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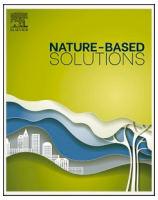

Implementing nature-based solutions: Insights from private contractors and consultants

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ABSTRACT

With strong backing from global initiatives, Nature-based Solutions (NbS) are increasingly recognized for their potential to address multiple socio-environmental challenges. However, despite such recognition, on-the-ground implementation remains limited, as traditional 'grey' measures continue to dominate agendas. While extensive research has explored the broader barriers and enablers to NbS adoption, little attention has been given to the challenges and opportunities faced by private-sector professionals directly involved in their implementation process as contractors or consultants. A clear understanding of these challenges is crucial, as these actors play a central role in translating NbS concepts into tangible projects and shaping their effectiveness and sustainability. To address this gap, we interviewed 17 professionals across Europe who have contributed to NbS projects in contractor or consultant roles. Our findings reveal key challenges, including limited NbS-specific expertise and skills, difficulties in recruiting and retaining skilled staff, insufficient evidence of NbS effectiveness, and constrained funding that limits work opportunities. Other obstacles include the absence of regulations and clear standards, a persistent reliance on traditional 'grey' infrastructure, a siloed mindset among project owners, competition, administrative complexities, and concerns over risks and liability. Despite these challenges, our study revealed strategic opportunities in actions such as networking and collaboration, leveraging available data and technology, capitalizing on green market growth, forming multidisciplinary teams, and increasing training and awareness efforts. We recommend future research on the expertise and knowledge required for different NbS categories and professional roles, as it would help enhance capabilities and support more effective contributions to NbS implementation and scaling.

1. Introduction

Nature-based Solutions (NbS) have surged in popularity as sustainable and effective approaches to addressing a wide range of environmental and social challenges. They are increasingly applied across multiple contexts to mitigate and adapt to climate change, reduce disaster risk, protect biodiversity, and enhance human well-being [1–3]. Defined by the UNEP [4] as "actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits", NbS are gaining traction in ambitious global and regional policy initiatives. The United Nations, for instance, has set a target to triple NbS investments by 2030 [5]. In Europe, NbS are central to the EU Biodiversity Strategy for 2030 [6], the Green Deal, and the recently adopted Nature Restoration Law [7], which emphasizes NbS as essential for climate resilience and biodiversity restoration.

Despite the growing policy support and rising demand, the adoption of NbS remains limited [8,9], and traditional 'grey' solutions continue to dominate agendas [10]. Several factors contribute to this slow uptake and have been extensively studied. These include a lack of funds and financial instruments, insufficient legal frameworks, limited collaborative governance, insufficient data, knowledge and awareness, path

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dependency, and technical difficulties [11–14]. Addressing these barriers requires, among others, fostering knowledge, skills, and expertise across all relevant stakeholders [15], which can promote a more comprehensive exploration of NbS options, streamline their implementation, improve durability, and ultimately increase recognition and demand [16].

While numerous resources such as guidelines, manuals, and webinars are available to build NbS-related capacities, their uptake appears limited and unevenly distributed among recipients. For instance, private-sector professionals have reported limited capacity and knowledge when supporting the development and on-the-ground implementation of NbS [15,17]. Public entities remain the primary proponents and funders of NbS initiatives [5,18]. Typically contracted by public authorities, external professionals from the private sector, such as landscape architects, ecologists, and engineers, generally involved on a temporary contractual basis, play a pivotal role as contractors and consultants across all project stages [18–20]. They are essential for the success of NbS [21]. Yet, little is known about the specific challenges and opportunities affecting their roles.

This research aims to address the knowledge gap by eliciting the perspectives and experiences of private professionals engaged in the NbS implementation process. We draw on semi-structured interviews with 17 professionals working in the construction or providing consultancy services for NbS projects across Europe. The research identifies key challenges and opportunities they face. By addressing the challenges identified in this study and leveraging the enablers, practitioners, policymakers, and researchers can work together to create a more conducive environment for the successful implementation and scaling of NbS.

2. Background

2.1. The role of contractors and consultants in NbS projects

The successful implementation of NbS calls for interdisciplinary expertise across diverse areas such as environmental science, ecosystems management, engineering, and construction [22,21]. Consequently, project owners or lead stakeholders often engage external professionals from the private sector to support various project aspects, particularly in areas where they lack sufficient expertise or workforce [19,23]. These actors are typically employed through a procurement process to perform specified tasks or provide expert advice. They may be contracted as individual entities or as part of a consortium, with the latter often simplifying project management and communication, particularly in case of large-scale initiatives [6].

A broad range of professionals contribute to NbS (Fig. 1) [22], including landscape architects, hydrologists, forestry specialists, and ecologists, among others. Many of these align with Nature-based Enterprises (NbE), defined as "enterprises engaged in economic activity that uses nature sustainably as a core element of their product/service offering" [20]. Additionally, other professionals such as civil engineers and data analysis providers are equally relevant despite that their primary business activities are not centred around nature provision. Regardless of their practice area, but depending on the specific NbS and tasks in question, these actors may participate as contractors or consultants [17,24]. While contractors are generally tasked with the physical implementation or construction of measures, consultants assist by adapting their knowledge to the client's situation to guide and generate solutions [25,26]. For a comparative description of contractors and consultants, see Appendix A.

The specialized skills and experience of external professionals significantly impact the effectiveness, efficiency, and innovation of NbS projects [23,16]. By introducing innovative strategies and leveraging best practices, they contribute to the scalability and sustainability of NbS initiatives [29]. Even when engaged on a short-term basis for concrete assignments, the involvement of contractors or consultants can shape solutions and the decision to adopt NbS over traditional engineering approaches. Public authorities with limited experience may hesitate to prioritize NbS [6]; however, engaging experienced professionals from the outset can instill confidence by providing technical assurances and recommendations.

While the tasks and contractual status of external professionals will vary according to the NbS context, their roles in the project lifecycle stages can include:

- **Feasibility and assessment**: Conducting site evaluations to determine the ecological, hydrological, and geological feasibility, as well as the potential suitability of NbS [21]. Assisting in understanding local culture and behaviours to, for example, inform the development of engagement plans [16,25].
- **Planning and design:** Assisting the development of detailed project plans [18]. In this stage, external professionals often play a key role in proposing and influencing the adoption of NbS, as well as the selection of locally appropriate options through the analysis of local context (e.g. ecosystemic context) [22].
- **Construction/Implementation**: Constructing NbS on the ground, such as creating wetlands for stormwater management or restoring coastal habitats for erosion control [23,16]. The provision of lower-skill or manual labour is more common in this stage, where private professionals often participate as contractors on a short-term basis [22]. External professionals might have less influence over the solutions at this stage as most design decisions are taken in earlier stages [30].
- **Operation and maintenance:** Providing services such as periodic watering, pruning, and erosion control, among many others to ensure the long-term functioning of the solution [23,6].
- **Monitoring and evaluation:** Monitoring NbS performance, for example, monitoring changes in water quality or ecosystem conditions [22,20].

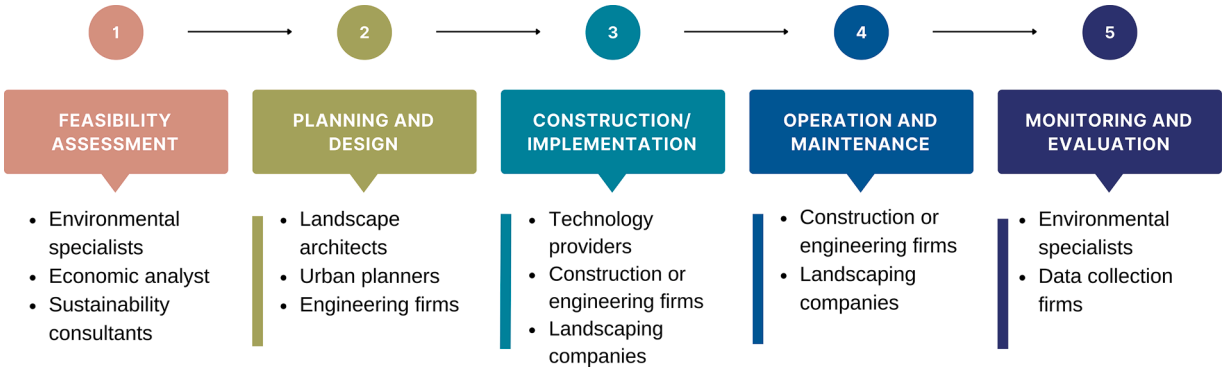

Fig. 1. Illustrative examples of external professionals involved in the different lifecycle stages of NBS projects. Adapted from Brill et al., [[16], p. 5], p. 5. Sources: Barkved et al., [23]; Brill et al., [16]; ILO & IUCN, [22]; Moreau et al., [27]; Zingraff-Hamed et al., [28].

2.2. Challenges in the involvement of private professionals in NbS

Despite their crucial role in NbS projects, recent studies highlight both a shortage of qualified experts with NbS-related expertise [18,6] and significant gaps in necessary capacities and knowledge [22,31–33]. For example, while many NbE possess strong technical or ecological expertise, they may lack business or communication skills [34]. These difficulties are particularly acute in cases where companies with little or no prior NbS experience are contracted, which frequently occurs when construction companies specializing in 'grey' infrastructure are encouraged to participate in NbS procurement processes [35,17].

Path dependency presents another challenge, as some professionals, who are accustomed to 'grey' infrastructure, often struggle to shift towards NbS solutions due to established habits and processes [35–37]. Combined with limited experience, this can result in suboptimal outcomes and manifest in a low number of bids for projects [20,23,38], poor data collection, and difficulties in conducting robust project evaluations to ensure effectiveness [39]. These issues consequently lead to higher costs and a reduced quality of the deployed measures [6,17].

To overcome these barriers, increase the involvement of external professionals in NbS implementation, and enhance NbS uptake, the ILO, UNEP, and other observers have proposed numerous measures. These include promoting equitable employment opportunities [22], expanding learning and capacity-building initiatives [21], establishing clear NbS standards and safeguards, and creating platforms for knowledge exchange [40]. Moreover, increasing NbS public financing while supporting private investment is strongly suggested [41,35]. This would translate into more projects and opportunities for practical experience.

This paper builds upon and extends these existing observations and contributes by eliciting the perspectives of NbS contractors and consultants on the limitations they face and the factors they judge necessary to overcome them.

3. Methodology

This study employed two primary research methods: (i) a desk-based review examining the role of contractors and consultants in NbS implementation; and (ii) targeted semi-structured online interviews with private-sector professionals in Europe selected through purposive sampling [42], all of whom had prior experience working on NbS projects. The desk-based review involved the analysis of 'grey' literature, scientific publications, reports, newspapers, and websites. It helped identify key research gaps and informed the development of the interview protocol.

The semi-structured online interviews explored the experiences and perspectives of professionals. While participants may assume different roles depending on the specific project, interviewees for this study were categorized as either contractors or consultants (see Appendix B). We refer to 'contractors' as those actors primarily tasked with on-the-ground implementation or construction of solutions. 'Consultants', on the other hand, refer to those experts who provide specialized advisory services, strategic guidance, and technical support on various aspects throughout the project lifecycle, including design, ecological assessments, and regulatory compliance guidance.

The semi-structured interview format was chosen to capture detailed insights into the professionals' experiences and perspectives [43], asthis flexible format allowed for in-depth responses and the inclusion of spontaneous follow-up questions. Building on the pillars of qualitative research methodology [44], two tailored survey protocols were developed: one for respondents with extensive NbS experience (primarily consultants) and one for a more diverse and less experienced audience. Both protocols focused on three key themes:

1. Familiarity and experience with NbS;
2. Internal and external challenges and opportunities associated with NbS implementation;
3. Perceived opportunities for future engagement with NbS.

Interviews delved into topics such as financing, competition, collaboration, legal considerations, knowledge and capacities, and potential strategies for increasing NbS uptake. Contractors were also asked about their interest in participating in future NbS projects and their strategic measures to enhance their competitiveness within the sector. Both questionnaires can be found as supplementary materials.

The interviews were conducted in English or Spanish via Zoom, with participants located across ten European countries (Fig. 2): Spain (n = 3), France (n = 2), Germany (n = 2), Ireland (n = 2), Italy (n = 2), Norway (n = 2), Austria (n = 1), Netherlands (n = 1), Switzerland (n = 1), and the United Kingdom (n = 1). Participants were selected from the PHUSICOS project demonstration sites (see acknowledgments for details about the project) and the Connecting Nature Business Platform, a digital repository of NbE [20].

3.1. Interviewee profiles

The NbS sector features a diverse work landscape, encompassing a wide range of roles and varying levels of expertise [22]. This study involved 17 private-sector professionals with different educational backgrounds and experience levels in NbS, working across both urban and rural contexts. Participants were selected through purposive sampling [42] to ensure they could offer first-hand, practice-based insights into implementation challenges and opportunities. Although the sampling was not intended to be proportionally representative, each participant was categorized as either contractor or consultant based on the primary services they provide (or have provided) in NbS projects. This classification recognizes that their contractual roles may shift depending on the specific context and requirements of each project, as determined by project authorities. As illustrated in Fig. 2, 59 % of the interviewees reported being exclusively or predominantly dedicated to activities that align with what is classified as green economic initiatives [45,21]. In contrast, 23 % worked mainly on 'grey' measures and 18 % were involved in both 'grey' and green initiatives. Their level of experience with implementation varied, with 12 participants reporting substantial expertise in the field and 5 indicating limited experience. Despite these differences, all interviewees expressed strong interest in participating in or continuing to work on NbS projects.

3.2. Data analysis

Interview data was analysed using qualitative content analysis [44, 46–48], adhering fully to data protection laws. All interviews were transcribed, and those conducted in Spanish translated into English for consistency. To ensure confidentiality, each participant was assigned a unique identifier. Inductive coding was applied to the transcript [43] facilitated by QSR International's NVivo software. While at times supported by the topics covered in the questionnaires, the coding process remained flexible, allowing themes to emerge naturally from the data. As new insights were identified, subcodes were manually generated. This approach ensured that the analysis accommodated unanticipated findings, enabling a comprehensive interpretation of the data and a deeper understanding of the research outcomes.

4. Findings

This section outlines the key challenges and opportunities identified through interviews with private-sector professionals involved in NbS projects, organized thematically for clarity. A summary of these findings is provided in Table 1. The figures in parentheses indicate the number of respondents who referred to each item, rather than the total number of mentions.

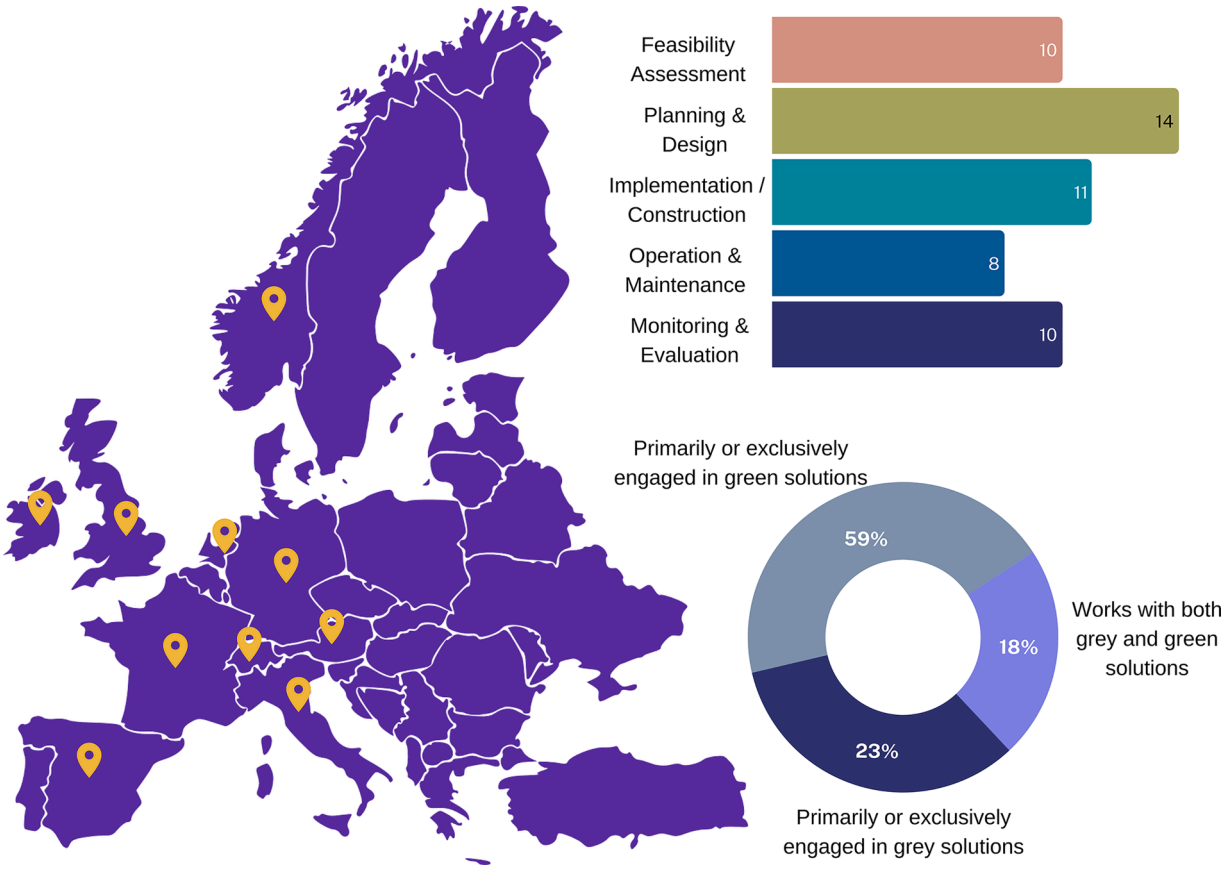

Fig. 2. Geographical distribution of interviewees (left), distribution of interviewees engaged in the different NbS lifecycle stages (top right), and proportion of interviewees based on the primary focus of their economic activities (bottom right). Note: The country locations (left) do not reflect the specific geographic distribution of respondents within each country.

Table 1
Main challenges and opportunities identified by the interviewees. The number of respondents indicating each item is shown in parentheses.

	Challenges	Opportunities
Knowledge and expertise	• Knowledge gaps (10) • Shortage of skilled labour (5) • Limited evidence on NbS effectiveness (10)	• Networking and collaborating (11) • Awareness raising and capacity building (14) • Multidisciplinary teams (7) • Data and technology (6)
Economic and market	• Uncertainty in market demand (8) • Dependency on traditional "grey" infrastructure (7) • Limited funding for NbS (7) • Market competition (3)	• Expanding market potential (11) • Availability of financial incentives and funding opportunities (7)
Governance and administration	• Absence of clear standards and regulations (7) • Lengthy procurement processes (3) • Liability (5)	• Standards and regulations (5)
Socio-cultural	• Siloed mindsets (5) • Risk aversion (7)	

4.1. Knowledge and expertise

4.1.1. Challenges

4.1.1.1. Knowledge gaps. Interviews revealed that private professionals face NbS knowledge and expertise gaps within their firms stemming from the multidisciplinary nature and complexity of many solutions. A participant specializing in plant-based water, air, and soil purification remarked that the performance of their measures is heavily influenced by climatic conditions. A French consultant echoed this sentiment, explaining: *"We often view NbS solutions as being very basic, such as just planting one type of tree. However, as we now delve deeper into the complexities of these solutions, we uncover a large number of factors that must be considered." (I14).*

Among the interviewees working on the on-the-ground construction of NbS, two had participated in only one such project, as their firms primarily focused on the construction of 'grey' infrastructure. Interestingly, both joined NbS projects at the invitation of project coordinators rather than through their proactive efforts. In one case, the company was selected to participate based on its perceived relevant skills and local presence, in the other case, the firm was invited for its expertise in addressing similar issues via conventional 'grey' approaches.

A contractor attributed limited NbS-related capacities among peers to a lack of training and environmental focus in engineering curricula: *"People are not used to it [implementing NbS] because they do not have any training in the field, unless it is someone with an environmental or forestry background, as in my case, a civil engineer."(I2).*

Insufficient knowledge and expertise within firms is also said to impact working dynamics and, at times, delay project timelines. As described by an interviewee involved in the design and construction of NbS: *"One problem is that NbS are very multidisciplinary projects. The different partners must work in areas that are outside their comfort zone and that are new to them, which causes them some hesitation. This lengthens the design process or the preliminary works as it requires coordination for finding a solution where everybody understands what they need to do." (I7).*

4.1.1.2. Shortage of skilled labour. Closely connected to knowledge gap issues, five interviewees expressed difficulties in recruiting staff with the necessary skills for NbS. Although they observe a growing interest for such initiatives, this interest often fails to translate into practical experience among junior professionals, who tend to possess research-oriented rather than hands-on skills. According to an expert from a company specializing in landscape restoration, conservation systems, and urban space naturalization, this shortage of personnel occasionally hinders the uptake of job opportunities: *"Our main challenge is finding qualified personnel to work with us. Sometimes we are obliged to inform our clients that we are unable to undertake projects due to a lack of qualified staff." (I19)*. Meanwhile, one participant related his firm's struggles to compete with non NbS firms that offer better salaries and career prospects: *"It would be good if we could attract more engineers interested in this field. There are, but they often receive better salary offers or more promising and secure career prospects elsewhere." (I7)*.

4.1.1.3. Limited evidence on NbS effectiveness. According to interviewed professionals, not only can the design and implementation of NbS involve complex objectives, but there are also challenges in accurately assessing NbS effectiveness. More than half of respondents (59 %) noted the lack of reliable data for this purpose, which can seriously hamper consultants and other professionals from integrating nature-related measures into projects. In their opinion, traditional 'grey' measures benefit from established industry standards and abundant evidence, which make them easier to evaluate and justify. A consultant remarked: *"The absence of concrete evidence poses a significant barrier. Stakeholders, such as water companies, often say: 'If I buy concrete, I know that engineers can predict the outcomes with certainty, but NbS proposers can't.' "(I16)*. Another person experienced in the design and construction of solutions echoed this sentiment: *"It is a challenge being able to point to reference projects and measures you previously implemented. To give new clients the confidence that they can opt for NbS" (I7)*.

Respondents once again linked the lack of data on NbS benefits and effectiveness to the numerous variables influencing their performance and the absence of consistent evaluation, both of which complicate comparison and hamper the availability of supportive evidence.

4.1.2. Opportunities

4.1.2.1. Networking and collaboration. Collaboration and networking were mentioned as valuable strategies for boosting both professional capacities and NbS success. According to 65 % of the respondents, collaborating with peers enables them to engage in new projects, increasing their knowledge and practical experience. Reportedly, these collaborations include establishing links with local universities or companies at the local level that are familiar with NbS, local regulations and the implementation environment. An expert indicated collaborating with "competitors": *"I work sometimes with many of my competitors for large scale projects. In many cases, we ask each other if we can collaborate together so that we will learn from each other." (I15)*. A consultant mentioned that his firm is a member of the Connecting Nature Business Platform, and while they have not secured any projects through it, the platform gives them the opportunity to observe what other companies are pursuing in their fields.

4.1.2.2. Awareness raising and capacity building. Interviewees consistently emphasized the importance of raising awareness and building capacity for the successful implementation of NbS, both within firms and among the general public and authorities. Such efforts were considered essential for increasing the participation of private professionals and reducing reliance on 'grey' infrastructure. Strengthening the understanding of risk, NbS co-benefits, and maintenance requirements among public officials with decision-making authority, could help mitigating dependence on conventional approaches.

When it comes to mitigating knowledge deficiencies at the internal level, half of the interviewees reported that their companies trained new employees through ongoing hands-on learning, gradually assigning them small responsibilities and, in some cases, dedicating a short training period each year. Regarding the learning strategies used in his company, a participant explains: *"I try to be open to learn. We make internal sessions, sometimes practical and sometimes only theoretical to improve our knowledge about these things [NbS]. Some of our team members have attended conferences and workshops." (I19)*. According to respondents, strengthening training approaches and investing in capacity building could not only alleviate the current shortage of qualified personnel but also cultivate a more knowledgeable workforce capable of effectively implementing NbS, even if such measures are not their primary focus.

4.1.2.3. Multidisciplinary teams. Respondents reported benefiting from building in-house teams that bring together a range of competencies and experiences to address the complexity of NbS projects effectively. A design expert from Italy explained: *"We have a diverse team because NbS projects cover many aspects. We need expertise in agriculture, geology, engineering, and understanding nature. Our landscape architecture team typically includes professionals from five to six different fields." (I20)*. The expert considered that integrating diverse knowledge areas ensures a comprehensive approach to NbS implementation.

4.1.2.4. Data and technology. Four interviewees indicated that technology is key to providing detailed information on the effectiveness and potential success of numerous NbS. Two respondents noted the value of technology in tracking reforested areas or evaluating green water purification systems. One consultant working in the design of solutions said: *"Technology does help. In the design stage it helps because we can ask our hydrologists or ecologists, for example, to model certain territories to observe where the water flows, where we have to drain, where we have to infiltrate, and so on." (I1)*. In her opinion, this has been improving over the years, since modelling is now easier and more flexible.

Similarly, although participants frequently identified data availability as a challenge rather than an opportunity, they emphasized that access to sufficient data, well supported by real-world cases, would significantly boost the NbS market. At the same time, one consultant suggested that harnessing data science to accelerate the demonstration of NbS effectiveness could contribute to the same end.

4.2. Economic and market

4.2.1. Challenges

4.2.1.1. Uncertainty in market demand. Uncertainty over future demand for NbS was another challenge reported. While 41 % of interviewees expressed a strong desire to increase their participation in NbS projects, they cited a lack of opportunities as a constraint. Despite observing a growing interest in NbS adoption, particularly from public authorities (88 % of participants), contractors and consultants voiced concerns about the market's stability and growth trajectory. Consequently, they tend to approach the expansion of their NbS operations with caution. An interviewee working in the design and construction of NbS in Italy explained: *"Until the market is less uncertain, until it is clearer and NbS becomes the business of the future, we cannot risk growing too much." (I17)*.

Moreover, such uncertainties are also said to influence their decisions to invest in NbS-related training and skill development. A respondent from a Spanish construction company with very limited experience in NbS remarked: *"The training is usually at the same time or posteriori. You cannot say 'I am going to train because I am going to implement these projects later', because you don't have the capacity to decide [on the future projects demand]. I would not train people on NbS, because if the administration does not carry out work or does not tender this type of*

projects, it would be useless." (I10).

4.2.1.2. Dependency on traditional "grey" infrastructure. Interviewees noted the prevailing tendency of professionals to stick with conventional 'grey' approaches as a problem that not only constrains the widespread adoption of NbS but also restricts the development of related competencies among experts. A participant from a construction company stated: *"Both designers and construction companies are used to pouring concrete, they are not accustomed to using the solutions that nature often offers and that are equally or even more efficient." (I2)*.

This sentiment was echoed by an interviewee providing consultancy services, who sees this problematic as also an internal issue within firms influenced by a lack of knowledge: *"Design engineers in the company have always been doing the same thing. They use the same design approach and that's easier. We know the costs and how to estimate them. We know how to put a business case together. Going through a new approach means thinking outside the box, working out a business case for my boss and convincing him. I think it's a matter of knowledge and staying in the comfort zone." (I13)*. This phenomenon appeared linked to a number of factors, including the absence of incentives, legal mandates or financial support to encourage NbS adoption among the private sector.

This challenge is closely connected to a siloed mindset among project owners and authorities, another issue discussed further below.

4.2.1.3. Limited funding for NbS. While observing that the NbS market is gradually growing, 41 % of the research participants identified insufficient funding for NbS as a critical obstacle that limits project development and the expansion of the market and expertise. An interviewee working in the construction of green infrastructure highlighted that, because it takes considerable time to observe the effects of NbS and to recover initial investments, long-term financing is particularly important for maintenance purposes. The interviewee remarked: *"The challenge is that no one likes to pay for maintenance. While investment is not usually the main issue, in NbS, such as those that incorporate plants into buildings, [initial] investment is only half of the equation. The lack of maintenance of these installations can lead to overgrowth within a few years, and vertical gardens, in particular, demand lots of care." (I8)*.

One participant based in the Netherlands recounted observing funding constrains for NbS projects in natural habitats and ports due to economic interests, as decision-makers feared that such initiatives could later hinder the economic development of the involved area.

4.2.1.4. Market competition. Interviews with experts from small companies working in the construction of measures reported challenges in project bidding, particularly in competition with larger, well-established firms focused on 'grey' solutions. In this case, the competitive landscape is further complicated by the often high costs associated with NbS, which at times creates financial burdens that make it difficult for smaller firms to compete effectively. For instance, an interviewee from a company specialising in water purification services using plants and microorganisms noted that, in their case, regulatory requirements significantly inflate the expenses of laboratory analyses: *"Clients prioritize lower operational costs. This means that sometimes we lose out to other solutions that are more affordable, easier to implement, and simpler to maintain." (I7)*.

By contrast, most other interviewees indicated minimal competition at the moment, observing that the NbS market is only slowly emerging. Their primary concern is not competition itself, but the rising risk of greenwashing by opportunistic and unethical actors.

4.2.2. Opportunities

4.2.2.1. Expanding market potential. The rising interest in NbS coupled with growing competition were regarded by interviewees as an enabling environment for their firms, and 65 % of them considered the expanding market potential as a key opportunity. A professional working in the construction of vertical greening systems projected continued market growth in the next 20–30 years. In the opinion of an urban designer, the growing momentum of NbS creates a prime opportunity for the emergence of successful cases that can help NbS proposers demonstrate the tangible benefits of NbS, helping stakeholders adopt and invest in NbS more confidently. The designer remarked: *"I think in the future the market will only grow and will give clients a first reference that NbS, or at least hybrid solutions, can be used." (I1)*.

4.2.2.2. Availability of financial incentives and funding opportunities. Interview discussions indicate a perceived urgent need to optimize the allocation of public funds for NbS. Respondents suggested pooling resources from various administrative sectors (e.g. water management, infrastructure development, and education) to support joint NbS initiatives, thereby maximizing benefits and societal impacts. They also pointed to the value of municipal collaboration with private developers, where incentives and partial financial support could encourage the integration of NbS on private properties. Likewise, innovative mechanisms such as redirecting tourism or local business taxes towards NbS and related environmental initiatives were proposed. A French participant explained: "*The local tourist taxes should be used to fund rewilding projects. Similarly, local taxes from restaurants should be allocated to improving the local bioregions." (I14)*.

Participants noted that documenting the successes of existing projects could encourage more stakeholders to adopt NbS strategies, creating a positive feedback loop of funding and implementation. However, an experienced consultant highlighted a key difference between publicly and privately funded projects regarding financial priorities and project longevity: *"Privately funded projects are more focused on demonstrating outcomes linked to financial inputs. Publicly funded projects are more about reporting on the project's progress to ensure it meets milestones. Once the project reaches its milestones, it's considered finished. I think private projects tend to take a longer-term view, often spanning 30 years, because without that sustained effort, problems tend to resurface once the project ends." (I16)*.

4.3. Governance and administration

4.3.1. Challenges

4.3.1.1. Absence of clear standards and regulations. Our findings reveal that interviewees perceived the lack of clear standards for NbS as an obstacle to both market development and quality assurance. An Italian civil engineer remarked: *"Traditional engineering solutions usually have a codex that you can use and that is admitted by law. However, NbS can have more variable results and are not codified." (I20)*. Another expert added that, even in cases where a regulatory framework is in place and applicable to their activities, the dependency of some solutions on weather conditions complicates compliance: *"The fact that the effectiveness of solutions that make use of living plants is difficult to calculate accurately is a problem."(I7)*. In this case, the experts suggested that ongoing research and accumulated experience could help address this challenge. Difficulties in navigating applicable, and often conflicting regulations for some type of NbS measures, were also mentioned.

Although not regarded as an internal challenge for firms, interviewees emphasized that existing regulations offer little incentives for adopting NbS. A professional responsible for conducting Environmental Impact Assessments (EIAs) in engineering projects noted that infrastructure proposers typically aim only to meet the minimum requirements for planning approval, neglecting environmentally beneficial solutions unless explicitly mandated by law. While some clients are open to options that benefit biodiversity, they are generally reluctant to accept any solutions that could incur additional costs or cause project delays. As one consultant explained: *"I have almost never*

seen it [the explicit requirement for NbS]; they [clients] never ask for solutions to be NbS. They just ask for your proposal to solve a given problem, and they evaluate it." (I1). Another expert emphasized the need for regulatory change, stating: *"Public calls should to a larger extent demand that NBS solutions are at least considered when we propose a mitigation project." (I3)*.

4.3.1.2. Lengthy procurement processes. Bureaucratic constraints and lengthy procurement processes, particularly when working for the public sector, were also identified as a barrier. For instance, an Irish-based consultant indicated long lead times for obtaining planning permissions, yet, he pointed out that this issue affects both 'grey' and 'green' projects similarly. In the experience of an expert from an Italian NbS design firm: *"Public projects have an administrative process that is quite different from the private one, it is more difficult and more constrained. It's the administrative part that's different, not the design which is almost the same. In the private sector we also have to deal with public authorization, so it is bureaucratic from that side, but when working for the public sector, there are many constraints and bureaucratic stops throughout the whole process." (I20)*.

4.3.1.3. Liability. Liability for NbS performance (e.g. on the case of NbS with disaster risk reduction objectives) emerged as a source of concern and uncertainty. Interviewees seemed doubtful on whether project authorities, construction engineers, or designers could be held accountable for non-performing measures. One consultant working in the design of both 'grey' and green measures explained: *"As a designer, you have 10 years of liability. If there's something that breaks down in the 10 years following the finalization of the project, it's on you. I know that's the case in France and Belgium." (I1)*.

The lack of clear industry standards is said to complicate access to liability insurance and, when coverage is available, results in rigorous reviews and approval processes. An interviewee remarked that: *"At the moment there are not enough risk analyses or variance analyses being conducted, and there are no just industry standards for insurers to know whether they're insuring something that's worth." (I16)*. Therefore, it was emphasized that setting industry standards is essential to help the insurance industry offer more affordable and consistent coverage for NbS. Standards would aide in establishing clear guidelines for performance expectations to contractors and consultants.

By contrast, one practitioner dedicated to NbS construction expressed little liability concerns, stressing the complexity of attributing liability for, for example, incidents or losses. In his opinion, this complexity arises from the need to thoroughly assess evidence of negligence, such as the lack of much needed maintenance practices.

4.3.4. Opportunities

4.3.4.1. Standards and regulations. As earlier mentioned, our findings underscore the urgency for legal requirements and clear standards and regulations. Interviewees suggested that regulatory requirements could, for example, incentivize private firms and professionals to invest in NbS-related training and innovation by offering greater certainty regarding long-term demand for such projects. It was considered that specific standards and regulations would help formalize certain NbS measures as recognized and reliable approaches withing the market by setting clear expectations for performance, compliance, and outcomes. A German consultant explained: *"The imposition of legal requirements would put the training onto contractors. However, because they would secure enough contracts, they would be willing to take the risk of investing in training and acquiring new tools. If the public sector awards contracts for a substantial number of units, contractors would be confident in their ability to generate profit and be motivated to invest in training." (I13)*. Another participant added that if the use of NbS were mandated in public projects, firms would inevitably identify such opportunities and submit tenders. Moreover, it was expressed by another expert that industry standards would enhance reliability and foster expertise in his field (modelling and mapping of ecosystem services).

4.4. Socio-cultural factors

4.4.1. Challenges

4.4.1.1. Siloed mindsets. A siloed mentality among both project owners and contracted experts was a further challenge referred to. According to a landscape architect with extensive experience in designing green and hybrid measures, the main obstacle to NbS is not necessarily a lack of funding but rather the fragmented mindset that prevails among project authorities. He argued that decision-makers often fail to fully recognize and integrate the multiple benefits and co-benefits of NbS, especially in the long-term. In his words: "*I think it's necessary they start looking at the budget from a different angle. In my opinion, that would shift the discourse from not having sufficient funds to investing money in a different and smarter way." (I1)*. Collaborative, cross-sector projects were suggested as a way to accelerate NbS implementation, deliver better outcomes, and increase awareness in sectors where NbS adoption remains limited.

4.4.1.2. Risk aversion. Interviews revealed a certain degree of risk aversion among respondents. A participant from a firm with over 20 years of experience in consultancy for natural hazards mitigation stated: *"If we decide on a solution fully based on NBS, we would probably be very conservative to gain experience and reduce uncertainties." (I3)*. This cautious approach appears to stem, in part, from a reliance on traditional engineering practices and the framework provided by ISO standards. Additionally, an Austrian interviewee links risk aversion to recent crises, such as the COVID-19 pandemic, explaining: *"With the many crises we are having recently, everyone is scared. I don't know if people are willing to take risks with NbS, or to invest for the benefit of all when marginal economic profits are smaller." (I7)*.

5. Discussion

This study examined the experiences and perspectives of 17 private-sector professionals with prior experience in NbS projects working as contractors or consultants. Participants were selected through purposive sampling, and data was collected via semi-structured interviews with the objective of capturing a deeper understanding of the constraints and opportunities that shape their participation in the implementation of NbS. The analysis of the interviews unveiled significant challenges and potential opportunities affecting their engagement and work with NbS.

A key finding is the pervasive lack of NbS-related knowledge and expertise, even among professionals often assumed to possess the required technical capacities [17]. While some consultants and contractors have specialized knowledge, many (in particular those with backgrounds in conventional infrastructure) struggle with insufficient familiarity with NbS design, implementation, and evaluation. Compounding this, firms face difficulties recruiting and retaining staff with adequate hands-on experience, particularly when competing with better-resourced 'grey' infrastructure companies. This finding echoes earlier reports on the shortage of qualified professionals [17,23] and the absence of formal training and professional development opportunities tailored to NbS [22,34,49]. Without sufficient expertise and supporting evidence, professionals find it difficult to advocate for NbS or integrate them effectively into projects.

Yet, these knowledge gaps are not uniform across roles. Consultants, who often influence early-stage decisions, including the selection of NbS, tend to possess more expertise than contractors charged with NbS construction, who are sometimes tasked with constructing NbS measures they may be unfamiliar with [50]. To address this limitation, interviewees emphasized the value of networking and interdisciplinary

collaboration, particularly for smaller firms and those transitioning from 'grey' infrastructure work. Partnering with established NbS practitioners facilitates knowledge transfer. Additionally, the use of digital tools such as hydrological modelling and geospatial analysis offers support in project design, implementation, and monitoring, helping address some of the existing knowledge gaps and performance uncertainties. NbS solutions, however, still require supporting policies and financial mechanisms to become widely accessible [5,18,35]. Addressing knowledge gaps requires more than individual capacity building; it also demands systemic support through training pathways, standards, and procurement processes that generate implementation opportunities.

Financial uncertainty is an additional barrier. Interviewees noted that NbS are often perceived as less financially attractive due to longer return-on-investment horizons and higher maintenance needs compared to traditional infrastructure. Although public institutions are key funders and implementers of NbS, some contractors and consultants reportedly avoid public projects due to lengthy procurement processes and excessive administrative burdens. This finding suggests that current public procurement mechanisms may be inadvertently discouraging private sector participation and, in doing so, slow mainstream adoption, therefore, reforming these frameworks to better accommodate NbS is crucial [34]. Relatedly, the previously observed path dependency, where past decisions and institutionalized practices shape future choices, also remains a significant barrier [15]. According to the interviewed professionals, project proposers continue to rely on established tools and practices for convenience, reinforcing conventional approaches and making it difficult to adopt innovative solutions like NbS. As a result, the burden of proof often falls on NbS proponents (e.g. consultants) who must demonstrate effectiveness, reinforcing the existing institutional and financial biases toward 'grey' infrastructure, as decision-makers tend to favour familiar, well-documented approaches over alternatives perceived as uncertain or untested [35]. Without intervention, these issues will persist, limiting NbS from becoming a viable mainstream alternative.

Similarly, a key issue concerns the lack of clear and consistent technical standards offering support to practitioners. While frameworks like the IUCN Global Standards for NbS provide high-level principles and broad applicability, they often lack the specificity and detailed guidance needed for effective implementation across different environmental and geographical contexts [51,52]. In contrast to conventional infrastructure, which benefits from well-defined technical standards and historical performance data, NbS continually face regulatory ambiguity [32]. According to our findings, without standardized methodologies for evaluating their effectiveness, professionals struggle to convince decision-makers of their viability.

The previously reported liability concerns and uncertainties appear to add another layer of complexity [50]. Our findings indicate that different professionals experience risk differently, and that liability is still unclear: some design professionals report being contractually liable for NbS performance, whereas contractors involved in construction consider that either public authorities or engineering firms would absorb such risks. This discrepancy suggests a need for clearer regulatory guidelines on responsibility-sharing among project stakeholders. In addition, interviewees emphasized that many NbS are highly complex and vulnerable to doubts. When combined with the siloed mindset of project owners, which often leads to sectoral fragmentation and misaligned goals, these factors inevitably hamper opportunities for contractors to gain hands-on experience with NbS and hinder broader adoption within the industry [32,37,53,54]. Notably, although most interviewees did not explicitly propose direct solutions for siloed thinking or risk aversion behaviours, related opportunities such as awareness raising, clearer regulatory frameworks, and enhanced collaboration among public authorities, private actors, and across sectors closely align with such barriers and could help mitigate their effects. Complementing these insights, recent literature suggest additional strategies to overcome silos, including polycentric governance, participatory co-design, Living labs, and actors coalitions [32,54,55].

Finally, this study is not without limitations. First, the semi-structured nature of the interviews may have introduced potential bias and subjectivity on the part of the researchers [56,57]. Furthermore, although Guest et al. [58] suggest that a sample size of 12 interviews is typically sufficient for most research studies and that 17 individuals were interviewed in this research, the heterogeneous nature of interviewees—who had diverse professional roles, varying NbS experience, and worked across different European countries — could warrant a larger sample. In this case, the semi-structured approach adopted is expected to mitigate the potential shortcomings related to sample size inadequacy. Future research should examine how these barriers and enablers vary across different project types, industries, and geographical contexts, as Dorst et al. [59] note significant contextual sensitivity in the factors influencing NbS barriers.

6. Conclusion

Drawing on 17 semi-structured interviews conducted across Europe, this paper offers insights into the challenges and opportunities faced by contractors and consultants involved in the NbS lifecycle, including the assessment of their feasibility, planning and design, construction, operation and maintenance, monitoring and evaluation. Our findings reveal that professionals – even those expected to fill technical gaps in projects – frequently struggle with knowledge gaps that can hinder their ability to implement NbS effectively.

Despite more than half (59 %) of the interviewees working primarily with 'green measures', limited exposure to NbS projects appears to constrain their capacity to continue developing specialized expertise. Professionals find the complex multidisciplinary nature of NbS projects particularly challenging, as it requires the integration of diverse knowledge and skills that are not always covered in traditional training programs. While interviewees acknowledged opportunities for improvement, such as networking and collaboration with more experienced actors, or attending specialised courses and training (albeit costly), most of the identified challenges remain systemic and beyond their control. This is, for example, the case for the still strong market orientation towards 'grey' solutions which, compounded by the limited availability of reliable quantitative data on NbS performance, significantly affect professionals' ability to advocate for these solutions. Without robust evidence of long-term effectiveness and co-benefits, professionals (particularly consultants) often struggle to justify NbS to clients, notably because traditional methods are still perceived as more reliable.

Similarly, contractors and consultants face regulatory and liability uncertainties, as standards and technical guidelines for NbS are not always available and, when they are, they may be too generic. Interviews showed that liability responsibilities remain highly unclear, a challenge heightened by the essential role of maintenance in ensuring NbS effectiveness. Well-defined standards are indispensable to provide the necessary framework, encouraging contractors engagement, and mitigating risks and liabilities. At the same time financial incentives and funding opportunities, especially for the long-term maintenance of NbS, are critical to ensure long-term sustainability and effectiveness.

While this study highlights key barriers and enablers for NbS implementation and the effective involvement of private-sector professionals, additional research and data on testing practical solutions in real-world settings is desirable. This includes evaluating the effectiveness of professional training and knowledge-sharing initiatives, further exploring financial mechanisms such as green bonds and blended finance to support NbS adoption, and developing new technical standards and guidelines for implementation or update existing ones. New studies could also examine regulatory adaptations, such as improved procurement processes and liability-sharing models to reduce administrative burdens and provide clearer legal guidance. Importantly, future research could further investigate the perspectives of professionals

primarily or solely engaged in implementing 'grey' measures and show growing interest in NbS, to better understand the transition toward NbS. Addressing these information gaps can help create a more supportive environment for external professionals' engagement and the long-term success of NbS.

Although the path to widespread NbS adoption remains challenging, their potential to address pressing environmental and societal issues is undeniable. By tackling the challenges identified in this study and leveraging the enablers, practitioners, policymakers, and researchers can foster a more supportive environment for the successful implementation and scaling of NbS. Continued research and collaboration among public and private-sector stakeholders will be vital to advancing knowledge and promoting broader NbS adoption.

NBS impacts and implications

The following are some highlights from the paper, focusing on how it addresses environmental, economic, and social concerns:

Environmental: By fostering a better understanding of the challenges and opportunities facing private contractors and consultants in implementing Nature-based Solutions, this research aims to support their wider adoption, effectiveness, and long-term sustainability. Strengthening these strategies is crucial for addressing pressing environmental issues, including climate change, biodiversity loss, and water security.

Economic: The paper discusses the economic factors that private contractors and consultants perceive as influencing the adoption and sustainability of Nature-based Solutions, such as market demand, funding availability, and competition. At the same time, it highlights perceived opportunities for market expansion and innovative financing strategies.

Social: Our study highlights the social dimension of slow Nature-based Solutions adoption, rooted in risk aversion and entrenched project management practices. Despite growing awareness of NbS benefits, decision-makers often default to traditional methods due to familiarity and perceived reliability, making it harder for innovative solutions to gain traction.

Informed consent statement

Informed consent was obtained from all subjects involved in the study.

CRediT authorship contribution statement

Julia J. Aguilera-Rodríguez: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Anna Scolobig:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **Juliette G.C. Martin:** Writing – review & editing, Supervision, Methodology, Funding acquisition, Conceptualization. **JoAnne Linnerooth-Bayer:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Julia J. Aguilera-Rodriguez reports financial support was provided by European Commission. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.nbsj.2025.100278.

Appendix A

Table A1

Table A1
Key characteristics of private-sector professionals participating in NbS projects under contractor and consultancy contracts.

	Contractor	Consultant
Primary role	Execute and deliver physical work or construction activities as per specifications.	Provide expert advice, planning, and guidance on project strategies and methodologies.
Responsibilities	Manage construction, oversee labour, materials, and equipment, and ensure project completion on time and within budget.	Analyse needs, design strategies, provide recommendations, and ensure compliance with regulations and best practices.
Output	Tangible results, such as built infrastructure or implemented solutions.	Intangible results, such as reports, plans, designs, or strategic advice.
Involvement stage	Typically involved during the construction/implementation phase.	Often engaged during the planning, design, and feasibility assessment stages.
Expertise/skills	Practical, hands-on skills in construction, engineering, or physical execution.	Mainly theoretical or analytical expertise in environmental science, policy, or project design.

(*continued on next page*)

Table A1 (*continued*)

	Contractor	Consultant
Contractual relationship	Typically work under a contract with clear deliverables and timelines.	Often engaged on an advisory basis, with flexibility to adapt to project needs.
Liability position	Project owner or government agency typically liable for contractor's performance.	Consultancy company commonly responsible for consultant's performance.

Adapted from New Zealand Ministry of Business, Innovation & Employment [24]. Sources: Barkved et al. [23], Brill et al. [16], ILO & IUCN [22], Mačiulytė & Durieux [17], New Zealand MBIE [60].

Appendix B

Table B1

Table B1
Descriptive information of interviewee professionals.

ID #	Country/ Region	Short description of services	Working scale	NBS expertise	Implementation phase participation*
1	France	Landscape architecture and urban planning.	International	Works both with grey and green solutions	1, 2, 5
2	Spain	Construction of wooden structures and wood treatment.	Regional	Exclusively or mainly engaged in grey solutions	3, 4
3	Norway	Civil engineering firm providing expert advice on floods, landslides, mapping, and design.	National	Exclusively or mainly engaged in grey solutions	1, 2, 3, 4, 5
4	Switzerland	Landscape restoration and tree planting services.	National	Exclusively or mainly engaged in green solutions	3, 4, 5
7	Austria	Developers of water, air and soil purification nature-based technology.	International	Exclusively or mainly engaged in green solutions	1, 2, 3, 4, 5
8	Germany	Construction and maintenance of vertical gardens.	National	Exclusively or mainly engaged in green solutions	3, 4, 5
9	Netherlands	Consulting on ecosystem restoration, biodiversity, water management.	International	Exclusively or mainly engaged in green solutions	1, 2
10	Spain	Construction company focused on road infrastructure.	National	Exclusively or mainly engaged in green solutions	3
11	Ireland	Engineering consultancy firm.	International	Exclusively or mainly engaged in grey solutions	1, 2, 5
13	Germany	Large international infrastructure consulting company.	International	Exclusively or mainly engaged in grey solutions	1, 2, 3, 4, 5
14	France	Smart technology developers. Data collectors.	National	Exclusively or mainly engaged in green solutions	2
15	Norway	Planning, architecture and engineering.	National	Works both with grey and green solutions	1, 2, 5
16	United Kingdom	Technology, modelling and mapping.	International	Exclusively or mainly engaged in green solutions	1, 2, 5
17	Italy	Sustainable water management.	International	Exclusively or mainly engaged in green solutions	1, 2, 3, 4
18	Ireland	Green roofs and IT monitoring.	National	Exclusively or mainly engaged in green solutions	2, 3
19	Spain	Design and execution of landscape restoration and conservation systems.	International	Works both with grey and green solutions	2, 3
20	Italy	Waste treatment services.	Regional	Exclusively or mainly engaged in green solutions	1, 2, 3, 4, 5

* NbS lifecycle stages: (1) Feasibility assessment, (2) Planning and design, (3) Construction/implementation, (4) Operation and maintenance, (5) Monitoring and evaluation.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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