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Can the EU taxonomy for sustainable activities help upscale investments into urban nature-based solutions?

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ABSTRACT

We analyze the potential of the European Union (EU) Taxonomy (ET) for Sustainable Activities to mobilize investments for the sustainability transition toward urban nature-based solutions (UNBS). We map the current investment landscape of UNBS in Europe and combine this mapping with document analysis of UNBS inclusion in the ET to understand how the ET might help overcome the well-documented barriers to UNBS finance. We suggest that the ET has a legitimizing effect on UNBS as climate investments, which can support their uptake, but also conclude that only some UNBS subtypes are explicitly included when they fit with existing investment classes. In particular, the ET (1) disregards innovative - and specifically urban - UNBS types and (2) fails to provide incentives for investments that can deliver multiple sustainable objectives, which would enhance the investment case for UNBS. Since the current investment landscape of UNBS is characterized by a strong presence of public actors and a high incidence of co-financing, we recommend that public actors leverage the ET to obtain private funding for UNBS via (green) bond issuance and public-private co-finance instruments. Our analysis indicates that the ability of the ET to upscale investments for specific sustainability transitions depends on the interplay among their current investment landscapes, specific financing barriers, and explicit inclusion in the ET.

1. Introduction

The European Union (EU) Taxonomy (ET) for Sustainable Activities, which is a standardized, science-based classification system for sustainable economic activities,¹ is aimed at stimulating private investments toward sustainable activities, and in supporting Europe's environmental goals (Schütze and Stede, 2021; TEG, 2020). The ET is also aimed at increasing transparency and reducing information asymmetry by disclosing the sustainability characteristics of investments (Bertomeu and Magee, 2015; Chiyachantana et al., 2013) and by decreasing greenwashing via identifying and codifying 'green' investable activity. One of the ET goals is to reduce market fragmentation by providing a set of environmental objectives to be included in all types of investments (Schütze and Stede, 2021). The ET is considered a means by

which the European Commission can incentivize private finance to support widespread sustainability transitions across Europe in the domains of climate change mitigation, energy transition and biodiversity preservation (Nedopil et al., 2021; Steffen and Schmidt, 2021).

A sustainability transition that has entered the European policy domain over the past decade is the mainstreaming of nature-based solutions² (NBS) (Cohen-Shacham et al., 2016; Faivre et al., 2017). NBS are considered the strategic, cost-effective implementation of nature to address multiple sustainability challenges (Maes and Jacobs, 2017; Seddon, 2022), e.g. water management, food security, health, climate change and biodiversity protection (Raymond et al., 2017; Seddon et al., 2020). In Europe, NBS in cities – also referred to as 'urban' NBS (UNBS) – have gained traction to address multiple social, economic and environmental sustainability challenges that cities in particular face – including

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² Defined as "actions inspired by, supported by or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions, for example, mimicking how non-human organisms and communities cope with environmental extremes." (EC, 2015, p 24)

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climate adaptation and mitigation (Khatri, 2022; Tozer et al., 2022). Specific manifestations of UNBS include urban parks and forests, green roofs, walls and facades, and urban agriculture (Kabisch et al., 2017; Raymond et al., 2017).

Private companies, mostly engaged in agriculture, water management, and energy sectors (ICADE, 2023; OECD, 2016, 2020), have become actively involved in including NBS in their daily operations by designing, financing, and implementing UNBS projects (Razzaghi Asl, 2022). These companies view UNBS as a tool to support green activities within the Nomenclature of Economic Activities (NACE) - the European statistical classification of economic activities, and ultimately enhance their revenues (D'Angelo et al., 2023) and transform their 'business as usual' operations (Scheyvens et al., 2016). The companies' revenue, as well as the capital and operating expenditure becomes taxonomy-aligned in case they channel private finance towards activities comprising UNBS projects and therefore, make the company's profile more attractive for equity investors seeking to align their portfolios with sustainable and environmentally responsible criteria (ASN Bank, 2022; Mirova, 2023; Triodos Bank, 2020). Emphasizing nature-positive goals, these companies direct their investments toward ecological restoration initiatives, setting tangible on-site restoration objectives that align with the principles of UNBS and demonstrate their commitment to biodiversity preservation within their operations (L'Oréal Groupe, 2021).

Moreover, the financial sector has witnessed the expansion of the voluntary carbon market (VCM), a dynamic arena where various stakeholders participate in trading carbon credits (Spilker and Nugent, 2022). The VCM ecosystem comprises a network of public and private entities, including carbon offset programs, project developers, carbon buyers, financial institutions, and brokers who participate in credit transactions via bilateral agreements or market exchanges (Favasuli and Sebastian, 2021). The VCM is valued at over one billion dollars for the first time in 2021 and as mentioned by the World Economic Forum (2023), it is projected to reach between five and ten billion dollars annually by 2030. Notably, nature-based projects accounted for more than 66 % of the transaction value in the voluntary carbon markets in 2021, illustrating the increasing demand for NBS projects (Bhutada, 2022). The market of biodiversity credits is still emerging but shows promising potential for growth. In 2023, Swedbank Group revealed that it has invested in a pilot project that will generate biodiversity credits from around 13 ha of forested area in Sweden over 20 years (Swedbank, 2023).

Despite the compelling economic benefits UNBS may offer to investors and the collective efforts of practitioners, policymakers, and academia, widespread adoption of UNBS faces persistent barriers, particularly related to financing (Dorst et al., 2022; Droste et al., 2017; Mayor et al., 2021; Toxopeus and Polzin, 2021). The public good character of UNBS is central to this challenge - privately capturing UNBS value creation is difficult, leading to a lack of private return on investment - while public finance is often insufficient or difficult to arrange due to competing political priorities (Almassy et al., 2018; Dorst et al., 2022; Droste et al., 2017; Toxopeus and Polzin, 2021). Other barriers include insufficient policy development to incentivize their uptake (Dorst et al., 2022; van der Jagt et al., 2023) and a lack of standardization, transparency and scale (Toxopeus and Polzin, 2021).

The development of the EU Taxonomy is an important part of the policy mix of the European Commission (van der Jagt et al., 2023), which is aimed at reducing financing barriers that sustainability transitions such as UNBS face by offering standardization and non-financial disclosure guidelines for private investment (European Commission, 2015). Since the initiation of the 2016 Global Reporting Initiative and the 2018 Sustainability Accounting Standards Board (Busco et al., 2020), voluntary non-financial disclosure standards have become increasingly popular for private investors to promote their contribution to society (Abeysekera et al., 2021; Li et al., 2021; Pedersen et al., 2021).

While previous research explains how standards might lower carbon

emissions (Alhorr et al., 2014; Downar et al., 2021; Hahn et al., 2015; Robinson et al., 2018) our understanding of how an ambitious financial standard - such as the ET - mobilizes sustainable finance for specific sustainability transitions - such as UNBS - remains largely conceptual (Schütze and Stede, 2021; Weber, 2018; Nedopil et al., 2021). To shape our empirical understanding of the ET's potential to accelerate sustainability transitions, we use a qualitative textual analysis approach to examine how the ET might start mobilizing private investment for UNBS. After reviewing the literature on the UNBS financing barriers, we explore the current European UNBS investment landscape analyzing the data gathered under the Urban Nature Atlas - Naturvation project (Xie and Bulkeley, 2020). We statistically describe the main sources and amount of finance for each UNBS category, the trends in monitoring and reported impact indicators, and the types of financial products supporting UNBS projects. We investigate the conceptualization and inclusion of UNBS in the current ET. Our results provide important insights on how to enable private UNBS finance through the ET and highlight the ways in which standards may support sustainability transitions. While not expecting complete ET alignment, our aim is to initiate a first assessment of the role of ET in generating a new stream of finance that, although relatively small in financial market terms, holds significance for UNBS (Blin et al., 2023; Finance Earth, 2021).

We contribute to the emergent literature of NBS financing (Alhorr et al., 2014; Brand and Salzgeber, 2019; Hagedoorn et al., 2021; Mayor et al., 2021; Toxopeus and Polzin, 2021) that documents enablers and barriers in financing UNBS, which hamper their scalability. We specifically add how a sustainable finance standard (Nedopil et al., 2021; Slager et al., 2012a; Weber, 2018) such as the ET (Schütze and Stede, 2021) might help overcome these barriers to UNBS, offering broader implications for other similar sustainability transitions such as energy, climate, and social transitions facing the same challenges (Steffen and Schmidt, 2021; Tozer et al., 2022; van der Jagt et al., 2020). We document a high-level legitimizing effect but an uneven potential of the ET to impact financing towards specific UNBS types. The ET impact depends on a combination of (1) inclusion into ET criteria - whether a UNBS type is explicitly considered part of an asset class - and (2) the current investment landscape in a UNBS type.

We propose that sustainable finance standards such as the ET can generate 'sweet spots' of investment, where their inclusion in ET criteria coincide with, and can leverage, existing private financing streams towards sustainability interventions (e.g., for building-integrated greening, green roofs, and facades). Second, we suggest that public actors can use the ET to obtain private UNBS investment via green bond markets and public-private co-finance, and that institutional investors can target corporates that invest in UNBS for ET alignment. The ET and comparable standards are unlikely to launch new UNBS-related asset classes that are not considered profitable (e.g., community gardens) and could even slow the uptake of innovative (UNBS) interventions if they are excluded from their criteria.

The remainder of the paper is organized as follows: Section 2 introduces the ET and provides conceptual background on financial standards as enablers of sustainable finance. Section 3 presents the methodology of this study, data sources and the analytical framework. Section 4 presents our findings, while Section 5 incorporates a discussion on the three dimensions of financial standards (commensuration, legitimacy and legibility) for stimulating sustainable finance and recommendations about how the ET could be improved to stimulate UNBS investments.

2. Conceptual background

2.1. ET for sustainable activities - origin, principles and objectives

The ET originates from the EU's High Level Expert Group on Sustainable Finance, which recommends establishing a harmonized sustainability taxonomy in Europe that is consistent with the EU's public

policy goals (Esposito et al., 2020; HLEG, 2018). Published in 2020 and implemented in 2021, the ET is a classification system, based on NACE categories, that aims at providing “clear guidance on activities that qualify as contributing to environmental objectives to help inform investors about the investments that fund environmentally sustainable economic activities” (European Parliament, 2020, p2), incentivizing and supporting market players to shift towards green investments (Schütze and Stede, 2021). The framework was created via consultation process with financial market stakeholders and is rooted in existing voluntary standards such as the Principles of Responsible Investments (PRI)³ combined with knowledge developed by the Platform on Sustainable Finance.⁴ It sets specific definitions within six objectives for which economic activities are considered environmentally sustainable (Fig. 1). The ET framework specifies that an economic activity is qualified as environmentally sustainable when it substantially contributes to at least one of these six objectives, while ‘doing no significant harm’ (DNSH) to the other environmental objectives, and is compliant to minimal social safeguards (European Parliament, 2020).

However, this is not a static regulation; its policy design has evolved according to changes in science, technology, new data and activities, consistent with the literature on institutional standardization, which stresses that standards represent a constant collaborative learning and modification process (Gond and Piani, 2013; Lawrence et al., 2011; Timmermans and Epstein, 2010) and their legitimacy depends on multiple stakeholders (Mio et al., 2020; Suddaby and Greenwood, 2005). The ET addresses financial players in two different ways: pension funds, asset managers, insurers and corporate & investment banks have financial disclosure obligations (mandatory use of the ET framework under Articles 5, 6, and 7 – Fig. 1), while retail banks and corporates have only non-financial disclosure obligations (Article 8 – Fig. 1). For each product, investors should disclose if and how the ET has been utilized to determine the sustainability of an investment, what proportion of their investments are funding ET-eligible (Fig. 1) activities, and the proportion that meets the ET’s requirements.

A key section of the taxonomy assessment includes defining what part of a corporate’s performance is sustainable. The degree to which a company can be considered environmentally sustainable depends on the individual contribution of each eligible economic activity to the company performance, in terms of not only turnover, or revenues when appropriate, but also capital or operational expenditure. This alignment enhances the company’s profile, making it more attractive to equity investors who prioritize sustainable investments. As a result, these equity investors indirectly invest in such ‘green’ (e.g., nature-positive) solutions within the company’s operations, recognizing their value and potential.

At the end of 2021, the first financial market participants were required to complete their initial set of disclosures against the ET (TEG, 2020). Based on this first round of implementation the ET has set the standard for mandatory company disclosure of non-financial information, allowing investors to start screening whether the economic activities of the firms in their portfolio are ET aligned. In the future, financial institutions must progressively disclose to what extent their portfolios are taxonomy-aligned. By providing a basis for such disclosure, the ET is evolving to become a financial standard that is aimed at both mandatory and voluntary use by investors, in support of mobilization of private finance for sustainable projects (visualized in Fig. 1).

2.2. Mechanisms through which the ET impacts sustainable finance: mandatory and voluntary use

First, the ET represents **mandatory regulation**, providing the basis for other important legislative initiatives in the EU’s sustainable finance

strategy, linked to sustainability reporting – financial and non-financial disclosure, labelling and standards for sustainability-themed financial products. This regulatory framework promotes both **standardization and disclosure**, operating as interrelated governance processes that reinforce one another (Weber, 2018, p. 2). The concepts of standardization and disclosure represent robust mechanisms for analyzing the ET effectiveness from an environmental governance tool perspective.

The mechanism of standardization defines the required characteristics of its subject – in this case sustainable investments or firms – thereby exerting disciplinary power on, and influencing, organizational practices (Sin and Saunders, 2014; Slager et al., 2012a). Standards facilitate the implementation of Green Policy Agendas such as the Paris Agreement and the Green Deal (Barry and Hoyne, 2021; Gilbert et al., 2011), by accelerating the uptake of sustainable finance and investments (Chiapello, 2020). By incentivizing *compliance*, the EU can coordinate sustainable finance efforts and leverage private and public stakeholders to co-finance green solutions under harmonized indicators (Schütze and Stede, 2021). According to Loconto (2015, p. 66), standards are not only harmonization tools but also rather “sociotechnical devices used to discipline and govern humans, things and the processes that bring the two together”. Building on legitimacy theory, *disclosure* standards are used by markets to offer recognition and validation to ‘revealed’ information and sustainability performance to external parties (Gelb and Strawser, 2001; Rezaee and Tuo, 2017) and – consequently – to stakeholders applying this information (Deegan, 2002; Manes-Rossi et al., 2018; Mio et al., 2020; Muserra et al., 2020).

Second, the ET acts as a **voluntary standard** for financial market participants (policymakers, investors, issuers, etc.) providing a common language for aligning financial products, investments, and activities with scientifically rooted criteria. Similar to the mandatory use, the ET provides the basis for voluntary *disclosure* of performance on economic activities, allowing for external monitoring (Nedopil et al., 2021; Schütze and Stede, 2021; Weber, 2018). Via standardization the ET enhances *commensuration* by transforming diverse green qualities into common metrics, facilitating comparability and reducing transaction costs (Slager et al., 2012a; Espeland and Stevens, 1998). The ET creates *legibility* by capturing and reflecting the value of activities across different financing mechanisms (Lawrence et al., 2011; Slager et al., 2012a; Caplan et al., 2013).

2.3. The ET as an enabler of UNBS investment

UNBS studies acknowledge finance as a key barrier to mainstreaming of UNBS (Dorst et al., 2022; Kabisch et al., 2017; Sarabi et al., 2020; Seddon, 2022), and a literature stream that specifically addresses the financing barriers of UNBS is currently emerging (Droste et al., 2017; Hagedoorn et al., 2021; Mayor et al., 2021; Seddon et al., 2020; Toxopeus and Polzin, 2021).

Finance does not readily flow into UNBS for three reasons. First, urban nature is traditionally considered a public good⁵ (Ver Eecke, 1999) and therefore as the (financial) responsibility of municipalities (Droste et al., 2017), who face severe budget constraints and competing political priorities (Kabisch et al., 2017). Their multiple benefits are captured in a fragmented way across different domains and (public/private) stakeholders. For example, real estate owners capture a property value increase (Bockarjova et al., 2020b, 2022), insurance firms might capture lower insurance payouts (Botzen et al., 2009) and different departments within municipalities will value biodiversity (Xie and Bulkeley, 2020), water management (Aguiar et al., 2018) and/or citizen wellbeing (Barron and Rugel, 2023). While the potential of financially benefiting from UNBS implementation is high when jointly

³ Principles of Responsible Investments

⁴ Platform on Sustainable Finance

⁵ “an opportunity for gain for a collectivity because of nonrivalness in consumption, where the opportunity for gain is difficult in finance because of the nonexclusion possibility”

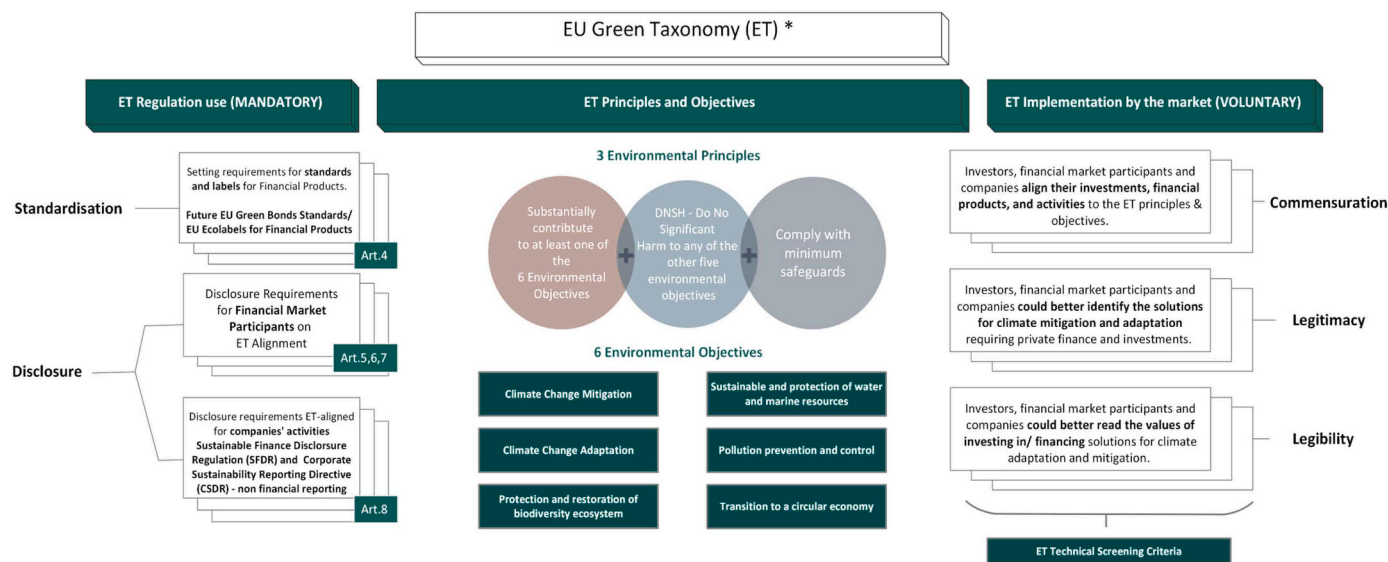


Fig. 1. Mechanisms through which the EU Green Taxonomy may impact investment toward sustainability transitions (Source: Authors analysis). * **ET Principles and Objectives:** a transparency tool based on a classification system that translates the EU's climate and environmental objectives into criteria for specific economic activities for private investment purposes. **ET eligibility:** activities are mentioned in the ET Regulation and Delegated Acts. **ET alignment:** activities meet the sustainability criteria targeted under the ET Regulation and Delegated Acts.

valuing UNBS across benefits and actors (for example in a public-private partnership), few of these decision makers have an incentive to invest in UNBS alone, as the value they capture from their investment will only partially recuperate their upfront costs (Dorst et al., 2022; Droste et al., 2017; Ershad Sarabi et al., 2019; Mayor et al., 2021; Sarabi et al., 2020; Toxopeus and Polzin, 2021).

Inclusion in the ET – which is targeted at financial market participants – can attract private funding by triggering the development of UNBS as new investible asset classes (European Commission, 2015), and signaling their role in the NACE activities that are considered ‘green’. Related, there is insufficient policy development to incentivize the uptake of the UNBS and political short-termism hindering UNBS and its financing (Dorst et al., 2022; Sarabi et al., 2020; Seddon et al., 2020). The ET can address both by providing a long-term European level political commitment towards UNBS through inclusion into its criteria. This long-term approach is especially relevant for performance-based finance for larger corporate actors, financed by green bonds or public equity. Similarly special purpose vehicles for larger projects exclusively rely on the cash-flow from their main operation, such as real estate (Den Heijer and Coppens, 2023).

Second, UNBS are often highly contextual and many are relatively small-scale (Dorst et al., 2022), whereas financial documentation and standardization - including harmonized indicators, valuation and performance metrics - would improve the ability to more precisely channel finance and scale-up investments to a higher number of UNBS projects (Bockarjova et al., 2020a; Raymond et al., 2017; Toxopeus and Polzin, 2021) and would reduce the reliance on donations and other not-for-profit finance.

The ET can incentivize the development of standardized performance metrics for UNBS projects that are consistent with ET screening criteria, to allow for (ET-eligible) financing. The primary impact of the ET is to enhance the legibility and legitimacy of UNBS projects that contribute to NACE activities, while not imposing standardization on project design or financing mechanisms that are tightly linked to geographical specificities and the local context. Instead, the ET focus is to facilitate the scaling up of UNBS by ensuring comparability among the types of financial mechanisms for specific types of UNBS thereby transforming them into investible asset classes. This approach can support scaling and replication of UNBS projects, to build portfolios with enough scale to attract private investment.

One of the most important constraints for private investors of UNBS is the lack of direct financial return (Seddon et al., 2020; Toxopeus and Polzin, 2021). The multiple benefits that UNBS provide (Raymond et al., 2017; Seddon et al., 2020) are captured by different public/private stakeholders, making the promised cost-effectiveness of UNBS difficult to realize in practice (Droste et al., 2017; Mayor et al., 2021; Seddon et al., 2020; Toxopeus and Polzin, 2021). UNBS indirectly contribute to the revenues, turnover and capital or operational expenditure when integrated in activities related to energy efficiency or real estate projects; natural solutions support energy cost savings or signaling to equity investors the actual greenness of the projects (Alessi and Battiston, 2022; Schuetze and Stede, 2020). Since the ET has numerous environmental objectives (Fig. 1), it could be a vehicle for coordinating some of the UNBS benefits to realize improved/integrated business cases for (co-) financiers. Furthermore, increased transparency of UNBS projects through standardization and disclosure within the ET could make their value more salient (legible), improving creditworthiness and investment readiness (Schwarze et al., 2018). Last, the development of non-financial performance metrics for UNBS could attract investors that are interested in both impact and financial return, making relatively attractive compared to traditional, grey investments (Heeb et al., 2023 for a general discussion on the link between impact and financial returns in investor decision making).

3. Methodology and data

This paper adopts a qualitative approach to develop a comprehensive understanding of the potential effectiveness of the ET for investments into UNBS (Creswell, Clark, 2017). First, we analyze the current investment landscape of UNBS. Second, we conduct a systematic text analysis of the regulatory text of the ET and its Delegated Acts in relation to UNBS. Third, we connect these two analyses to understand how the ET can support increased investments into UNBS (Fig. 2). Multiple perspectives, qualitative data and descriptive statistics are intentionally combined reducing the “deficiencies and biases that stem from any single method” (Mitchell, 1986, p. 19). Through this approach and available evidence, we map the potential of the ET as a financial standard and the current investor landscape in UNBS to understand the investor-specific challenges in financing UNBS.

The first part of the analysis (step 1) explores the current

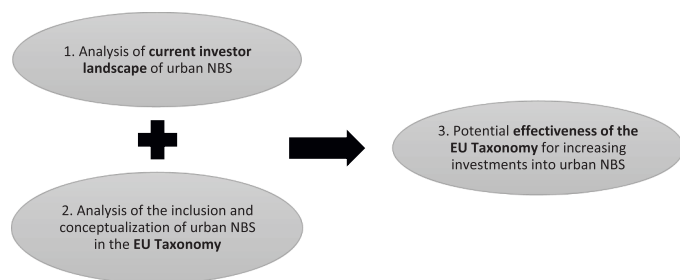


Fig. 2. Analytical approach: addressing the effectiveness of the ET for increasing UNBS investment.

involvement of different types of investors in financing European UNBS and which types of UNBS are attracting private capital. The analysis providing the descriptive statistics is performed on the Urban Nature Atlas database by displaying information of 913 UNBS across European cities, with projects started in 1990–2019, and with the data collection ended in 2020 (Appendix C).⁶ The sample primarily consists of projects conducted during the period of 2004 through 2019 with a significant uptick in project initiation in 2007 and 2015 (Fig. A2 in the Appendix).

The patterns of financial flows across different UNBS categories are examined. The frequency of private investors financing for each UNBS category is quantified (Figs. 3, 4, and 5), with multiple types of UNBS projects receiving multiple streams of financing (Fig. 3). Additionally, the size of investments by eight main investor types is plotted to illustrate their contributions to UNBS interventions of varying scales, pointing out that most projects have more than one financing source (Fig. 6). Monitoring efforts are explored by the analysis of reported impact indicators for each UNBS, describing key performance indicators or other measures of impact. Furthermore, the presence of public records or valuation reports for UNBS supported by corporate investors and public financiers is assessed, noting no publicly disclosed information on the monitoring system or valuation reports (Fig. A3 and A4 in the Appendix).

The second part of the inquiry (step 2) is a qualitative, in-depth document analysis of the EU Taxonomy Climate Delegated Act and related annex. We examine if and how UNBS are included in the ET for climate change mitigation and adaptation, i.e. which NBS types are explicitly mentioned and under what terms, by using the Nvivo software

for both counting words and tagging them according to their recurrency.

The process was implemented by two different researchers and include both comprehensive reading as well as counting specific occurrences of words to ensure inter-coder reliability. The concept of NBS and specifically references to its urban applications in the ET are investigated via the in-depth document analysis. To demarcate UNBS types, we follow the classification provided in the Urban Nature Atlas database (Almenar et al., 2021), which was developed from well-accepted categorizations and is also utilized in the analysis of the current financing conditions for UNBS (Table 1).

As a final step (3), we combine our descriptive analysis of the current UNBS investment landscape from step 1 with our in-depth analysis of UNBS inclusion in the ET and its annexes in step 2 (Table 1).

4. Results

4.1. Current financing landscape of UNBS

Our findings reveal the predominant role of public actors as investors in UNBS, with municipal authorities being the primary financiers (582 cases). EU funds, regional and national governments also significantly contribute (between 160 and 180 cases). While there is some UNBS investment from corporates (157 cases), NGOs (114 cases), foundations/trusts (100 cases), and crowdfunding (58 cases), financial players such as private equity funds, multilateral funds, and commercial banks are notably underrepresented in our dataset.⁷ Even when UNBS receive corporate or not-for-profit funding, public finance plays a crucial role. The majority of corporate-supported UNBS projects are co-financed, often involving co-investment with public actors. Notably, there has been a slight increase in private companies supporting UNBS projects initiated after the Paris Agreement (post-2015).

Regarding project size, public investors (EU, national, regional, or municipal) show a preference for larger-scale UNBS investments (above EUR 4mn.), with municipal budgets serving as the most common financial resource for such projects (146 cases). Approximately 34 % of UNBS funded by corporate investors involve co-funding for large-scale investments. Corporate UNBS investments primarily rely on direct funding, subsidies, and donations, indicating that profitability is not the primary motive for these investments. Notably, institutional investors such as pension funds or insurers are absent from our database, suggesting limited meaningful contributions from this investor type in

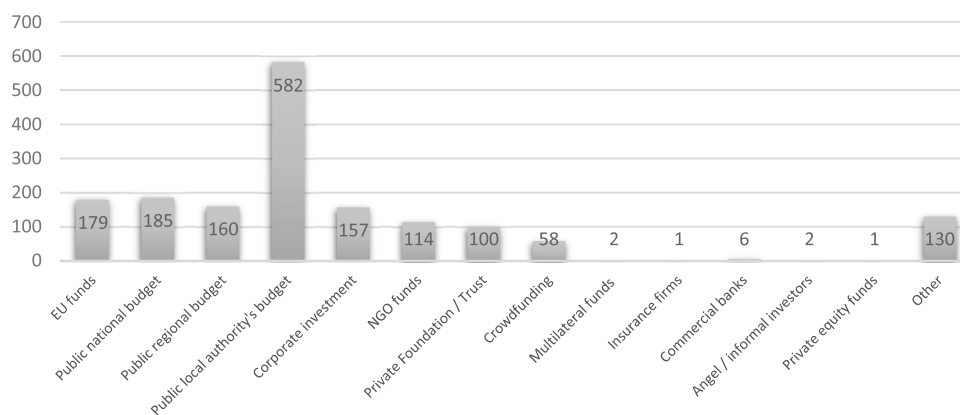


Fig. 3. Number of NBS financed by each financing source.

⁶ The initial dataset contains 1000 UNBS. We removed NBS from the sample whose financing source was unknown. More details on the data collection and data building process are provided in Appendix C.

⁷ Only 1 UNBS is supported by a private equity fund, 2 UNBS are supported by multilateral funds, 6 UNBS are supported by commercial banks and 1 UNBS is supported by an insurance firm.

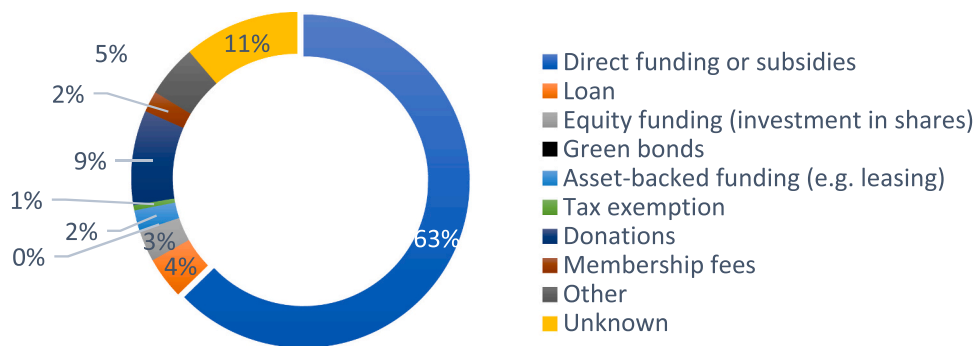


Fig. 4. Instruments used to finance UNBS via corporate investment.

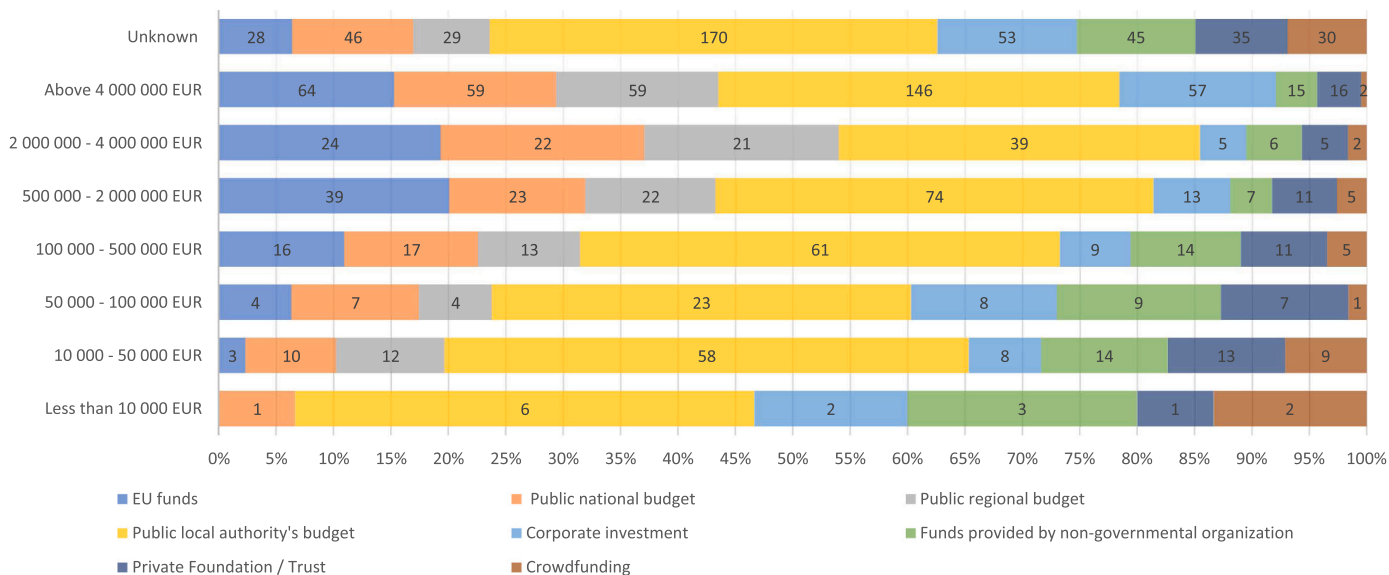


Fig. 5. Distribution of financing sources by different sizes of investments in UNBS.

financing UNBS in the EU.

The analysis shows that the lion’s share of corporate investment, which represents the most meaningful private investment in UNBS within our data, is direct funding, subsidies or donations (Fig. 4). UNBS currently lack investment via profit-seeking financial instruments. Most corporate investment is channeled toward external building greens (37 %) and urban grey infrastructure with green features (17 %), e.g., green parking lots, suggesting that corporate investors green their own real estate assets, such as office spaces (Fig. 4).

All these investments lack a formal monitoring system including official targets and evaluation processes set on the project and checked by official bodies on a recurrent basis, as well as publicly available impact reporting (Fig. A3, Fig. A4, and Appendix). A comparison of the indicators for measuring impact reveals a dispersed set of publicly reported markers with no pattern or strategy of reporting for the same type of UNBS projects or by the same type of investors.⁸ More than 65 % of the selected UNBS do not have any public records (Fig. A3, Appendix) for any kind of monitoring system. The corporate investors’ disclosure on the existence of formal monitoring systems exhibits the lowest level for specific UNBS categories, namely parks and seminatural urban green areas (69 UNBS), urban green spaces linked to grey infrastructure (48

⁸ The descriptive information varies among the attained key performance indicators, certificates received, outputs and outcomes of the UNBS in relation with CO2 reduction, water protection, temperature decrease, etc. or other climate mitigation or adaptation effects.

UNBS), blue areas (35 UNBS), and community gardens (32 UNBS) (Fig. A3, Appendix).

Note: The number of UNBS calculated per urban setting do not add to 100 % since one project may have been financed by more than one type of funding.

4.2. Inclusion and conceptualization of UNBS in the EU Taxonomy

The ET explicitly refers to the use of UNBS for climate mitigation and adaptation, adopting the definition of NBS used by the European Commission (2022). This definition of NBS used in the ET explicitly incorporates urban interventions as eligible for investment: “Such solutions increasingly bring more diversity nature and natural features and processes into cities, landscapes and seascapes, via locally adapted, resource-efficient and systemic interventions”(European Commission, 2022, p. 6).

The ET’s technical screening criteria – which includes the standardized characteristics of sustainability for both climate change mitigation and adaptation – also refers to UNBS. NBS that occur in an urban setting are explicitly mentioned in relation to specific measures linked to climate mitigation - for example green roofs to enhance energy efficiency - or to capture and store carbon, such as protection and restoration of wetlands. Regarding climate change adaptation, UNBS are positioned as measures to address flooding and storm water management, cooling, and education related to climate change, and priorities associated with

public authorities but less often corporate investors. Specifically, criterion 4.b of the ET serves to *prioritize* that adaptation solutions should “favor nature-based solutions or rely on blue or green infrastructure to the extent possible” (European Parliament, 2020, p. 15). NBS are therefore not only recognized in the ET, but also recommended as suitable tools to enhance compliance for climate adaptation across sectors and business activities. The business sectoral approach is also mapped by identifying the NACE categories – with four digits - for all the UNBS mentioned within the ET (Table 1).

Despite the broad legitimization of the concept of NBS in the ET, and explicit recommendation of its use for adaptation purposes, we find that only four (sub)types of UNBS are explicitly incorporated into the framework: (1) wetlands, (2) green areas for water management, (3) green walls, facades, roofs, and (4) botanical gardens.

First, wetlands are strongly endorsed within the ET for both climate mitigation and adaptation purposes. Wetlands⁹ is an expansive category within the ET, encompassing both the urban and rural context, which falls largely under ‘blue areas’ in the UNBS categories. Wetlands are considered to have high capacity for carbon storage and are therefore protected in the Do Not Significant Harm criteria for economic activities in the forestry sectors (i.e., afforestation). Second, green areas for water management are explicitly named in relation to the economic activities “construction, extension and operation of wastewater collection and treatment” and “renewal of wastewater collection and treatment” (European Commission, 2021, p. 116–120,160–165). In the technical criteria for both climate mitigation and adaptation, UNBS are mentioned as tools that could serve as alternatives to grey approaches to “mitigate excessive storm water overflows”. Third, green roofs, external walls and facades are considered part of the economic activity “individual measures and professional services” in the real estate industry to address climate change. They are included within the ET as eligible for sustainable investment both for climate mitigation and adaptation. In this context, the “installation of façade and roofing elements with a solar shading or solar control function, including those that support the growing of vegetation” are deemed eligible under the ET (European Commission, 2021, p. 174,249). Finally, botanical gardens are eligible to contribute to climate change adaptation (not mitigation) as part of the economic activity “libraries, archives, museums and cultural activities”, which are considered a means to implement environmental education projects offering guidelines and increasing awareness on green and sustainable transitions. To highlight these findings, and the missed potential of the ET for legitimizing these UNBS, we also matched the NACE green activities mentioned under the ET to the missing UNBS (Table 1).

4.3. Effectiveness of the ET as a financial standard for increasing UNBS investments

The effectiveness of the ET for unlocking private investments is likely to be heterogeneous across UNBS (sub)types, depending on existing corporate investment in a (sub)type and its explicit inclusion in the ET (Fig. 6). For example, external building greens (green roofs, facades, and walls) are specifically mentioned in the ET for both mitigation and adaptation, and a significant level of corporate investment (37 % of all corporate investment in UNBS). Blue areas and green areas for water management, are both explicitly included in the ET (both adaptation and mitigation) and have some corporate investment inflow (9 % and 15 %, respectively). Two other UNBS types that attract corporate investment are absent in the ET: urban green space connected to grey

⁹ Defined to “include a wide variety of inland habitats such as marshes, wet grasslands and peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, intertidal mudflats and seagrass beds, and coral reefs and other marine areas no deeper than six meters at low tide, as well as human-made wetlands such as dams, reservoirs, rice paddies and waste water treatment ponds and lagoons” (European Commission, 2021, p.34).

infrastructure (17 % of corporate UNBS funding) and allotments and community gardens (9 % of corporate UNBS funding). Both indoor green spaces and derelict areas are excluded from the ET and lack corporate investment, making it unlikely that these UNBS categories will profit from the ET framework.

The mentioned UNBS types lack a formal monitoring system and publicly available information on their contribution to the environmental goals. The lack of standardization is reflected in not only the design of UNBS but also in the way both project implementers and investors declare the achieved impact publicly available (Fig. A3 and A4, Appendix). The mandatory ET standards on disclosure address these gaps and could have a consistent contribution in improving the publicly available monitoring systems, especially on corporate UNBS investments.

In summary, the ET seems to promote private investment into UNBS by a high-level legitimizing effect of the general concept of NBS with mention of its application in cities. Importantly, the ET includes specific UNBS as being ET-eligible for mitigation and/or adaptation as part of its sector-based criteria, most of which are UNBS (sub)types that already receive some corporate funding (external building greens, blue areas, and green areas for water management). External building greens represent a ‘sweet spot’ where (nearly 40 % of) corporate UNBS investment is received (Fig. 6) and ET inclusion is explicit for both mitigation and adaptation: real estate is the domain of private/institutional investment, which makes private funding flows toward this UNBS a logical step. However, in other domains, specific UNBS are absent. The high-level legitimizing effect of the ET is not translated into concrete inclusion in the financial standard, since several categories that already witness some corporate funding flows are not included (urban green spaces and allotments/community gardens).

The missing attention of financial players (insurers, banks, and pension funds) in the funding landscape of UNBS is an important outcome of our analysis, showing that UNBS in European cities are currently highly dependent on public actors, some (non-profit seeking) corporate investments and not-for-profit – funding. Corporate investments therefore seem to be a potential ‘linking pin’ between private UNBS investment and the ET – corporations are included in investor portfolios and UNBS thus indirectly enter into financial holdings. However, we also show that corporate UNBS funding is predominantly not profit-seeking, but mostly consists of direct funding, subsidies and donations.

The inclination toward profit-seeking behavior is further supported by matching the mentioned UNBS with the NACE codes specifically associated with ET green activities. Notably, investments related to the NACE categories F, M, and C (as detailed in Table 1 at 2 and 4 digits) represent highly attractive sectors for direct returns on investments and by acting as a green signal - reduction in corporate actors’ cost of capital. However, we also conducted a similar matching process for the NACE categories corresponding to the unmentioned UNBS under the ET categories. There exists untapped potential within the ET sector to draw attention to the utilization of UNBS categories E-H (Table 1) for green activities encompassing agriculture, forestry, fishing, construction, and real estate. These sectoral activities might have the potential to attract investors with the same motivation of cost reduction and increased profitability as the other UNBS classes.

Our results show that while the ET acknowledges the urban aspect of NBS, specific manifestations of UNBS – such as blue areas – are not explicitly connected to potential urban applications. Currently, a narrow operationalization of the ET toward climate mitigation/adaptation also limits NBS-eligibility and therefore, a broader consideration by financiers.

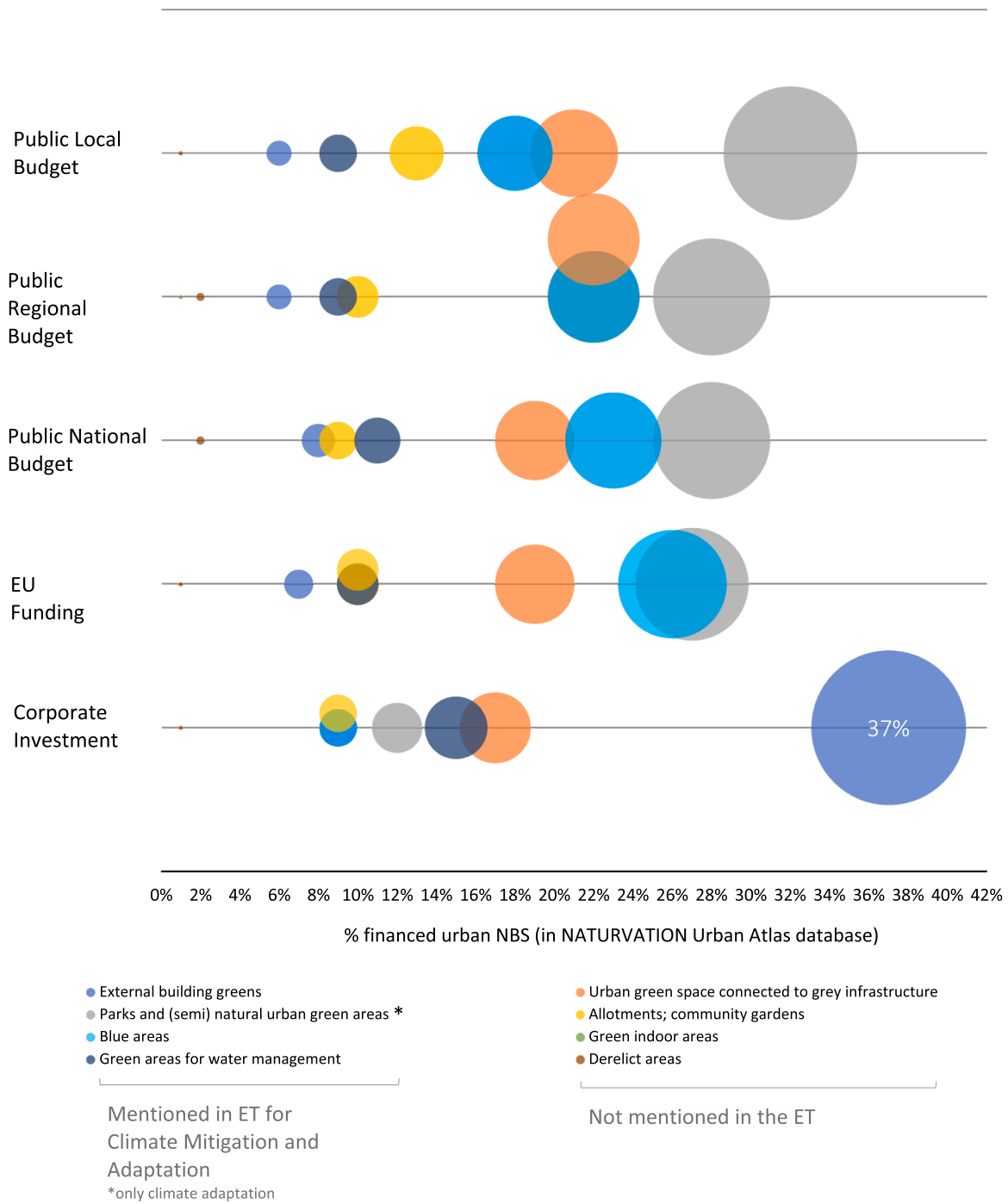


Fig. 6. Comparative distribution of five main sources of finance by type of urban NBS (full data in Table 1).

5. Discussion

The recent development and implementation of the ET in Europe points to whether such a financial standard can support investment in sustainability transitions. Our analysis of the current investment landscape of UNBS and its conceptualization and inclusion in the ET standard suggest three ways in which this policy instrument may support UNBS finance with wider lessons for sustainability transitions.

First, the ET serves to legitimize UNBS as a form of ‘green’ investment for private investors, disrupting the traditional view that urban nature investment is the domain of public authorities alone (Droste et al., 2017; Mayor et al., 2021) and demonstrating high level political commitment that can contribute to mainstreaming (Tozer et al., 2022;

van der Jagt et al., 2023). Second, the coherent and long-term nature of the ET standard also counters the political short-termism that is often mentioned as a barrier to investment in UNBS (Abeysekera et al., 2021; Dorst et al., 2022; Droste et al., 2017; Leuz and Wysocki, 2016). In categories with strong interest amongst private investors in UNBS – for example external building greens for energy efficiency – there is a potential ‘sweet spot’ where explicit linking with the ET could drive further investment. By making nature-based elements of buildings ‘visible’ by disclosure via the ET, their presence can be integrated into investment decision-making processes in a specific asset class (e.g., real estate) and rewarded with ET-compliance, potentially re-routing private finance.

However, by only including a few specific UNBS (sub)types into specific ET-eligibility criteria, many UNBS cannot profit from these

Table 1
Categories and subtypes of UNBS included in the ET's objectives compared to current investment flows into UNBS.

UNBS Category (URBAN NATURE ATLAS ^a)	Specific manifestations of UNBS included in the category (subtypes)	(U)NBS from this category that are ET eligible (using ET's wording)	NACE related Codes	For which EU environmental objective?		% per financier flowing to a certain UNBS type				
				Climate Change		Corporate funding	EU funding	Public National Budget	Public Regional Budget	Public Local Authorities Budget
				Mitigation	Adaptation					
A. External building greens	Green roofs; green walls and facades; balcony green	Green roofs and green walls/facades	Installation, maintenance and repair of energy efficiency equipment - F42, F43, M71, C16, C17, C22, C23, C25, C27, C28, S95.21, S95.22, C33.12	X	X	37 %	7 %	8 %	6 %	6 %
B. Blue areas	Lake/ pond; river/ stream/ canal/ estuary, delta, seacoast, wetland/ bog/ fen/ marsh	Floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, intertidal mudflats and seagrass beds, and coral reefs and other marine areas no deeper than six meters at low tide.	Restoration of Wetlands - class 6 of the CEPA ^b (no NACE) Infrastructure for water transport - F42.91, F71.1 or F71.20, E	X	X	9 %	26 %	23 %	22 %	18 %
C. Green areas for water management	Rain gardens, swales/filter strips, sustainable urban drainage systems	Dams, reservoirs, rice paddies and wastewater treatment ponds and lagoons; Sustainable urban drainage system	Restoration of Wetlands - class 6 of the CEPA (no NACE) Renewal of waste water collection and treatment - E37.00	X	X	15 %	10 %	11 %	9 %	9 %
D. Parks and (semi) natural urban green areas	Large urban park or forest; Pocket parks/ neighborhood green spaces; botanical garden; green corridor	Botanical gardens	Creative, arts and entertainment activities - R90 Libraries, archives, museums and cultural activities - R91		X	12 %	27 %	28 %	28 %	32 %
E. Urban green space connected to grey infrastructure	Alley and street trees/ hedges/ greens; house gardens, green playground/ school grounds; green parking lots; riverbank greens	No mention	** Construction and real estate (F, L, N81, R91, NACE category)			17 %	19 %	19 %	22 %	21 %
F. Allotments; community gardens	Food production areas; horticulture	No mention	** Agriculture, Forestry and Fishing (A NACE category)			9 %	10 %	9 %	10 %	13 %
G. Green indoor areas	Indoor vertical greeneries (walls and ceilings); atrium	No mention	** Construction and real estate (F, L, N81, R91, NACE category)			0 %	0 %	0 %	1 %	0 %
H. Derelict areas	Abandoned and derelict spaces with growth of wilderness or green features	No mention	** Agriculture, Forestry and Fishing (A NACE category)			1 %	1 %	2 %	2 %	1 %

** NACE codes are not mentioned directly under ET Regulation as the solutions are not mentioned. This is a manual matching provided by the authors to exemplify.

^a <https://una.city/>.

^b CEPA statistical classification of environmental protection activities.

(Source. Naturvation Urban Atlas).

advantages (Schütze and Stede, 2021). Because of its focus on climate mitigation and adaptation, many (co-)benefits of UNBS (Raymond et al., 2017) are not recognized and therefore do not benefit from the legitimation and leverage the ET provides. This is an especially missed opportunity for UNBS types that already attract some corporate funding (e.g., urban green space connected to grey infrastructure and allotment gardens), and produce a multiplicity of social, economic and environmental benefits. Extending the range of benefits that are recognized within the ET has the potential to generate more opportunities for UNBS investment, which is also important because our results show that UNBS connected to traditional asset classes – such as real estate – might be included more readily in the ET than emerging technologies and novel infrastructures. Recent studies express concerns toward the ET as stifling innovation, especially in promoting investments for breakthrough technologies (Schütze and Stede, 2021) which may also disadvantage innovative UNBS types (Toxopeus and Polzin, 2021) that do not yet ‘fit’ into existing asset classes.

5.1. Drawing institutional investors into UNBS investments

Institutional investors have not been active to the UNBS financing to a large degree yet, which considering the multiple financing challenges it is not unforeseen: UNBS projects required a relatively young, small sized, and innovative nature of the finance. These characteristics affect the risk and cost profile of the projects. The path to unlock institutional capital towards UNBS is twofold: on the one hand, more tailored investment opportunities may be created by leveraging the ET, on the other hand, institutional investors may further develop their impact investment strategies to leave some (prudent) room in their investment mandates for more innovative and additional investments.

A key challenge in leveraging ‘sweet spots’ is that institutional investors play no role in the current UNBS investment landscape, whereas they are the primary target group of the ET. Public actors – especially municipalities – comprise the largest share of UNBS funding, whereas corporate investment is also considerable. Drawing institutional investors into UNBS is therefore a key issue to address. Our results show that one way for institutional investors to invest in UNBS is by holding shares of corporations that fund UNBS. By standardizing and disclosing (Weber, 2018) UNBS characteristics of corporates consistent with ET screening criteria (e.g., disclosing the presence of green roofs/facades on real estate assets of corporations), institutional investors are enabled and incentivized to invest (Heeb et al., 2023) in corporations that fund UNBS and, therefore, become ET-aligned investors. This may particularly be a promising approach in real estate and infrastructure assets, where corporates contribute most to UNBS.

Another approach to institutional investment - considering the large share of public investments in UNBS – is the use of (green) bond markets, in which public actors could ‘sell’ portfolios of public UNBS investments to the market. Disclosure through the ET could increase the transparency of such public infrastructural projects by offering a legible value of UNBS and thus improve their bankability and creditworthiness (Schwartz et al. 2018).

Green bonds are an attractive financing tool for infrastructure projects and could channel institutional (private) funding into UNBS interventions using municipal balance sheets (Brand and Salzgeber, 2019; Tozer et al., 2022), especially since the ET serves as the basis of the EU Green Bonds Standards (Fig. 1). The issuance of green bonds by (local/regional) public authorities could support large-scale NBS projects, tapping into institutional investors’ large capital holdings and diffusing UNBS projects (Monk and Perkins, 2020; Pastor et al., 2022). Green bonds could provide a potentially low cost and long-term source of capital when compared to traditional financing methods such as bank

loans, that can come with higher interest rates and more stringent lending criteria. Green lending or project finance does not bring any direct returns to the financiers, green bonds standing out as a more promising financial vehicle for scaling-up NBS projects.

Third, public-private co-investment via ET-eligibility is another route to attract private UNBS investment. Our results show that UNBS, which attract corporate investments, are often publicly co-financed. Assuming that public actors will remain important financiers of UNBS even when private funding is drawn in (Mayor et al., 2021; Toxopeus and Polzin, 2021) and acknowledging that risk-return ratios may become more attractive when investments are de-risked by public players (Geddes and Schmidt, 2020), the ET may serve as a vehicle for enabling public-private co-investments (Seddon et al., 2020; Toxopeus and Polzin, 2021) and accelerate sustainability transitions (Markard et al., 2020; Steffen and Schmidt, 2021). By initiating ET-eligible UNBS projects and actively seeking co-investment, public actors could validate their own investment as climate-friendly and draw in private investors to the field of UNBS.

5.2. Recognizing and capturing multiple NBS benefits

One opportunity that the ET currently does not (yet) capitalize on is its potential to support and incentivize investments into projects that support multiple environmental and/or social objectives (European Commission, 2021) such as UNBS, which are considered cost-effective due to their multiple benefits (Raymond et al., 2017; Seddon et al., 2020). Therefore, by a standardized implementation of ET criteria and financial and non-financial disclosure, investors could observe the clear objectives to which they contribute as well as the financial benefits; the coordination of objectives and financiers could make NBS financing more attractive (Toxopeus and Polzin, 2021). Our analysis shows that ET-eligibility does not require a substantial contribution to more than one of the six environmental objectives. The current climate-focus of the ET highlights the potential of UNBS primarily in adaptation and mitigation terms, while their potential to simultaneously contribute to other objectives of the Green Deal - e.g., realizing biodiversity goals (Xie and Bulkeley, 2020) or enabling just transitions (Cousins, 2021) – remains unaddressed to date. Thus, the ET currently does not address a key challenge of NBS finance, namely the need to recognize the multiple benefits of NBS (Raymond et al., 2017) to make the business case attractive (Mayor et al., 2021; Sharfman and Fernando, 2008; Toxopeus and Polzin, 2021). By requiring investments to contribute to at least two of the total six objectives, the ET could make the disclosure of multiple benefits mandatory, and encourage more cost-effective sustainability investments by incentivizing the integration of different environmental objectives.

6. Conclusion and policy implications

UNBS are considered a promising transition path to sustainable development in Europe (European Commission, 2015; Maes and Jacobs, 2017) while the ET represents a key policy intervention aimed at re-routing finance toward Europe’s sustainable economic activities (HLEG, 2018; Schütze and Stede, 2021). In this study, we analyze the ability of this financial standard to support UNBS financing with the aim of taking stock of its ability to steer investment into specific sustainability transitions.

Future research could broaden the existing analysis. Scholars could explore other compliance and disclosure standards or taxonomies still in development such as voluntary environmental, social and governance (ESG) ratings or upcoming mandatory regulations such as the Corporate Sustainability Reporting Directive (CSRD) and their effect on mobilizing

private financial institutions (Beerbaum, 2021). This exploration might be especially relevant as previously disregarded areas such as biodiversity are being incorporated into financial regulation as they pose significant financial risks (Kedward et al., 2022).

More specifically, we suggest codifying UNBS in investors' portfolios or as company characteristics and link these to financial performance metrics (such return on investment or cost of capital) to explore the relationship between return and impact and thus further highlight the mandatory (compliance and disclosure) as well as voluntary (commensuration, legitimacy and legibility) use of the ET.

The insights of this study can be employed by policymakers for the ET's further development, implementation, and evaluation. First, we recommend policy makers to investigate those UNBS that are not yet included in the ET, such as urban green space connected to grey infrastructure and urban green areas for water management, and to envision a process by which ET-eligibility can include the innovative and/or urban interventions of sustainability transitions.

Second, we suggest several indirect routes for policy makers to draw in private, profit-seeking investment to sustainability transitions such UNBS: the ET eligibility of certain UNBS, via its standardization and disclosure mechanisms, can be promoted and used by public actors - that already invest - to engage institutional investors, for example under green bond issuance or public-private co-financing instruments. We particularly suggest public investors to start applying the ET guidelines and disclosing obligations towards the ET for UNBS, to develop best practices and to create momentum for leveraging private finance via the ET financial standard. Furthermore, institutional investors can be drawn in by selecting corporate actors that fund UNBS. We recommend future research investigates these (more indirect) mechanisms of accessing institutional UNBS investment via the ET.

Appendix A

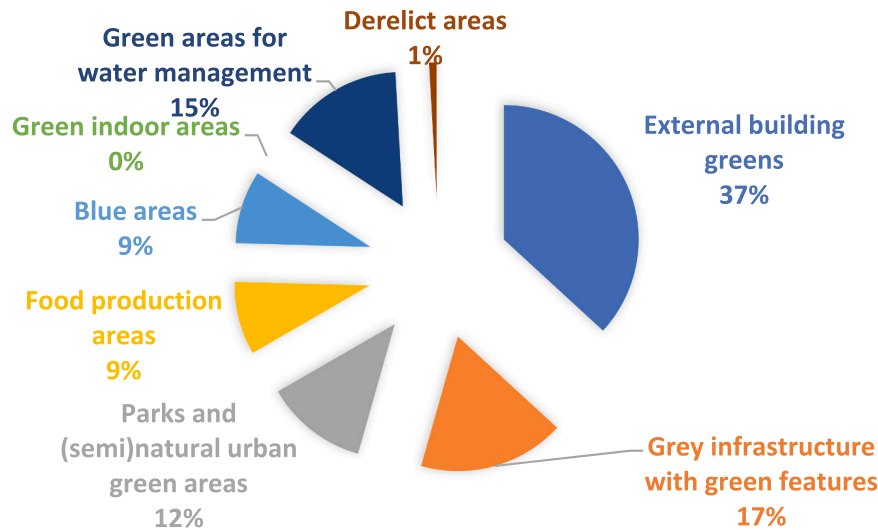


Fig. A1. Distribution of corporate investments by type of urban NBS.

Third, we recommend incentivizing green investments that contribute to multiple objectives, rather than only referring to the 'do no harm' principle for other objectives (i.e., following ESG or multiple SDGs targets). This approach would create a strong impulse for interventions such as UNBS that simultaneously offer multiple sustainability benefits (Raymond et al., 2017) and thus become cost-effective; such an integrated approach could lead to more effective use of public and private finance in Europe, with more intelligent decision-making on the use of its scarce resources (public budget, time, and space). This discussion perfectly fits within the context of ET extension on the other four environmental objectives, building up on future Delegated Acts.

Finally, the EU market should raise the bar of advancing its financial disclosure policy and green financing efforts to other global initiatives that financially support biodiversity and UNBS.¹⁰ Public funders, corporate investors and decision makers across the world need to be confident that the UNBS they support are scalable and effective, and the ET should not be a frail chance to advance the EU UNBS investments at the global stage. While our paper focuses on the EU Taxonomy, other taxonomies, such as those in Canada and the UK, are being developed based on the EU framework.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

¹⁰ Global Environment Facility, Global Forest Finance Pledge, UCN Global Standard for NBS LEAF Coalition, China's Kunming Biodiversity Fund, US Conserve and restore forests, New Zealand launched the NBS for Climate Manifesto - Nature Based Solutions for Climate, United Nations, 2019

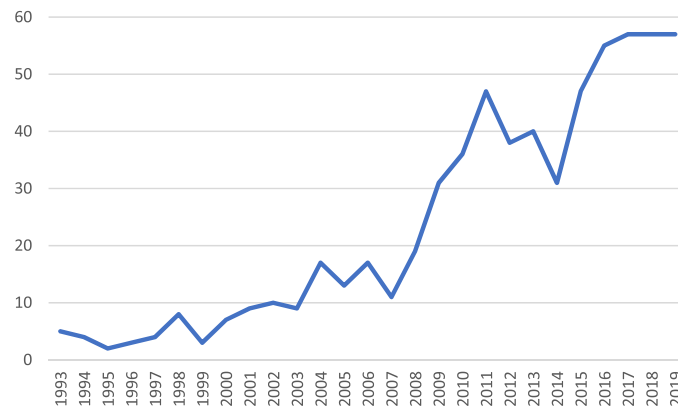


Fig. A2. Distribution of UNBS initiated projects every year (300 projects with missing records for the starting date).

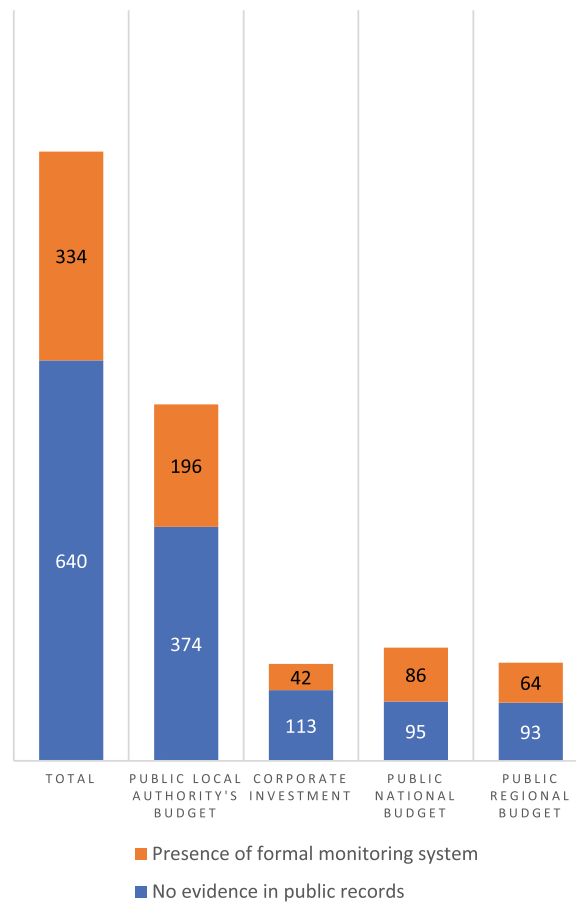


Fig. A3. Public Disclosure on monitoring system.

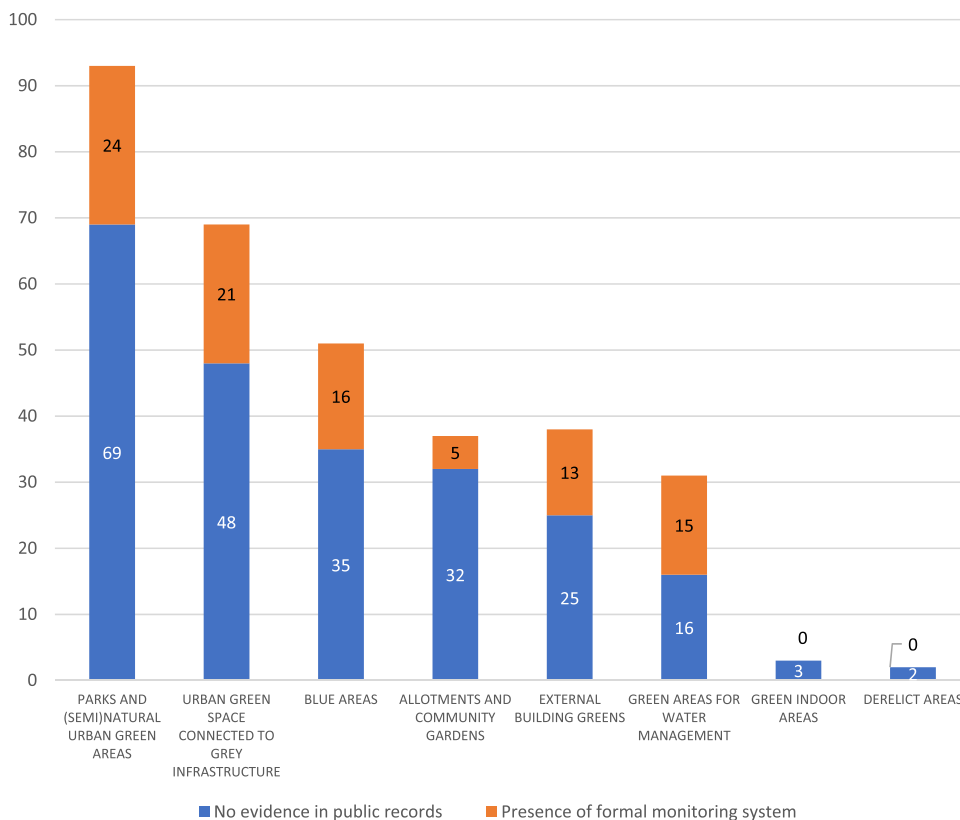


Fig. A4. Public disclosure on monitoring system for UNBS types supported by Corporate Investors.

Appendix B

Table B1

Financial models for UNBS.

Type	Model	Description	
Public financing, public funding	Taxation	Levying new general taxes or shifting tax systems to generate and allocate revenue for NBS investments	
	Grants	Public capital raised through grant programs, often for specific projects	
	Public co-financing	Combining the funds of various government departments benefitting from NBS investments	
	Development banks	Debt, equity, or grants sourced from governmental financing facilities	
	Endowments	Transfer of public capital to private managers, who subsequently apply the return-on-investment of this capital to finance NBS projects	
Public financing, private funding	Participatory budgeting and competitions	Existing public funds are allocated at the discretion of local communities or through competition between citizens	
	Developer obligations	Land value capture instruments allowing public authorities to request compensation for costs incurred when permitting new development, including infrastructure provision	
	Private financing, public funding	Betterment taxes, 'park tax'	Land value capture instruments to recover windfall value gains of property caused by public NBS investments
		Tax increment financing, special assessment districts	Land value capture instruments where, in demarcated districts, public authorities earmark surplus property tax revenues to fund the infrastructure projects that produced the tax increment
	State revolving loan funds	Government funds provide capital for NBS, with repayment mechanisms in place to recoup the investment	
	Utility fees	Fees charged to utility users to compensate for the use and maintenance of utilities, including NBS measures	
	Commercial exploitation	Monetizing the use of public green space by receiving payments from ticketed events, concessions, or corporate sponsorship	
	Green bonds	Fixed-income securities of which the proceeds are earmarked for sustainable investment	
	Environmental impact bonds (EIBs)	Green bonds with yield directly tied to the performance of underlying environmental projects	
	Policy performance bonds	Bonds that tie yields to how well policy objectives are achieved	
GARVEE bonds	Fixed-income securities backed by anticipated grant funding in the future		
PACE bonds	Fixed-income municipal securities which raise capital for sustainable investment of private property owners, and which are funded by reassessments of the property taxes of the participating entities		
Private financing, private funding	Catastrophe bonds (CAT)	Securities that raise capital for damage claim compensations following disasters	
	Resilience bonds	Securities that build upon the structure of CAT bonds to monetize avoided insurance costs resulting from resilience projects, to finance these resilience projects	
	Standard equity and/or debt finance	Capital provided through ownership stakes, commercial loans, or other types of regular debt instruments	
Private financing, private funding	Insurance-based finance	Investments in NBS by insurance companies, based on the risk-reduction effects of NBS	
	Philanthropy and charity funding	Donations to NBS projects by philanthropic organizations	
Private financing, private funding	Crowdfunding	Raising small amounts of funds from a large audience, often through digital platforms	

(continued on next page)

Table B1 (continued)

Type	Model	Description
	Community/Crypto currencies	Monetary subsystems with the aim of supporting local socio-economic and/or environmental agendas
	Community asset transfers, Land Trusts	Transfer of NBS assets and responsibilities to private management, often to reduce public budget dependency
	Transferable development rights (TDR)	Market system to secure undeveloped and ecologically valuable parcels by allowing actors to trade and sell unused development rights
	Business improvement districts (BID)	Districts in which local enterprises voluntarily commit to financing public services above those provided by the local authority
	Household/business investment	Private entities' investments in NBS, not necessarily tied to incentive programs
	Collective private commissioning	Private actors combine funds to commission larger-scale NBS implementations
	Credit trading systems/cap-and-trade systems	Market systems that allow entities to purchase credits to offset environmental impacts
	Payment for Ecosystem Services (PES)	Market systems in which beneficiaries of NBS voluntarily pay the providers of NBS
Hybrid financing and funding	Blended finance, incentives	Techniques that use government funds to stimulate private investments in underdeveloped or inaccessible markets, including incentives, certification schemes, preferential loans, etc.
	Public-private partnerships	Partnerships between private and public entities to source private capital for government investments

Source: (Den Heijer and Coppens, 2023).

Appendix C. : Information about the Nature Atlas Dataset and the sample used in this paper

Data extraction for the Nature Atlas dataset ended in 2020 and was processed in the current database by the end of the NATURVATION project in 2021, just before the start of ET implementation. Initially data collection took place from June to mid-August 2017, with 20 interns from CEU, Lund University, and Utrecht University utilizing the online questionnaire. In 2017 first data collection was completed, and in September 2017, data analysis and the development of the online public platform were initiated. The collected data was cross-referenced with external documents related to the specific projects.

Until the present day the dataset is updated being hosted by a new platform, comprising also Global and Asian Extension 2021–2022. However, in this study we use only EU based data, up to 2021.

In terms of timescale, 50% of the UNBS were completed by June 2017, while 40% are currently being implemented. Section 1, Section 4 (with focus on category iv. Financing aspects and i. key actors and stakeholders), Section 6 (particularly i. impacts and iii. Presence of impact assessment mechanisms) were primarily used in the analysis proceeded in this paper.

For a more comprehensive understanding of the data collection and sample selection, refer to Almassy et. al. (2018) the study by which served as a guiding reference for our research.

Table C1

From Almassy et. al. (2018) Overview of the questionnaire Nature Atlas – NATURVATION.

Section 1. General Information	(i) Location and description of the project in which basic information about the intervention is requested such as the name of the project, country and city of origin, short description, (ii) contact information and (iii) timeline
Section 2. Objectives	Goals of the intervention, quantitative targets and underlying monitoring indicators, implementation activities and sustainability challenges addressed.
Section 3. Key characteristics	(i) Ecological domain(s) where the NBS was/is being implemented, (ii) ecosystem services provided , (iii) spatial scale and (iv) primary beneficiaries . The NBS ecological domains and scale were defined by the project, while the classification of ecosystem services used the TEEB classification system.
Section 4. Governance and financing	Governance arrangements , including (i) key actors and stakeholders involved in the planning and implementation of NBS, participatory methods used; (ii) policy drivers of the NBS intervention at EU, national and local levels; (iii) enablers of the project e.g., strategies, research projects, subsidies; (iv) financing aspects , such as the sources of funding, total cost and types of funding used.
Section 5. Innovation	Innovation potential with technological and/or social components, novelty level and replicability or transferability potential.
Section 6. Evaluating and Learning	(i) Impacts of the NBS intervention (environmental, social and economic) and which indicators were used to assess them; the (ii) evidence for use of the assessment ; (iii) presence of impact assessment mechanisms and (iv) if there was citizen involvement in the assessment/ evaluation and analysis
Section 7. Sources	References and links to source materials used.

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