need for skills to foster collaboration across silos and a need for contextual analytical skills relevant to urban planning as they interrogate their local context documents to identify appropriate NBS interventions.

On implementing NBS, a range of *knowledge* needs have been identified by the city team. From a technical perspective, the lack of real-time and long-term monitoring of SuDS is a barrier to understanding, and demonstration of benefits, across the council departments. Related to this, is the absence of data with regards to private land. Communities living around NBS lack knowledge about their functions, leading to a lack of understanding about their value and relevance, and also to a lack of care. With regards to *skills* to implement NBS, the 40-50% council staff reduction over the last five years has caused a significant decline in expertise and resources to maintain NBS. Also, whilst technically innovative approaches to SuDS may be taken, the design and construction of the NBS does not always deliver the vision, compounded by a disconnect between design and implementation

contractors. The strong tradition of top-down care for public space and the environment, means that developing a *partnership* culture is challenging, as the expectation is that the city council will continue to maintain spaces. And where the city council continues to maintain NBS, the compiled and dispersed responsibilities for development and maintenance, co-operation can be challenging.

For the policy phase of communicating co-benefits, Glasgow requires *knowledge* on the ways to better communicate multiple benefits internally across departments and to local communities. The city council needs *skills* in capturing broad values associated with NBS to the community in terms of health, wellbeing, biodiversity, social cohesion and crime. The opportunities for replicating, mainstreaming and scaling up are hindered by the bespoke nature of some NBS schemes that means replication across plots of land is not always considered and there is a need for expertise in scaled-up thinking. The data indicates that there may be constraints related to *partnerships*, in that some vacant land is in private landownership and therefore requires willingness to engage in NBS development, or that the community itself lacks capacity to engage in co-created NBS.

For Glasgow, the size and longstanding culture of the city administration and its historic role *vis-a-vis* residents, communities and other small-scale institutions, suggests that there are structural issues related to partnerships and collaborative governance skills that need to be addressed if NBS are to be scaled-up. This implies new ways of working collaboratively both internally within the city administration and also with external stakeholders – and how to re-contextualize this latter group as partners in NBS development.

3.3. Poznań city's policy needs for complementing the green wedge and ring system with small-scale nature-based solutions

Poznań's (population 540,000) green city planning has a historic basis, with a system of green wedges and rings being designed almost a hundred years ago (de Oliveira, 2017). They are still in evidence today. The city-wide green system is based on the Warta river valley running through the city from the south to the north and its right and left-side tributaries. The supplementing rings are based on the historical location of ramparts and fortifications. A substantial number of allotments are long established. Other, more recent examples of NBS projects have been developed, some with community involvement through the city administration's participatory city budget programme (Bernaciak et al 2017). Despite this positive environment, the system of green wedges and rings is under development pressures and the dense city core lacks green spaces. Therefore, the scaled-up exemplar is an initiative led by the municipality to complement the existing green system by developing a number of small-scale NBS such as green 'stepping stones' within the dense urban core that increase the accessibility of greenspace and enriching the multifunctionality of the green wedges. In this way, the NBS exemplar will help connect inner city greening with the network of green corridors and wedges that run across the city. These are being developed as open gardens in kindergartens and natural playgrounds. Within the green wedges increasing multifunctionality comprises improvement of recreational and cultural potential, through targeted interventions along the Warta river valley, including the development of urban beaches (The City of Poznan; KuiperCompagnons; DHV; SwedeCenter, 2012; Stępniewska, Sobczak, 2017).

Data from our research participants Poznań indicate that, in terms of the fundamental policy cycle phase to identify the challenge or opportunity for NBS, there are significant *knowledge* needs about the potential of NBS to fit in the Polish context. This appears to be the case despite interviewees suggesting that the existing policies are perceived to be orientated towards greenery, given the historic design embedded in the city through the green wedges and rings. Interviewees from the City Hall and stakeholders indicated that this system is still valued today for its multifunctional benefits.

They also highlight that Poznań boasts a substantial number of allotments that are well-used and valued by residents (Borysiak, Mizgajski, 2016; Speak et al 2015).

With regards to *knowledge needs*, the limited awareness of the benefits of NBS and alternative options to grey infrastructure among decision-makers, the private sector and communities has been identified as a significant challenge to developing new urban greening. Due to this fact, interviewees assess that NBS is often overlooked by policy makers in strategic policies. The lack of data and examples on effectiveness and value for money hinder persuading decision-makers to invest in NBS. Interviewees feel that this is compounded by the dispersed knowledge across multiple specialized departments by providing a challenge of co-ordination and prioritization between competing land uses.

When it comes to *skills*, there appears to be a challenge in terms of communication skills and information flows attracting local communities to be active and lead the development of social gardens, with a perception that the existing bounty of allotments means that all those with an interest in, and capacity for, gardening already have their own allotments. This links to the *partnerships-related* needs: identified as the need for improvement in co-operation between actors and stakeholders and the varying levels of social and environmental engagement in different parts of the city. The booming Poznań economy has created pressures on existing green spaces, including the historic green wedges, and high biodiversity value brownfield sites due to the demand for real estate development, and increasing traffic levels (and associated requirements for parking). The strengthening grassroots movements mean that contradicting interests are becoming evident. There is a need to build a common trust and understanding within a collaborative atmosphere between partners. Mitigation of arising spatial conflicts, needs better standards in urban planning that take sustainable development and society needs as a focus of interest.

When we look at the policy cycle phase of selecting and assessing NBS, *knowledge* needs have been identified as being understanding the benefits of specific NBS such as green roofs and walls. This is particularly important when faced with the challenge of finding space in the compact city, particularly the historic centre. *Skills* needs were identified in relation to the procurement process, which interviewees feel over-emphasises cost at the expense of multifunctional benefits. Whilst evidence of Poznań's experience in practising participatory spatial planning is growing (Kaczmarek and Wójcicki 2016; Kotus, 2013), not all of our interviewees were aware of the importance of consulting with the public before undertaking projects that impact local communities. It was also felt that a dedicated budget for NBS innovation is required. Inter-related *partnerships* needs were identified based on the dispersed decision-making on green initiatives within the city hall and the overlapping yet compartmentalized competencies regarding water management, consequently with a perceived lack of strategic co-ordination undermining efforts to develop NBS.

Interviewees suggest that designing NBS implementation processes in Poznań has *knowledge* needs because of a lack of direct inclusion of NBS approaches in urban policy documents that would facilitate multifunctional NBS outcomes. This shows the need for stronger political support expressed in the urban policies (Zwierzchowska et al 2019). There are also knowledge needs related to assessing trade-offs in terms of best uses for specific sites. For implementation of NBS, the scoping of fine-grain knowledge of a local area and its arrangements is missing in policies, and there is no systematic or formal evaluation of impacts. This implies that knowledge (needs) on ways to monitor and evaluate the impacts of such policies and projects, as well as on the ways lessons from monitoring and evaluation can be integrated to future plans, is important.

4. Discussion

Blending the themes of knowledge, skills and partnerships in relation to Raymond et al's (2017) NBS policy cycle has provided a useful analytical framework. We now present a review of the findings in relation to the conceptual framework outlined in section 1 and in relation to recent NBS literature that also points at knowledge, skills and partnerships. Figure 2 shows a synthesis of the findings from each of the three case study cities, drawn from analysis of the four methods deployed in each city (as summarised in section 2). Reflecting from the synthesis of the findings, we see that all three cities identified needs for knowledge, skills and partnerships in the first three phases of NBS implementation that relates to the 'new approaches' required in general for selecting and designing integrative systemic solutions like NBS. These phases as our Figure 2 shows, require new skills and new knowledge that cities need to acquire for a successful implementation of nature-based solutions. As the cities progress on the NBS policy cycle, their needs shift to identifying new partnerships and new knowledge especially for monitoring and evaluation. Monitoring and evaluation require new skills and knowledge especially since it is seen as fundamental to policy learning and as a feedback loop to identifying opportunities for NBS scaling (see Raymond et al 2017). Our three case studies provide a rich and nuanced basis for exploring the policy needs of up-scaled NBS.

Figure 2: Cross case analysis of the three case study cities

NBS policy cycle	Genk	Glasgow	Poznan
Identify problem/opportunity	K, S, P	K, P	K, S, P
Select NBS	K, S, P	K, S, P	K, S, P
Design implementation processes	K, S	K, S	
Implement NBS	P	K, S, P	K
Engagement and communication		K, S, P	K, P
Transfer and upscale		K, S, P	
Monitoring and evaluation	K	K, S	K, S

K = Knowledge needs; S = Skills needs; P = Partnerships needs

This synthesised data points to the known needs in each city as expressed by the research participants. Additionally, we suggest that the results also indicate potential unknown needs. This relates to the nascent status of NBS in the repertoire of cities –with policy needs particularly evident at the latter stages of the NBS policy cycle. It also underlines the importance of the interface between science and implementation, which our conceptual framework starts to explore. The following sections reflect on this emergent research area in the light of our empirical data.

4.1. Knowledge needs for implementing NBS

Two overarching knowledge needs have been identified from all three cities for implementing NBS: *systems' thinking* knowledge as a knowledge basis to understand the complexity of nature-based solutions and their multiple benefits and *solutions-oriented thinking* that is a shift from analysing and identifying the problem to orient knowledge and expertise in (co)designing and monitoring and evaluating systemic solutions. In every phase of the NBS implementation cycle, these two knowledge needs have different operational forms, as our cross-case synthesis and overview shows. Specifically:

- During the first two phases of the NBS planning cycle (identify challenge or opportunity and selecting the type of NBS), knowledge on systems and on their susceptibility to change with NBS is identified as important, as is their inherent adaptability (Krauze and Wagner, 2019). This also relates and conditions the knowledge needed to select the type of NBS to better provide business opportunities. An example of this is the potential role of the linear park of Stiemer Valley to generate income from tourism or increased visits to the area.
- For designing the implementation of NBS, a knowledge need concerns overarching design principles for NBS to guide the localization of a solution and its institutional embedding (that is the operational form of solutions-oriented thinking). This knowledge need is intensified by the existence of rich information about NBS across different case studies in Europe but without a common overarching framework for their design and implementation. Current literature also points to this need (Blau et al 2018, Dryzek et al 2013, Nita et al 2018, Sun et al 2012, and Prestamburgo et al 2016) while Keeler et al (2019, p.36) point to the need for design frameworks that are evidence-based from research that is “historically, culturally and socially grounded”.
- Another identifiable knowledge need is the guidance in selecting monitoring and evaluation frameworks for the multiple impacts of NBS. All three cities have identified this as a knowledge need for understanding the policy learning and social learning achieved with NBS in relation to the evaluation of multiple benefits in contrast to grey infrastructure. A weighted evaluation of NBS that also considers wider social benefits such as social cohesion and social justice is largely needed (Keeler et al 2019). Recent research on ecosystem services evaluation has often neglected this knowledge gap and pointed to the conceptual or semantic challenges in valuing ecosystem services and respectively NBS (Small et al 2017, p.59; Guerrero et al 2018).
- For the phase of the transfer and upscaling of NBS, all cities identified that the lack of knowledge on how to transform NBS into business cases is a barrier to their mainstreaming. We infer that knowledge on ways and approaches to think, design and operate a NBS as a valid business case is a known unknown to the cities and an appealing perspective by turning an investment into a socio-economic impactful project. Aerts et al 2018 also point to this knowledge gap especially for sustainable drainage systems in cities.

4.2. Skills required for planning and implementing NBS in cities

Research on urban governance and environmental management for NBS has underspecified what the required skills are for planning and implementing large-scale systemic urban solutions, that posits our research as novel in this context. For all three cities, it has been rather challenging to identify the skills required for every phase of the NBS planning cycle. After additional focus group discussions with the city teams and from an expert group from Connecting Nature project, we propose that two key skills are required throughout the planning cycle: *negotiation and collaboration*. This is in order to facilitate the initiation and maintenance of partnerships with diverse urban actors in every phase

of implementing NBS. Additional skills that have been identified as essential for specific phases include:

- For the phase of identifying the challenge or opportunity for NBS, planners require communication skills to engage with citizens and businesses in order to co-create the narratives, understandings and contextualized problem framings that will resonate the co-design of NBS.
- For the phase of selecting the type of NBS, it is important that urban planners have acquired analytical skills for being able to understand, compare and assess compatibility/suitability of different types of NBS in relation to opportunities offered by the specified place for implementation. Albert et al (2019, p.17) point to the required skills for “facilitating joint exploration of societal challenges, NBS, alternative interventions, and their respective implications”. Davies and Laforteza (2019) argue for the need for ecosystem literacy and reflective practice in selecting and designing NBS.
- For the phases of designing and implementing NBS, institutional leadership skills are important together with negotiation skills. This includes navigating across departmental silos that exist in cities to create inter-departmental alliances and/or institutional coordination. Santoro et al (2019) also highlight the skills of navigating institutional complexity as being important in managing and dealing with the implementation of NBS.

4.3 Partnerships and collaborative governance needs for implementing NBS

For all the phases of NBS planning and implementation, identifying opportunities to collaborate with a wide spectrum of urban actors has been specified as essential by all three cities. Forging partnerships with civil society, local businesses and knowledge actors has been identified as a policy need for realizing NBS. Small et al 2017 (p.60) and Keune et al (2015) acknowledge that the plurality of beneficiaries of NBS contributes to the social complexity in designing, managing and implementing them. With environmental, ecological, social and economic benefits all achievable through appropriate design and management of NBS, partnerships across communities of interest and practice must be engaged. This includes such diverse actors as developers, local/regional authorities, ecologists, architects, landscape architects, governmental public bodies responsible for the natural environment, site managers, and infrastructure managers (Connop et al 2016; Nesshöver et al 2017; Lopez-Rodriguez et al 2017, p.1035). However, it is important to note that the type of partnership is of essence for addressing policy needs for NBS implementation. Partnerships that are co-opted, often temporary and location-specific, are also found as vital for progressing the practice of NBS.

4.4 Limitations of current research

In this paper, we have proposed a new conceptual framework that enables a more action-oriented analysis of policy needs for NBS implementation that moves beyond the more established analysis of gaps. Given the nascent state of NBS implementation, we find a varying amount of empirical data, with less data across the latter stages of the NBS policy cycle. This means that robust testing of this framework will need further iteration as the implementation of scaled-up NBS becomes more mature in cities. Furthermore, researching in multiple cities presents challenges for comparative analysis, but we feel this systemic approach is important for robust testing of conceptual frameworks and their potential for influencing practice. This study predominantly focused on an administrative perspective on the policy cycle with limited insight from external societies and business partners. Because each city team picked interviewees based on broad criteria open to subjective

interpretation, they are not objectively comparable, but are rather context relevant. Nevertheless, we did find reasonable comparability in terms of range of departments represented, the seniority of attendees and their openness to provide individual insights. Potential bias from interviewees, or indeed those who selected the interviewees, was mitigated by having a 4-step methodology allowing for a level of triangulation of data. Certainly, further research including more quantitative data collection, could further test our findings.

5. Conclusions

Cities are struggling in dealing with urban challenges, however solving contemporary problems with the use of NBS may require changes in previously applied approaches that encompasses a policy needs approach. Our conceptual framework and analysis indicate that bridging processes or approaches are required that simultaneously address knowledge needs, required skills, establishing of partnerships and ensuring political commitment. We propose three such bridging processes as suggestions for the cities to address their policy needs.

First, to enrich cities' knowledge base for NBS and to advance their skills (vocational, professional and networking skills) establishing and investing in targeted and tailored capacity building programs are recommended. The analysis we provide can be a guiding spectrum for knowledge acquisition and for tailoring training programs in every city. Urban intermediary actors such as ICLEI, C40, UCLG, IUCN that pioneer capacity building programs and urban charters for NBS can further use our conceptual framework to tailor their programs to city needs.

Second, we propose cities to create institutional spaces that enable collaborative learning through and for partnerships. In this way, the knowledge needs of cities for mainstreaming nature-based solutions in urban agendas can be addressed through learning alliances or other knowledge-driven partnerships while at the same time, partnerships nurture collaborative skills and communication skills to those involved for better planning and implementation of NBS. Institutional spaces that enable collaborative learning include large-scale research programs such as those funded by European Union's Horizon program, thematic city networks such as those supported by URBACT and knowledge sharing and advocacy platforms such as Cities With Nature.

Third, we propose cities accelerate institutional and governance innovations that promote evidence-based policy and urban planning by linking knowledge of NBS to political commitment and decision-making. To promote and accelerate institutional innovations for NBS, urban planners need to act as change agents or policy entrepreneurs which means adopting bridging narratives, creating enabling space for innovation to scale up and for evidence to inform multiple urban agendas. Most importantly, a future proposition for NBS is to accelerate institutional and governance innovations that support systemic evidence of the multiple benefits of NBS and mainstream them as social, economic, environmental and business solutions for sustainable and resilient cities.

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