PHISHES

PHysically-based Integrated Soil HEalth Simulation platform

Predicting soil health to protect ecosystems

D 5.3. Scientific Opinion Paper:

Policy Instruments for Nature-based Solutions

DRAFT (PENDING EC APPROVAL)

Authors: Kloppe, A.

Disclaimer

This report was written as part of the PHISHES project under EC grant agreement 101157438. The information, documentation and figures available in this deliverable were written by the PHISHES project consortium and do not necessarily reflect the views of the European Commission. The European Commission is not liable for any use that may be made of the information contained herein. This paper also does not necessarily reflect the views of the Umweltbundesamt, and the Umweltbundesamt is not liable for any use that may be made of the information contained herein.

Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

How to quote this document?

Kloppe, A. (2026). Scientific Opinion Paper: Policy Instruments for Nature-based Solutions. (PHISHES Deliverable 5.3)

This deliverable is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0).

DRAFT (PENDING EC APPROVAL)

Project Acronym: **PHISHES**

Project Full Title: PHysically-Based Integrated Soil HEalth Simulation Platform

Grant Agreement Number: Project: 101157438 - HORIZON-MISS-2023-SOIL-01

Type of Action: **HORIZON-RIA**

Deliverable number	**5.3.**
Deliverable name:	Scientific Opinion Paper: Policy Instruments for Nature-based Solutions
Dissemination level:	
Type of document:	Scientific Opinion Paper
Deliverable Leader:	Anna-Sophie Kloppe
Delivery due date:	31/05/2026
Actual date of submission:	31/05/2026
Deliverable description:	Scientific Opinion Paper that discusses the debate around Nature-based Solutions (NbS) definitions, knowledge gaps and critiques. In the second part of the paper, the legal and policy framework for NbS is delineated on an EU level and on Member State level for each of the PHISHES test cases (Czechia, Poland, the Netherlands and Sweden) to show what enablers and barriers to NbS usage are.
WP / WP number:	5
Lead author(s):	Anna-Sophie Kloppe
Contributors:	/
Reviewers:	Alexandra Murray

DRAFT (PENDING EC APPROVAL)

Version log

Version	Date	Issued by	Description	Summary of changes
1	18/05/2026		First submission	

Table of content

List of Tables 4
Keywords 5
List of acronyms and abbreviations 6
1 Introduction 7
2 Nature-based Solutions: Definitions, Critiques and Indicators 7
2.1 Definitions 7
2.2 Knowledge Gaps 9
2.2.1 Ecosystem and Ecological Services and Disservices 9
2.2.2 Natural Scientific Assessment Metrics 10
2.2.3 Social and Health Co-Benefits Assessment Metrics 11
2.2.4 Assessing Cost (effectiveness) 12
2.2.5 Temporal Dimensions of NbS Impact Assessment 13
2.2.6 Synergies, Trade-offs, and Differential Impacts 14
2.3 Critiques 15
2.3.1 The Solution in Nature-based Solution 15
2.3.2 Neoliberal Critique 16
2.3.3 NbS as a Neoliberal Instrument: Three Foundational Assumptions 17
2.3.4 Towards a Repoliticisation of Urban Re-Naturing 17
3 PHISHES usage of NbS 18
3.1 Test Cases 18
3.2 Permanence and the Risk of Reversal 18
4 Policy Instruments for NbS use 19
4.1 NbS at the EU Level 19
4.2 NbS at the Member State Level: Strategies and Plans 21
4.3 NbS at the Member State Level: Public Procurement Regulations 23
4.4 Financing Instruments for Nature-based Solutions: Landscape, Challenges, and Emerging Mechanisms 24
4.4.1 The Current State of NbS Finance 24
4.4.2 Principal Financing Instruments 25
4.4.3 Supplementary and Emerging Revenue Mechanisms 26
4.4.4 Structural Challenges 26
5 Conclusion 27
6 Bibliography 28
7 Annex 33

DRAFT (PENDING EC APPROVAL)

List of Tables

Table 1: The scale at which the strategy is applicable, the document, its publication date and its legal standing.

Executive Summary

This Scientific Opinion paper critically examines Nature-based Solutions, actions that aim to protect, manage and restore ecosystems while generation socio-economic benefits, within the context of the EU-funded PHISHES project. It reviews the current state of NbS definitions and knowledge gaps, presents key critiques of the concept, and maps the policy, legal and financing landscape for NbS across the EU and the four PHISHES test case countries: Czechia, Poland, the Netherlands, and Sweden.

While multiple institutions have developed distinct NbS definitions, scholarly consensus is clear: an intervention qualifies as an NbS only if it demonstrably delivers both environmental and socio-economic co-benefits. Furthermore, robust assessment methods for NbS impacts remain underdeveloped across several dimensions. For example, quantifying carbon sequestration and biodiversity outcomes is methodologically complex and context depending. Moreover, cost-effectiveness analysis is hampered by the difficulty of monetising ecosystem services, temporal mismatches between costs and benefits, and the exclusion of social value from most economic models.

At EU level, the NDC, Biodiversity Strategy, Green Infrastructure Strategy, and Adaptation Strategy are analysed. While these strategies reference NbS (albeit to differing extents), most instruments are non-binding. The EU Climate Law is binding but only weakly mandates NbS inclusion in national adaptation plans. Across the four test countries, NbS integration varies significantly. Sweden's national adaptation strategy is most comprehensive, while Poland's is still under development. None of the countries' National Energy and Climate Plans adequately frame NbS with the co-benefit requirements that the concept demands. Furthermore, public procurement frameworks could be mobilized to encourage NbS use further.

Financing NbS remains a barrier. At the moment, NbS in Europe is mostly financed through public sources. Principal instruments include grants, market and concessional loans, equity, guarantees and thematic bonds. Emerging mechanisms such as carbon NbS credits, biodiversity credits and payment for ecosystem services schemes show promise but weak blended finance frameworks and limited institutional capacity for economic valuation pose structural barriers.

The paper concludes that NbS should not be treated as a "silver bullet", particularly as long as assessment metrics are not adequately enough development. Significant investment in assessment methodology, particularly for social, health and long-term outcomes is urgently needed to substantiate NbS claims.

Keywords

Nature-based Solutions, policy instruments, legal framework, PHISHES.

DRAFT (PENDING EC APPROVAL)

List of acronyms and abbreviations

CO_2	Carbon Dioxide
EC	European Commission
EU	European Union
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LTS	Long Term Strategy
MS	Member State
$MtCO_2e$	Megatonnes of Carbon Dioxide equivalent
NAP	National Adaptation Plan
NAS	National Adaptation Strategy
NbS	Nature-based Solution
NECP	National Energy and Climate Plans
NDC	Nationally Determined Contribution
tCO_2e	Tonnes of Carbon Dioxide equivalent
UNEA	United Nations Environment Assembly
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

DRAFT (PENDING EC APPROVAL)

Scientific Opinion Paper

Policy Instruments for Nature-based Solutions

1 Introduction

Nature-based Solutions (NbS), understood as certain actions that aim to protect, manage and restore ecosystems using natural resources, while creating socio-economic benefits, have gained increasing salience in the last decade. They are often heralded as a 'silver bullet', a solution that seemingly can fix everything at once. Particularly in the European Union (EU), their usage and prominence have grown. While well-designed, inclusive and environmentally just NbS certainly can attempt to bring about significant environmental and socio-economic benefits, doing so is not a 'logical' or 'automatic' consequence of choosing greener actions over grey solutions. It requires careful consideration, planning and constant evaluation and follow up, as well as a need to improve assessment metrics for the range of co-benefits NbS claims to bring about.

This Scientific Opinion paper will first detail the discussion ongoing in the literature regarding NbS, specifically focusing on how to define it, what knowledge gaps exist for the assessment of purported co-benefits (both environmental, social and economic), and what critiques of the concept are formulated in the literature. This review of the academic literature reveals that there is, exceptionally for the social sciences, strong consensus that an NbS can only be deemed an NbS if it realizes the socio-economic co-benefits, it sets out to achieve. However, it is also recognized that assessment methods for both the environmental and the socio-economic co-benefit impacts of NbS are lacking or incomplete, making a strong cost-benefit analysis and case for NbS use difficult. Despite this, the paper is of the opinion that, if enough attention is paid to the realization of co-benefits in the planning, implementation and review phase, and if all types of stakeholders are meaningfully involved in the process, NbS that achieves a multitude of benefits is possible. In light of that, the second part of this paper will analyse the policy instruments at the EU level, as well as in four PHISHES Member States (MS) namely Czechia, Poland, the Netherlands and Sweden, where NbS use can be encouraged, or barriers can be posed against implementation. Finally, an overview is provided of the different financing instruments for NbS, as it is recognized that, while the neoliberal critique of NbS has merit, its financing cannot exist outside the dominant economic system.

2 Nature-based Solutions: Definitions, Critiques and Indicators

2.1 Definitions

Although the World Bank (WB) is frequently credited with introducing the term "nature-based solutions" into international governance discourse, its early publications did not directly name NbS as such, nor provide a formal definition of the concept. Rather, they advanced the argument that the sustainable management and use of natural ecosystems were fundamental to achieving the institution's broader objectives of poverty alleviation and sustainable development.[1] Moreover, it emphasized that well-managed ecosystems generate a wide range of societal benefits and opportunities, thereby framing ecological stewardship as intrinsically linked to human well-being, economic resilience, and long-term development trajectories.[2]

[1] World Bank Group, "Annual Report," *World Bank* (2008): https://documents1.worldbank.org/curated/en/338051468338968060/pdf/470900WBAR0ENG00Box334114B00PUBLIC0.pdf. ; Reise et al., "Nature-based Solutions and global climate protection: Assessment of their global mitigation potential and recommendations for international climate policy," *German Environment Agency* (2022): 20.
[2] Ibid.

DRAFT (PENDING EC APPROVAL)

NbS as a concept has been heralded to be indicative of a paradigmatic shift in ecosystem management, moving beyond traditional single-objective approaches such as the compartmentalization of conservation, water management, and climate adaptation toward integrated and multifunctional interventions capable of generating multiple co-benefits simultaneously for both human societies and ecological systems.[3]

There are, in broad strokes, three types of NbS. The first is based on the usage of existing natural areas where humans do not (or only minimally) intervene. The second is based on restoration or management of traditional ecosystems, an example of which is agroforestry. The third type of NbS is the least based on naturally occurring ecosystems, and includes the establishment of completely new ecosystems, such as the building of a green roof.

Since its initial emergence within international environmental governance discourse, the concept of NbS has been formally articulated and institutionalized most prominently by the International Union for Conservation of Nature (IUCN) and the European Commission (EC), whose definitions have become among the most widely cited and operationalized within policy practice and academic literature.[4]

The IUCN defines NbS as "actions to protect, sustainably manage and restore natural or modified ecosystems, which address societal challenges (e.g. climate change, food and water security or natural disasters) effectively and adaptively, while simultaneously providing human well-being and biodiversity benefits."[5] This formulation remains the dominant reference point within NbS scholarship due to its broad yet conservation-oriented framing, which explicitly positions biodiversity protection and ecosystem integrity alongside societal resilience and human welfare.[6] In 2020, the IUCN further consolidated this framework through the publication of the Global Standard for NbS, which introduced a set of operational criteria and governance principles intended to clarify conceptual boundaries and provide a standardized framework for assessing and benchmarking NbS implementation.[7]

The EC subsequently advanced a related yet conceptually distinct understanding of NbS. In its 2015 formulation, NbS are described as interventions that assist societies in addressing environmental, social, and economic challenges through actions "inspired by, supported by or copied from nature."[8] The definition emphasizes the utilization and enhancement of ecosystem processes such as carbon sequestration and hydrological regulation, and introduced experimentation with biomimicry and innovative ecological design by its 2020 definition. NbS are thereby framed not merely as conservation interventions, but as multifunctional mechanisms capable of simultaneously reducing disaster risk and improving human well-being. In 2020, the EC expanded the definition to integrate nature into cities, landscapes, and seascapes through locally adapted and systemic interventions that enhance biodiversity and ecosystem-service provision. More importantly however, the EC went on to define NbS as "cost-effective" and "resource-efficient" interventions that generate environmental, social, and economic benefits while strengthening resilience.[9]

DRAFT (PENDING EC APPROVAL)

[3] C. Nesshöver et al., "The science, policy and practice of nature-based solutions: An interdisciplinary perspective," *Science of The Total Environment* 579 (2017): pp. 1215–1227.
[4] Reise et al., "Nature-based Solutions and global climate protection," 52 - 53.
[5] Ibid., 20; IUCN, "Nature-based Solutions," *IUCN* (2016): https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions (last updated on 16 Sep 2020, last accessed on 27 May 2026).
[6] Valeria de los Casares, and Marc Ringel, "Nature-based Solutions for climate adaptation in the European Union: Part I Mapping EU and National initiatives," *European Chair for Sustainable Development and Climate Transition at Sciences Po* (2023): 9.
[7] Ibid., 9.
[8] Reise et al., "Nature-based Solutions and global climate protection," 20.
[9] Ibid.

The United Nations Environment Assembly (UNEA) subsequently adopted a broader multilateral definition, describing NbS as "actions aimed at protecting, conserving, restoring, and sustainably managing 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, resilience and biodiversity benefits."[10] Conceptually, the UNEA definition closely aligns with the IUCN's conservation-oriented framing while expanding its ecological scope to encompass a wider diversity of ecosystems and governance contexts. Importantly, the UNEA definition carries particular political significance because it emerged through multilateral negotiation, giving it greater legitimacy within international environmental governance and therefore functions as the definition adopted by PHISHES.

A critical distinction emerges between the EC formulations and the earlier IUCN and UNEA definitions. The EC more explicitly situates NbS within agendas of urban innovation, resilience governance, and green economic growth - reflective of the EU Green Deal language. This economic and growth-oriented orientation has proven influential in shaping subsequent policy and market-based appropriations of the concept. Such an understanding has been, unfortunately, appropriated by corporate initiatives to imply that climate change can be sufficiently addressed through ecosystem restoration and carbon sequestration alone, downplaying the need for structural decarbonisation.

Differing definitions and the above-mentioned knowledge gaps do not merely complicate the benchmarking and evaluation of NbS implementation; they also create conditions conducive to the conceptual conflation of NbS with broader greening measures, blue-green infrastructure, and conservation practices more generally.

2.2 Knowledge Gaps

All three definitions presented above share several core characteristics. First, they conceptualize nature as a medium through which ecological functions can be protected, restored, and mobilized. Second, they frame these interventions explicitly as "solutions," thereby positioning ecosystems as active mechanisms for addressing contemporary environmental and societal concerns. Thirdly, and most importantly, each definition emphasizes that NbS must simultaneously address societal challenges while generating social and human well-being benefits, underscoring their inherently multifunctional and socio-ecological character. Without such 'dual use' an intervention should not be recognized as an NbS.

The purported effectiveness of NbS in generating both environmental improvements and human well-being benefits rests upon a range of conceptual assumptions and methodological frameworks that warrant scrutiny, suggesting that their presumed co-benefits should not be accepted uncritically. The following section highlights these assumptions and shortcomings per each co-benefit and afterwards critically assess general assumptions underpinning the NbS academic literature.

2.2.1 Ecosystem and Ecological Services and Disservices

As mentioned above, NbS definitionally has to produce positive effects for the environment and much of the literature has corroborated this. Yet, this does not mean that NbS are incapable of producing negative impacts, or 'disservices'. The Intergovernmental Panel on Climate Change (IPCC) has recognized that efforts must be made to "avoid any negative impacts resulting from NbS, such as enhanced competition for land and water with other sectors, reduction of human well-being and short term-only mitigation, pernicious investments in indigenous communities, and dynamics of

[10] United Nations Environment Program, "Overview of Nature-based solutions," *UNEP* (last updated 4 November 2024, last accessed 27 May 2026): https://www.unep.org/topics/nature-action/nature-based-solutions/overview-nature-based-solutions.

DRAFT (PENDING EC APPROVAL)

gentrification through increasing land values."[11] Such disservices are ecosystem functions that could negatively impact human-wellbeing.[12]

This domain remains critically understudied. Dumitru et al., have found that based on current scientific literature, there has been "limited evidence of systematic consideration of disservices, with only 8 [out of the 101 reviewed studies] assessed at least one type of disservice."[13] Similarly, Haase et al., have found unintended effects or disservices have also not been properly integrated into the evaluation of impacts of NbS.[14] These findings thus necessitate further review as to whether NbS' potential to remedy environmental challenges have been inflated and whether they have engendered ecosystem disservices.

2.2.2 Natural Scientific Assessment Metrics

The plethora of literature on NbS metrics is evidence of the vast range of methodological considerations that substantially affect the reliability and comparability of estimates regarding NbS mitigation potential. NbS mitigation potential is often expressed in absolute terms: as $MtCO_2e$ per year or tCO_2e per hectare per year. Research often draws on a top-down approach that uses global simulation models, or a bottom-up approach, which draws on locally and project level obtained empirical data. The geographic specificity of data inputs and the extent to which ecological processes (such as tree growth dynamics) are explicitly modelled constitute further dimensions of methodological variation that bear directly on the robustness of resulting estimates.

What Reise et al. crucially highlight is that quantifying NbS mitigation potential necessitates the establishment of baseline assumptions, particularly for measures whose outcomes are contingent on avoided land-use change.[15] Baseline assumptions also serve as the analytical foundation for evaluating whether NbS activities are additional to a country's existing emissions trajectory, which is a prerequisite for credible accounting within international climate policy frameworks. They find that many studies rely upon underlying assumptions concerning how interactions with the climate system are conceptualized and modelled.[16] A central question is whether such assessments adequately account for the effects of climate change on ecosystem services themselves, as well as the climatic consequences of ecological transformations, such as changes in vegetation cover. These interactions may either enhance or diminish the projected mitigation potential of NbS interventions. Uncertainty of the underlying assumptions used also is caused by the widely varying interactions of carbon sequestration rates and emission factors and ecosystems. These discrepancies reflect divergent methodological approaches but also the genuine diversity of ecosystem process responses to site-specific conditions including local climatic regimes, soil characteristics, and human interference thus underscoring the difficulty of producing universally applicable estimates.

Moreover, they question how much NbS can realistically contribute to climate change mitigation because the potential estimates are highly sensitive to the time frames under consideration, assumptions regarding available land, and a range of other methodological choices and assumptions.[17] One of the most influential and comprehensive studies on CO_2 mitigation has been

DRAFT (PENDING EC APPROVAL)

[11] Isabelle Anguelovski, and Esteve Corbera, "Integrating justice in Nature-Based Solutions to avoid nature-enables dispossession," *Ambio* 52 (2023): 46. Citing Intergovernmental Panel on Climate Change, "Climate Change 2022: Impacts, Adaptation, and Vulnerability. Summary for Policy-Makers," *IPCC* (2022).
[12] Nadja Kabisch et al., "Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action," *Ecology and Society* 21, no. 2 (2016): 42.
[13] Adina Dumitru, Niki Frantzeskaki, and Marcus Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," *Environmental Science and Policy* 112 (2020): 111.
[14] D. Haase, et al., "A quantitative review of urban ecosystem service assessments: concepts, models, and implementation," *Ambio* 43, no. 4 (2014): 413 - 433.
[15] Reise et al., "Nature-based Solutions and global climate protection," 31.
[16] Ibid.
[17] Reise et al., "Nature-based Solutions and global climate protection," 30 - 31; C. A. J. Girardin, S. Jenkins, N. Seddon, M. Allen, S. L. Lewis, C. E. Wheeler, B. W. Griscom, Y. Malhi, "Nature-based solutions can help cool the planet — if we act now," *Nature* 593, no. 7858 (2021): 191–194.

done by Griscom et al. who have estimated that NbS (or "natural climate solutions" as they title it in their paper) could deliver 37% of the necessary cost-effective CO_2 mitigation potential by 2030 and 20% by 2050.[18] The highest potentials in the study are associated with forest-related measures such as reforestation and avoiding conversion of forest to other land uses.[19] These results account for land demand arising from different NbS and, importantly, incorporate biodiversity and food security safeguards.

Compounding these methodological limitations is the large absence, in existing NbS assessments, of explicit modelling of climate-induced changes to ecosystem functioning. Phenomena such as ocean acidification and the increasing frequency and severity of drought events threaten to diminish ecosystem function and thereby erode the carbon sequestration and storage capacities upon which NbS mitigation estimates are premised. The failure to account for such dynamics represents a potentially significant source of optimistic bias in current assessments.

Additionally, several NbS typologies with substantive mitigation potential remain absent from the major global assessments. Urban greening and organic farming, both of which carry meaningful mitigation potential, have yet to be comprehensively quantified at the global scale in the foundational assessments of Griscom et al., Roe et al., or Jia et al.[20]

Just as carbon sequestration and mitigation potential is difficult to quantify, NbS reviews also struggle to capture the impacts it creates on biodiversity, and knowledge on the generation potential for positive biodiversity outcomes is currently limited.[21] Owing to biodiversity's pronounced spatial variability and ecological complexity, assessing and quantifying NbS impacts on it is considerably more difficult.[22] A critical methodological caveat is that locally observed increases in biodiversity following ecosystem restoration do not necessarily translate into regional or global biodiversity gains, particularly where improvements are driven by increases in the abundance of non-threatened generalist species rather than species of conservation concern.[23]

These considerations collectively point to the urgent need for the development of robust, standardised natural scientific assessment methodologies capable of quantifying and enabling meaningful comparison of the mitigation potential and biodiversity impacts associated with NbS interventions.[24]

2.2.3 Social and Health Co-Benefits Assessment Metrics

Evidence on the specific social and health impacts of NbS remains scarce and fragmented, with existing evaluations characterised by a reliance on single case studies, a restricted range of impacts under consideration, one-time rather than longitudinal assessments, and a disproportionate focus

DRAFT (PENDING EC APPROVAL)

[18] B. W. Griscom, J. Adams, P. W. Ellis, R. A. Houghton, G. Lomax, D. A. Miteva, W. H. Schlesinger, D. Shoch, J. V. Siikamäki, P. Smith, P. Woodbury, C. Zganjar, A. Blackman, et al., "Natural climate solutions," *Proceedings of the National Academy of Sciences of the United States of America* 114 , no. 44 (2017): 11645–11650.
[19] Ibid.
[20] Ibid.; G. Jia, et al., "Land-climate interactions," In: P. R. Shukla, et al., (ed.): *Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (2019): 131–247. ; S. Roe, et al., "Contribution of the land sector to a 1.5 °C world," *Nature Climate Change* 9 , no. 11 (2019): 817–828.
[21] N. Seddon, et al., "Understanding the value and limits of nature-based solutions to climate change and other global challenges," *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 375, no. 1794 (2020).
[22] H. M. Pereira, et al., "Essential Biodiversity Variables," *Science* 339, no. 6117 (2013): pp. 277–278.
[23] G. D. Lennox, et al., "Second rate or a second chance? Assessing biomass and biodiversity recovery in regenerating Amazonian forests," *Global Change Biology* 24, no. 12 (2018): pp. 5680–5694.
[24] N. Pettorelli, et al., "Time to integrate global climate change and biodiversity science-policy agendas," *Journal of Applied Ecology* (2021).

on particular NbS typologies.[25] Dumitru et al's study found that only 8 papers employed a comparative analysis that looked at multiple case studies, and they argued that even here "insufficient attention was paid to differentiating process characteristics (pertaining to design and implementation) from expected outcomes."[26] This conflation renders it impossible to isolate the causal mechanisms through which specific process features shape NbS social and health impacts, a prerequisite for evidence-based intervention design.

Despite the remaining gaps and difficulty in quantifying mitigation potential or biodiversity conservation potential of NbS, the environmental impacts of NbS have been studied more and have been subject to more extensive empirical scrutiny, while evidence pertaining to social and health outcomes remains notably scarce and fragmented.[27] This asymmetry is attributable, in a substantial part, to the conceptual imprecision that continues to characterise scholarly understandings of the relationship between NbS interventions and their manifold categories of outcomes.

This imbalance is reflected in the quantitative distribution of impact categories across the reviewed literature: Dumitru et al. find that environmental impacts are addressed in approximately 60% of reviewed articles, while social and health-related impacts feature in only 30%, and economic impacts in a mere 10%.[28] Reviews examining the multiple functions of NbS similarly accord primacy to environmental dimensions.[29] The relative neglect of social and economic outcomes has been attributed to the inherent difficulty of evaluating well-being outcomes (with the notable exception of poverty alleviation) compounded by insufficient data collection, the deployment of mixed methodologies drawn from divergent research traditions, and the interdisciplinary complexity that effective NbS impact assessment necessarily entails.

It is unfortunate that these kinds of effects of NbS remain so understudied, as there is a growing body of evidence that makes the case for the restorative effects of nature exposure on human health and well-being, with urban space designs that facilitate interaction with nature associated with enhanced well-being outcomes.[30] A significant gap persists in understanding the conditions under which NbS generate social and health impacts specifically. Drawing on parallel debates in conservation studies where traditional ecological assessments have been criticised for omitting social system impacts, it is argued that systematic NbS evaluation should explicitly map causal chains within social-ecological systems, clearly differentiating between direct and indirect impacts and identifying the mediating conditions that shape outcome trajectories.[31] Such an approach would constitute credible, cross-disciplinary evidence capable of informing both theory and practice.

2.2.4 Assessing Cost (effectiveness)

Some NbS definitions include a cost-benefit dimension to what it deems an NbS. However, conventional economic benefit metrics (and their expression in monetary terms) fail to adequately account for natural capital or the costs of biodiversity loss. The imposition of economic benefit as a definitional prerequisite risks introducing systematic distortions: it may unduly incentivise the prioritisation of short-term economic returns at the expense of the long-term delivery of a

[25] Dumitru, Frantzeskaki, and Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," 108.
[26] Ibid., 110.
[27] E. Brink et al., "Cascades of green: a review of ecosystem-based adaptation in urban areas," *Global Environmental Change* 36 (2016): 111 - 123.
[28] Dumitru, Frantzeskaki, and Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," 109.
[29] A. Fini, P. Frangi, J. Mori, D. Donselli, F. Ferrini, "Nature based solutions to mitigate soil sealing in urban areas: results from a 4-year study comparing permeable, porous, and impermeable pavements," *Environmental Research* 156 (2017): 443–454.
[30] K. Gillis, and B. Gatersleben, "A review of psychological literature on the health and wellbeing benefits of biophilic design," *Buildings* 5, no. 3 (2015): 948–963.
[31] J. Qiu, et al., "Evidence-based causal chains linking health, development and conservation actions," *Bioscience* 68, no. 3 (2018): 182 - 193.

DRAFT (PENDING EC APPROVAL)

comprehensive range of ecosystem services and may privilege those ecosystem functions amenable to monetary quantification over those for which such quantification is methodologically intractable. It would further presuppose a standardised methodological framework for measuring ecosystem economic benefits - one that has not yet achieved widespread implementation. By contrast, the concept of human well-being subsumes economic considerations within a more holistic and qualitative register, mitigating the biases inherent in quantification-driven approaches.

While the Natural Climate Solutions literature provides quantified evidence of cost-effectiveness as a mitigation instrument,[32] assessing the cost-effectiveness of multifunctional NbS is considerably more complex. Four principal challenges may be identified. First, there is a systematic undervaluation of NbS as many co-benefits are omitted from the cost-benefit calculations, as they prove too difficult to quantify. Second, trade-offs must be accounted for in the calculations, as different NbS measures and between stakeholder groups whose divergent preferences lead them to perceive benefits and costs in materially different ways. Third, there is significant uncertainty regarding future environmental and socio-economic benefits, which makes quantifying changes in ecosystem service provisioning difficult. The prevailing carbon price for example can fluctuate significantly, impacting a cost-benefit analysis of a carbon sequestering NbS. Fourth, it is difficult to isolate a causal relationship between an NbS intervention and other co-occurring factors. A further complication arises from the temporal mismatch between costs and benefits: "Finally, while NbS might be a more effective solution in the long term, the full scale of the benefits might not be evident while the costs are incurred."[33]

A limitation of existing cost-benefit modelling frameworks is their near-exclusive focus on private costs. These frameworks systematically exclude the wider social benefits generated by NbS. Although the value of climate mitigation is partially reflected in models through assumed carbon prices, the wider co-benefit portfolio of NbS remains largely unrepresented, leading to a structural underestimation of NbS contributions to human well-being and related outcomes.

Furthermore, direct implementation costs, ongoing management costs, opportunity costs and transaction costs must also be incorporated to create a realistic representation of cost barriers, yet they remain frequently absent.[34] These can create significant differences in the total cost calculation depending on the type of NbS implemented, and the context in which it is implemented. Using a carbon price of approximately USD 480 per tCO_2e, Roe et al. completed a top-down integrated assessment of NbS potential for a 1.5°C pathway, which concluded that at this level, a substantial share of the identified potential effectively disregards economic feasibility constraints.[35] Fuss et al. meanwhile, collated existing individual NbS potential and cost studies, though the data foundations and assumptions underlying the constituent studies lack full transparency.[36] The absence of methodological clarity and comparability across these assessments renders cross-study validation and comparison of NbS potential estimates highly problematic.

2.2.5 Temporal Dimensions of NbS Impact Assessment

The challenge of evaluating how policy interventions unfold across time is well-established within the urban sustainability literature, and NbS are no exception to this dynamic. While the immediate effects of NbS interventions are largely contingent upon design and implementation quality, long-term outcomes are more substantially conditioned by a broader constellation of factors including

DRAFT (PENDING EC APPROVAL)

[32] S. Osaka, R. Bellamy, and N. Castree, "Framing "nature-based" solutions to climate change," *WIREs Climate Change* 12, no. 5 (2021).
[33] Reise et al., "Nature-based Solutions and global climate protection," 26.
[34] Griscom, et al., "Natural climate solutions," 11645–11650.
[35] S. Roe, et al., "Contribution of the land sector to a 1.5 °C world," *Nature Climate Change* 9 , no. 11 (2019): pp. 817–828.
[36] S. Fuss, et al., "Negative emissions—Part 2: Costs, potentials and side effects," *Environmental Research Letters* 13, no. 6 (2018).

social uptake, the availability of sustainable maintenance mechanisms, and the institutional and community conditions that foster continuous renewal and adaptive use of NbS over time.

Current research often only uses limited time horizons, rarely exceeding four years.[37] The analysis also often remains project-based (explaining the short time horizon) rather than a complete longitudinal study.[38] Only 12% of studies reviewed by Dumitru et al. relied on longitudinal data to analyse NbS effects, and only 6 studies (of 174 total) completed data collection at more than one single time point.[39] The longitudinal studies that do look at an extended time horizon, employ panel data of (usually only) two time points, which some argue precludes meaningful insight into the dynamic processes mediating change between data collection intervals.[40]

It is important to note that the short-term evaluation focus is not problematic for all impact categories. For assessment of air and water quality improvement, short-term frameworks might be methodologically adequate. However, for complex, cumulative phenomena such as climate change resilience, longer-term analytical horizons are indispensable, such as the projects of climate change risks or health related outcomes.

These temporal gaps in the evidence base carry significant analytical and practical consequences. It could lead to a systematic under-evaluation of NbS and related co-benefits as compared to grey infrastructures, as a result risking the optimisation of NbS as impact over time cannot be adequately represented. The long-term performance of NbS has been closely associated with local capacities for regeneration and innovation: as the instrumental value of physical infrastructure tends to stabilise or diminish over time, the sustained performance of NbS depends increasingly on their capacity to accumulate social value including through mechanisms of co-ownership and community stewardship.[41] Moreover, as ecosystems become more established and resilient, their environmental value also increases over time, in direct contrast to grey solutions. Addressing these limitations constitutes a foundational prerequisite for the credible, long-term integration of NbS into sustainability governance.

2.2.6 Synergies, Trade-offs, and Differential Impacts

Different NbS co-benefits interact with one another in either synergistic or antagonistic ways, with positive effects in one impact category potentially reinforcing, or alternatively undermining, outcomes in another. Despite the frequency with which co-benefits and trade-offs are referenced in the NbS literature, only 5% of contributions reviewed by Dumitru et al. engage with these dynamics in a systematic empirical manner.[42]

The principally documented social trade-off identified is eco-gentrification, or green gentrification, the process during which housing and property prices increase as the result of a greening measure or greening NbS, leading to the displacement of local and socio-economically disadvantaged

[37] Dumitru, Frantzeskaki, and Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," 112; A. Fini, P. Frangi, J. Mori, D. Donselli, F. Ferrini, "Nature based solutions to mitigate soil sealing in urban areas: results from a 4-year study comparing permeable, porous, and impermeable pavements," *Environmental Research* 156 (2017): 443–454.
[38] Nadja Kabisch, and Matilda Annerstedt van den Bosch, "Urban Green Spaces and the Potential for Health Improvement and Environmental Justice in a Changing Climate," in Kabisch et al. (eds) *Nature-based Solutions to Climate Change Adaptation in Urban Areas: Theory and Practice of Urban Sustainability Transitions* (2017).
[39] Dumitru, Frantzeskaki, and Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," 112.
[40] Ibid.
[41] E. Cohen-Shacham, G. Walters, C. Janzen, and S. Maginnis, (Eds.), "Nature-Based Solutions to Address Global Societal Challenges," *IUCN* (Gland, Switzerland, 2017); M. Demuzere, et al., "Mitigating and adapting to climate change: multi-functional and multi-scale assessment of green urban infrastructure," *Journal of Environmental Management* 146 (2014): 107–115.
[42] Dumitru, Frantzeskaki, and Collier, "Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities," 111.

DRAFT (PENDING EC APPROVAL)

residents. Processes of green gentrification are frequently documented by Anguelovski, in her extensive research on the topic, and has been confirmed in cities all over the world: Barcelona, Boston, Montreal, Copenhagen, Utrecht and Rotterdam, just to name a few.[43]

NbS impacts hit different social groups differently, but these trade-offs remain underdeveloped and under researched. Dumitru et al.'s review highlights that only 22% of contributions examined how a particular impact is experienced across social groups.[44] Even when such reviews are done, they remain confined to one or two variables, when there are many more elements that impact differential experience of NbS. These variables often also compound to create complex intersectional experiences. A fuller understanding of how different groups use and experience NbS, particularly in urban areas, encompassing their behavioural patterns, activities, and subjective perceptions is essential for anticipating the distributional consequences of scaling NbS interventions across urban populations.

Both synergies and trade-offs are conditioned by the intrinsic characteristics of the NbS in question and by the governance processes through which it is designed and implemented. Further systematic identification of these dynamics is required to determine which NbS characteristics function as enablers or amplifiers of positive effects, and which may serve as buffers against negative trade-offs thereby expanding the potential for multifunctionality and innovation.

Reflecting on the methodological difficulties of proving NbS impacts, whether that be environmental impacts, social or health impacts, cost-effectiveness, disservices and trade-offs, and the long-term monitoring needed across these thematic areas to support the long lifespan of NbS interventions, PHISHES should ensure that the way in which impacts of the NbS are studied are cognizant of the aforementioned issues. Moreover, PHISHES should find ways in which - either quantitatively or qualitatively - these challenges can be overcome, to be able to contribute to the evidence base for NbS.

2.3 Critiques

2.3.1 The Solution in Nature-based Solution

Labelling and characterizing an intervention as a "solution" is inherently normative, as it embeds aspirational assumptions of efficacy, legitimacy, and desirability even where empirical evidence remains inconclusive. In doing so, the language of "solutions" risks producing a self-fulfilling dynamic: once an intervention is framed as a solution, political, institutional, and financial commitments may converge around validating and sustaining that framing, thereby incentivizing the selective interpretation of evidence and foreclosing more critical evaluation of its limitations, trade-offs, or potential failures.

Moreover, by labelling something a solution, little space is given for failure. Particularly considering the long-term impact cycle of NbS, a premature judgment of the supposed "failure" of a NbS may reflect more about the structural conditions that prevented it from being meaningfully implemented and are not a reflection of the NbS as a measure as such. For example, tree canopy covers do unquestionably provide shade and cooling, but after planting new seedlings/trees in urban spaces, the benefit from the NbS will take years (if not decades) to materialize. This discursive power can then be mobilized to justify renewing reliance on conventional grey infrastructure and technocratic approaches.

[43] Anguelovski, and Corbera, "Integrating justice in Nature-Based Solutions."
[44] Ibid.

DRAFT (PENDING EC APPROVAL)

2.3.2 Neoliberal Critique

Beyond the methodological difficulties of measuring NbS impact, there are more overarching neoliberal critiques that must be addressed. The increasing incorporation of concepts such as "cost-effectiveness," "green growth," and "resource efficiency", risks aligning NbS with neoliberal environmental governance, where ecosystems are valued primarily for their economic utility and capacity to sustain urban competitiveness. Moreover, the stipulated NbS co-benefits posits an axiom that assumes and does not question the relationship between greening and economic growth. Instead, it becomes an ontological prerequisite.

Furthermore, while all definitions of NbS reference human well-being, resilience, and societal challenges, they remain vague on issues of distributive justice, political power, participation, and the unequal social impacts of environmental interventions. As a result, NbS discourse can sometimes obscure the structural political-economic drivers of ecological degradation while presenting ecological restoration as a technocratic solution compatible with continued patterns of capitalist urbanization and growth.

Since the 1990s, environmental concerns have translated into 'private-oriented governance model(s) for the sustainability of socio-environmental systems. Water is privatised, and other land and resources are appropriated for 'better management'.[45] This has led to the governing of nature to be done in an increasingly neoliberal register, benefiting privileged social actors and reducing NbS' ability to function as a public good.

Pro-environmental discourse, far from constituting a counterweight to neoliberalism, has since the late 1970s and 1980s developed largely in parallel with it and has to a substantial degree been co-opted by it.[46] The discursive paradigm of sustainable development exemplifies this dynamic, as does the branding of 'smart growth' cities, and the marketisation of ecosystem services and carbon credits.[47]

In the urban context specifically, critical urban scholars have drawn attention to the dialectical relationship between urbanisation and neo liberalisation processes, within which climate change mitigation and adaptation strategies have frequently functioned as proxies for urban environmentalism and become entangled with what scholars have termed 'sustainability fixes'.[48] Within urban contexts (as well as beyond), authorities have actively deployed market proxies and introduced individual responsibilisation policies for the protection of nature (e.g. household recycling), redistributing the responsibility of environmental planning and protection away from the state.[49] It is argued that urban nature and re-naturing for example is used to enable neoliberal institutional transformations that preserve green space for the purpose of real estate value enhancement.[50]

DRAFT (PENDING EC APPROVAL)

[45] K.J. Bakker, "A political ecology of water privatization," *Studies in political economy* 70, no. 1 (2003): 35–58; Panagiota Kotsila, Isabelle Anguelovski, Francesc Baró, Johannes Langemeyer, Filka Sekulova, James JT Connolly, "Nature-based solutions as discursive tools and contested practices in urban nature's neoliberalisation processes," *Nature and Space* 4, no. 2 (2021): 255.
[46] Ibid.; J. McCarthy and S. Prudham, "Neoliberal nature and the nature of neoliberalism," *Geoforum* 35, no. 3 (2004): 275–283.
[47] Kotsila et al., "Nature-based solutions as discursive tools," 256.
[48] A. While, A.E.G. Jonas, and D. Gibbs, "The environment and the entrepreneurial city: Searching for the urban 'sustainability fix' in Manchester and Leeds," *International Journal of Urban and Regional Research* 28, no. 3 (2004): 549–569; M. Whitehead, "Neoliberal urban environmentalism and the adaptive city: Towards a critical urban theory and climate change," *Urban Studies* 50, no. 7 (2013): 1348–1367.
[49] D. Immergluck, "Large redevelopment initiatives, housing values and gentrification: The case of the Atlanta Beltline," *Urban Studies* 46, no. 8 (2009): 1723–1745; M. Rosol, "Vancouver's "EcoDensity" planning initiative: A struggle over hegemony?" *Urban Studies* 50, no. 11 (2013): 2238–2255.
[50] Ibid.

2.3.3 NbS as a Neoliberal Instrument: Three Foundational Assumptions

The concept of NbS represents one of the most explicitly utilitarian and instrumental approaches to urban nature governance, deploying the ecosystem services framework as an umbrella for a range of nature-based interventions, ecosystem-based solutions, and ecosystem-based adaptation strategies.[51] Three foundational assumptions embedded within the dominant NbS discursive framework crystallise its entanglement with neoliberal urban sustainability discourse and its unresolved structural contradictions.

The first assumption "concerns the capacity of NbS to deliver so-called 'win-win' and 'no regret' outcomes for the environment, society and the economy."[52] This assumption reproduces a faith in trickle-down economics and perpetuates the idea that GHG emissions can be decoupled from economic growth through technical fixes, such as NbS. In the urban context, this 'quick fix' and 'win-win' mentality occludes the actual material and energy consumption required by urban infrastructure. In the case of urban greening, NbS beautifies the space, without addressing underlying issues fuelling the climate crisis. They are communicated as incredibly important measures to implement, which can solve a range of issues. Yet, simultaneously, labour put into NbS is not seen as valuable or important, with projects often demanding free labour from community members, rather than investing into salaries for staff, while maintaining volunteer possibilities. NbS' economic output is thus often built on the backs of free labour of citizens.

The second assumption constructs nature as a repository of measurable, transferable, and instrumentalisable processes.[53] Such a framing reinforces the economic underpinnings of ecosystem services, reducing the value of trees or green spaces just to their quantifiable functions of carbon sequestration, stormwater retention, or thermal regulation with the irreplaceable cultural, memorial, and affective dimensions of situated socio-natural systems rendered invisible or irrelevant. As a result, "nature's commodification creates new sites for capital valuation and accumulation."[54] Moreover, when urban nature is apprehended exclusively through a lens of 'benefits', the adverse consequences of NbS interventions are readily marginalised.

The third assumption concerns the prescriptive character of NbS as a solution, as delineated earlier in this paper. It creates a framing that presupposes, rather than demonstrates, the socio-ecological trade-offs.[55] By pre-emptively designating interventions as 'solutions', researchers and policymakers confer upon them a positive valence that obscures weaknesses, contradictions, and contested effects. As a result, this framing risks reproducing the neoliberal logic of 'no alternative', foreclosing democratic deliberation over socio-ecological trade-offs and entrenching technocratic, top-down decision-making, potentially at the expense of justice.[56] By framing NbS as a solution, large polluters such as energy intensive industries, food conglomerates, and airlines stay in the shadows, and remain unaccountable. Doing so ignores patterns of resource-extraction and consumption and leaves other sustainable development pathways, such as drastically reducing consumption, unaddressed.

2.3.4 Towards a Repoliticisation of Urban Re-Naturing

Notwithstanding the previous discussion and stressing the necessary considerations that must be reflected upon in designing and implementing NbS, the underlying aspiration of re-naturing as a means of respecting and protecting biodiversity, and of caring for and working with nature to repair fractured socio-ecological systems, remains profoundly important and resonates across environmental science and activism. The critical challenge, therefore, is not to abandon the concept

[51] Kotsila et al., "Nature-based solutions as discursive tools," 257.
[52] Ibid.
[53] Ibid.
[54] Ibid.
[55] Ibid.
[56] Ibid.

DRAFT PENDING EC APPROVAL

but to reclaim it: to contest its co-optation by green growth discourse, and to redirect it toward socio-ecological transformations. Future visions of NbS, re-naturing and biodiversity must be grounded in, and inseparable from, commitments to emancipation, equity, and justice.

The conceptualisation, implementation and review of NbS measures must be grounded in an analysis of environmental justice dimensions: distributive justice, procedural justice and recognitional justice. These justice principles and their application to an urban NbS case of Rotterdam is extensively discussed in Deliverable 5.4., policy brief 2.

3 PHISHES usage of NbS

The uncertainties laid out above in regard to measuring the environmental, social, health, and cost-benefits of NbS will not disappear overnight. Yet, when NbS are implemented with full consideration of environmental justice dimensions, in meaningful co-creation processes with local communities, with long-term funding opportunities, they can be transformative and create extensive environmental benefits, as well as co-benefits. PHISHES is aiming to model several NbS across its test cases, to support the evidence basis for implementing NbS.

3.1 Test Cases

The PHISHES agricultural test cases (Koprzywianka and Zelivka) are testing the effects of the use of more nature-based, conservation agricultural management techniques. In particular, PHISHES is implementing the NbS of mechanical soil tillage, permanent soil organic cover, and crop rotation diversification in its agricultural test sites.

The PFAS test cases in PHISHES (Örnsköldsvik Airport, Sweden; BRGM laboratory, France) model contamination fate and transport and assess the effect of remediation measures, non-Newtonian fluid injection, and phytostabilisation including biochar application, which can be considered an NbS, although its determination as such is contested.[57] [58]

In the urban test case in PHISHES, Rotterdam, several NbS's will likely be modelled. Working together closely with the municipality of Rotterdam, PHISHES will model a drainage-infiltration-transport sewage system, and is considering the modelling of the effects of urban greening (ideally with native plants), biodiversity conservation through greening, and sludge recycling. The drainage system is already being implemented by the municipality and PHISHES will strengthen the project by showcasing the potential spread of contaminants in water and soil. The other proposed NbS are not yet implemented in real life and PHISHES might model the theoretical simulation. By doing so, PHISHES hopes to make a case for the implementation of these NbS, highlighting the benefits they can have for ecosystems and residents in the city.

3.2 Permanence and the Risk of Reversal

A recurrent challenge identified across the consulted literature, concerns the permanence of NbS measures and the associated risk of reversal of achieved climate mitigation progress. These challenges are attributable to a constellation of political, legal, governance, and social factors, and the sectors in which an NbS is implemented. Examples of reversal of success include the Ethiopian Green Legacy Initiative, where billions of seedlings were planted as part of the project, but their survival rates were drastically low, especially in locations where local communities were excluded from the planning process or where seedlings were planted on public land without adequate stewardship arrangements. This case underscores the critical role of participatory governance in

[57] Reise et al., "Nature-based Solutions and global climate protection," 28 - 29.
[58] Circularity Gap Report, "Sweden - A global standout for mineral, metal and biomass extraction," *Circularity Economy* (n.d.): https://dashboard.circularity-gap.world/report/sweden/extraction.

DRAFT (PENDING EC APPROVAL)

determining the long-term viability of large-scale restoration efforts.[59] Other examples include the Sumatra Merang project, where land management licenses were only issued for 25 years to the implementing partners, leaving them in ambiguity that constitutes a significant governance gap undermining the long-term credibility of the project's climate mitigation claims.[60] A further dimension of permanence risk arises from the dependency of NbS measures on the sustained engagement of land managers. Where financial or institutional support is withdrawn, stakeholders directly responsible for land management may revert to prior practices. More broadly, insufficient or short-term financing and bureaucratic impediments jeopardise the climate protection potential of NbS measures and constrain the structural shift away from established or economically lucrative land-use practices that cause environmental harm.

The multifunctionality of NbS must be embedded in the design phase, particularly with respect to ensuring that measures are appropriately calibrated to the functioning of the target ecosystem. Several of the measures examined in this analysis were conceived and initiated prior to the widespread adoption of a robust NbS definition, and as a consequence, design features were identified that constrain positive impacts on biodiversity, climate, or social well-being.

PHISHES should thus consider an exit strategy and ensure that support to maintain the NbS measures implemented in the test cases continues after project completion in 2028 to create long-term effects.

4 Policy Instruments for NbS use

Leaving the methodological and measurement uncertainties aside, the encouragement of the use of NbS must be accompanied by a legal context and policy instruments which are tailored towards it, in order to make its use attractive. The following section aims to highlight, at an EU level and at the MS level for each test case country, what the policy instruments are that could act as an enabler or a barrier to NbS use. This section then concludes with an overview of financing instruments for NbS.

4.1 NbS at the EU Level

Nature-based solutions are still a relatively new concept. In 2014, the Commission initiated an expert group on NbS, and in the decade since, the EU has become a forerunner in the implementation of NbS, particularly in urban areas, compared to the rest of the world.[61] Despite this frontrunner position however, the integration of NbS into the legal frameworks and climate strategies or adaptation plans at the EU and MS level remains limited, although there is wide variation amongst the test case countries.

Globally, the EU has a unified Nationally Determined Contributions (NDC) at the United Nations Framework Convention on Climate Change (UNFCCC). These are a common approach that embodies the EU's ambitions to meet the Paris Climate goals. In the NDC, nature-based solutions are mentioned twice, once in paragraph 73 and once in the Annex, though both are only marginal mentions. In the main text, it is argued that NbS should be promoted, in the framework of helping the EU and Member States meet their commitments under the Kunming-Montreal Global Biodiversity Framework.[62] In the Annex, the concept of NbS is expanded upon, and it is recognized that "NbS do far more than mitigate climate change or reduce disaster risks. They offer a broad spectrum of

[59] H. Kassa, A. Abiyu, N. Hagazi, M. Mokria, T. Kassawmar, V. Gitz, "Forest landscape restoration in Ethiopia: Progress and challenges," *Frontiers in Forests and Global Change* 5 (2022).
[60] Judith Reise, Cristina Urrutia, Sandra Dalfiume, Christina Ender, Ingrid Wawrzynowicz, and Pedro Pássaro, "Nature-based solutions for climate and biodiversity protection in selected national climate contributions," *German Environment Agency* (2025): 73-74.
[61] Valeria de los Casares, and Marc Ringel, "Nature-based Solutions," 4.
[62] European Union, "The nationally determined contribution of the European Union and its Member States," *UNFCCC* (2025): Paragraph 73.

DRAFT (PENDING EC APPROVAL)

benefits: improving public health, creating green jobs, revitalising urban spaces, purifying water and air, and fostering social inclusion."[63] The positive societal and economic co-benefits of NbS are recognized by the EU, and its usage in the Union is widely mapped, in the urban nature atlas that collects "almost 1,000 examples of NbS from across 100 European cities that contribute to adapt the urban system to climate change and European assessment maps of benefits of NbS for reducing Urban Heat islands for the 775 urban areas across EU."[64] These are publicly available and could serve as inspiration for other urban areas that would like to implement NbS.

However, these are the only mentions of NbS in the EU's NDC. While co-benefits are recognized, and information about NbS in the EU is shared, there is no clear outline of how NbS implementation is supported. In particular, there is no financial framework highlighted that could fulfil this task.

The 2030 Biodiversity Strategy however, expands on what is lacking in the NDC. It mentions the areas in which NbS can play an important role, including in all kinds of ecosystems and urban areas, but further highlights the governance and financial frameworks the EU is or will be creating to support NbS implementation. It calls for the inclusion of NbS in all urban planning[65], aims to "unlock at least 20 billion euro a year for nature and ensure that a significant proportion of the 20% of the EU budget dedicated to climate action is invested in biodiversity and nature-based solutions,"[66] creates incentives and eliminates barriers for businesses to use NbS[67] , encourages the use of NbS in green public procurement[68], and supports R&D in the field.[69] The strategy thus goes into more detail on the financial framework and other types of support that is given by the EU to encourage the use of NbS.

NbS are also included in the EU's Green Infrastructure Strategy, where it is noted that for policy objectives that are wholly or partially achievable through NbS, green infrastructure represents a vital mechanism for effective implementation.[70] Some examples such as green roofs and walls are explicitly mentioned, as well as the social and health benefits associated with these solutions.[71]

The EU's Thematic Strategy on the Urban Environment, does not explicitly mention NbS.[72] However, the Strategy stems from 2006, long before NbS as a concept was introduced, let alone became widespread, and as such the Strategy cannot be faulted for not having included the concept. In fact, it does encourage the use of NbS, without naming it as such, stating: "sustainable urban design (appropriate land-use planning) will help reduce urban sprawl and the loss of natural habitats and biodiversity. Integrated management of the urban environment should foster sustainable land-use policies which avoid urban sprawl and reduce soil-sealing, include promotion of urban biodiversity and raise awareness for urban citizens."[73] Furthermore, "sustainable urban transport plans will help reduce air pollution and noise, and encourage cycling and walking, improving health and reducing obesity. Sustainable construction methods will help promote comfort, safety, accessibility and reduce health impacts from indoor and outdoor air pollution, notably particulate matter from heating systems."[74]

DRAFT (PENDING EC APPROVAL)

[63] Ibid., Annex p. 39.
[64] Ibid.
[65] European Commission, "Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions: EU Biodiversity Strategy for 2030: Bringing Nature Back Into Our Lives," *Eurlex* COM/2020/380 final (2020): 19.
[66] Ibid., 22
[67] Ibid., 23
[68] Ibid., 24
[69] Ibid., 26
[70] European Commission, "Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: Green Infrastructure (GI) – Enhancing Europe's Natural Capital," *SWD(2013) 155* (2013): 3.
[71] Ibid., 9.
[72] European Commission, "Communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment," *EurLex COM/2005/0718* (2005).
[73] Ibid., 6.2.
[74] Ibid., 6.3.

The EU's Adaptation Strategy also highlights the importance of NbS and encourages its use. However, it has a tendency to label NbS as a "no regret" solution, which is one that is "worth pursuing regardless of the ultimate climate path"[75] and it does not question NbS' ability to bring positive co-benefits for nature and humans. This does not recognize the fact that negative side effects of NbS do exist, and thus it misrepresents the wide variety of effects that can arise out of NbS usage. What the strategy does importantly mention is that it "is vital to better quantify their benefits, and to better communicate them to decision-makers and practitioners at all levels to improve take-up."[76] Furthermore, it suggests the opening up of new financing routes for NbS, including funding "under InvestEU, targeted support under Cohesion Policy programmes, and support for investments, eco-schemes and advisory services in the Common Agricultural Policy."[77] Finally, the EU concludes that it still experiences significant knowledge gaps on community-led and nature-based adaptation that it wants to work on improving.[78] Working to create NbS in local communities, from the ground up, with meaningful involvement from a wide variety of local stakeholders could be an important learning-through-doing step forward in this area.

These strategies are non-binding instruments, but they are further expansions of the EU's Climate Law, which is a legally binding instrument. In article 5.4. it does call upon the MS to include NbS in their national adaptation plans and strategies, however as the content of these strategies and plans on an MS level are non-binding, the call on MS to include these loses legal strength.[79]

As most of these EU strategies are not legally binding, they cannot be understood as strong policy instruments that mandate NbS use across the Union. However, the presence of NbS (although often articulated in the EU centric definition), is encouraged in the strategies and they thus do not actively create barriers against NbS use, and leave the possibility open to mandate their use at a later point when the natural and social scientific underpinnings and evidence base for NbS is strengthened.

4.2 NbS at the Member State Level: Strategies and Plans

The NDCs and the aforementioned strategies are not the only instruments or strategies in which the EU communicates its goals to be climate neutral, and where NbS could be encouraged. The following part of this paper will analyse the National Energy and Climate Plans (NECPs), and Long Term Strategies (LTSs) and the National Adaptation Strategies (NAS) and National Adaptation Plans (NAP) of Czechia, the Netherlands, Poland and Sweden as PHISHES respective test site countries.

The NECPs are plans submitted every five years by MSs, which address energy specific aspects of climate change adaptation policy such as decarbonisation, energy efficiency and energy security. The current NECPs cover a period from 2021 - 2030, with the most recent plans having been submitted by MSs in 2024.[80] In the NECPs of Czechia and Poland, NbS are not mentioned explicitly. In the NECP of the Netherlands however it is, although only in relation to the potential of NbS to fulfil carbon sequestration needs.[81] Similar to the Netherlands, Sweden also only mentions NbS once,

DRAFT PENDING EC APPROVAL

[75] European Commission, "Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions: Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change," *EurLex COM/2021/82* (2021): 2.
[76] Ibid., 11.
[77] Ibid., 11.
[78] Ibid., 21.
[79] European Union, "Regulations 2021/1119 of the European Parliament and of The Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')," *Official Journal of the European Union* (2021): article 5.4.
[80] European Commission, "National Energy and Climate Plans," *EU* (n.d.): https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en.
[81] Ministry of Economic Affairs and Climate Policy, "Update of The National Energy and Climate Plan 2021 - 2030," *Ministry of Economic Affairs and Climate Policy* (2024): 81.

stating the government will encourage the increase of NbS usage to battle water scarcity.[82] Despite this inclusion, and following from the discussion on definitions above, it must be concluded that the NbS included by the Netherlands and Sweden in this way in their NECPs do not qualify as such, as they only aim to fulfil purely environmental goals, and do not pursue the required social and economic co-benefits to conform as an NbS.

The LTS are MS individual strategies that highlight how they aim to meet their Paris Agreement commitments, in line with their NECPs. None of the test case countries' LTS explicitly mention NbS, and Poland has yet to submit one.[83]

The NAS and NAPs of each MS are documents that flow from the wider EU Adaptation Strategy, and which outline the action plan across all sectors and thus goes beyond some of the sector specificness of the NECPs. In these plans and strategies, the use of NbS is much more widespread, although it differs per country. While Czechia, the Netherlands and Poland have a separate strategy and plan document, differentiating between a wider strategy and more concrete planning document, the EU does not define a difference in its communication.[84] Sweden has a single document that is the adaptation strategy and plan.

While the NAP[85] of Czechia does not explicitly mention NbS, its NAS does mention it quite extensively. 10 of the mentions of NbS are in relation to water management and flood control, and only 2 explicitly mention the introduction of NbS in urban areas.[86] However, none of the mentions recognize the co-benefits of NbS for human wellbeing and health, which questions their categorization as an NbS.

In the Netherlands, the opposite trend is observed. The NAS from 2016 does not mention NbS[87], while the 2023 NAP does.[88] Importantly, the NAP highlights a definition of NbS that is cognizant of the importance of co-benefits for humans, stating that "nature-based solutions are solutions and ideas that are inspired by or supported by the natural environment. Their goal is to provide effective solutions to societal problems that will benefit humans and the natural environment."[89] The NAP then notes the importance of using NbSs, both in general and in relation to NbS's ability to improve water conditions, as well as highlighting the Dutch commitment to the use of NbS within the context of the Global Climate Strategy and the Global Biodiversity Framework.[90]

The Polish NAP does not explicitly mention NbS, and for the NAS no analysis can be completed, as it is still in development.[91]

DRAFT (PENDING EC APPROVAL)

[82] Ministry of Climate and Enterprise, "Sweden's updated National Energy and Climate Plan 2021-2030," *Government Offices* (2024): 124.
[83] United Nations Climate Change, "Long-term strategies portal," *UNFCCC* (2026): https://unfccc.int/process/the-paris-agreement/long-term-strategies.
[84] European Commission, "Guidelines on Member State Adaptation Strategies and Plans," *EC* (2023).
[85] Ministerstvo životního prostředí, "Národní akční plán adaptace na změnu klimatu," (2021).
[86] Ministerstvo životního prostředí, "Strategie přizpůsobení se změně klimatu v podmínkách ČR," (2021).
[87] Stef Meijs, Ytsen Deelstra, Annemarieke Grinwis, Paul van Hemert, Kim van Nieuwaal, Tis Solleveld van Helden, Hilde Westera, and Berend van Zeggeren, "Adapting with ambition: National Climate Adaptation Strategy 2016 (NAS)," *Ministry of Infrastructure and the Environment* (2016).
[88] Ministry of Infrastructure and Water Management, "National Climate Adaptation Implementation Programme: Smarter, more systemic, for all and by all," *Ministry of Infrastructure and Water Management* (2023).
[89] Ibid., 59.
[90] Ibid., 58 and 62.
[91] Agnieszka Widuto, "Poland's climate action strategy," *European Parliament Briefing* (2024); –., "The Ministry of Climate and Environment is working on the National Strategy for Adaptation to Climate Change, along with the Adaptation Action Plan," *Ministry of Climate and Environment* (2026): https://www.gov.pl/web/climate/the-ministry-of-climate-and-environment-is-working-on-the-national-strategy-for-adaptation-to-climate-change-along-with-the-adaptation-action-plan.

Sweden has one document that is titled both the NAS and NAP, released in 2023, where NbS is (comparatively to the other countries) extensively mentioned.[92] It encompasses a specific subsection of the plan that highlights the importance of NbS in water management, water security and flood prevention.[93] Furthermore, the strategy and plan explicitly reiterate the government support for the usage of NbS, encouraging the use of EU funds for creating NbS[94], showcasing Sweden's national commitments to NbS on a Nordic[95], EU[96] and global level[97], or highlighting the guidance documents from the Swedish Environmental Protection Agency on the use of NbS in municipalities.[98] There is thus a clear governance framework encouraging the use of NbS, and the understanding of NbS that is articulated considers the "other positive effects such as increasing the uptake and storage of greenhouse gases, strengthening biodiversity or positively impacting human health,"[99] next to the adaptation goals it can help achieve.

The analysis of these documents thus shows that encouragement of NbS is extremely MS dependent, and it cannot be argued that there is a similar trend across the PHISHES test cases.

4.3 NbS at the Member State Level: Public Procurement Regulations

The public procurement regulations in the EU currently present both a barrier to NbS usage, as well as an opportunity to encourage its use further.

The public procurement laws of the EU, Czechia, Poland, the Netherlands, and Sweden do not explicitly mention NbS. However, environmental considerations are provided for - albeit differently in the countries. In the EU's public procurement process, cost-effectiveness is the leading indicator for making decisions, but qualitative, environmental and/or social aspects must also be considered when deciding to pursue a certain company for public procurement.[100] In Czechia too, the inclusion of positive measures for the environment can increase the economic advantageousness of a tender.[101] In the Netherlands, the tender is awarded based on a set of criteria that does, although low on the list, include environmental considerations.[102] It is left aside whether this proof must be quantitative or qualitative. In Poland, the contracting body can evaluate a tender more positively on the basis of environmental and social considerations, if the effects of a contract on these considerations can be obtained.[103] In Sweden, environmental considerations should be considered by the contracting authority, but only if the "procurement so justifies,"[104] leaving space for policy makers to argue it should not be considered. On the contrary, the law also allows for the "contracting authority to instate specific environmental, social, labour law or other conditions for contract performance."[105] These contradictory provisions - allowing environmental considerations to be set, but only if it is justified - allows individuals at contracting authorities too much leniency in deciding the importance of environmental considerations, which they could always argue are 'not justified'. This could lead to a fragmented landscape, influenced by politics. Across these four countries, and

[92] Regeringens skrivelse, "Nationell strategi och regeringens handlingsplan för klimatanpassning," 2023/24:97 (2023).
[93] Ibid., 50.
[94] Ibid., 18.
[95] Ibid., 92.
[96] Ibid., 26 and 93.
[97] Ibid., 93.
[98] Ibid., 71.
[99] Ibid., 25.
[100] European Union, "Directive 2014/24/EU of The European Parliament and of The Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC," *Official Journal of the European Union* 94 (2014): 80.
[101] Office for the Protection of Competition of the Czech Republic, "Public Procurement," ACT no. 134/2016 (2016): section 116.
[102] "Aanbestedingswet 2012," *Wettenbank* (in force from 30 April 2026): Article 2.115.
[103] Public Procurement Office, "The Public Procurement Law," *Public Procurement Office* (2019): article 17 and article 83.
[104] Swedish Competition Authority, "Swedish Public Procurement Act," *Swedish Competition Authority* (2017): chapter 4 section 3.
[105] Ibid., Chapter 17 section 1.

in the EU law, the quantified costs of environmental externalities are allowed to be calculated into the lifecycle costs, which is encouraged to play a role in the decision-making process to award tenders.

The public procurement regulation in the four test cases at the moment does not provide a clear "NbS first" mandate, but does allow, albeit to varying degrees, the inclusion (and sometimes prioritisation) of environmental considerations in the awarding decision making process. However, quantifying such environmental services is incredibly difficult, making it questionable to what extent high costs for NbS and environmental considerations are allowed in practice. Future research could explore this further, and see when, why and at what thresholds, environmental considerations are given precedence over financial ones.

Although public procurement thus acts as a barrier at the moment, public procurement regulations could be adapted to give more preference to environmental considerations, pushing contracting authorities to make better choices for the environment and people.

Across these EU wide and national strategies, documents, frameworks and support systems, it can be concluded that NbS is defined differently across the board, and the focus (or lack thereof) on the co-benefits NbS can have, particularly socially, is concerning, especially as this is in stark contrast to the consensus found in academic literature which deems an NbS only an NbS when it aims to produce in its planning, and actually produces in the implementation, these co-benefits.

4.4 Financing Instruments for Nature-based Solutions: Landscape, Challenges, and Emerging Mechanisms

4.4.1 The Current State of NbS Finance

Securing adequate financing constitutes a central challenge in the implementation and scaling of nature-based solutions (NbS). Existing research demonstrates that NbS projects in Europe continue to rely predominantly on public financing.[106] In their review of NbS interventions in European cities, Bockarjova et al. find that "91% of the selected interventions were financed from public sources, both national and local; 28% used EU funds; and 40% also attracted private and/or NGO finance."[107] This finding is corroborated by Papari et al., who identify public actors as the dominant investors in urban NbS, with municipal authorities acting as the primary financiers, supplemented by significant contributions from EU institutions as well as regional and national governments.[108] However, increasing public budgetary constraints, fiscal deficits, and broader austerity measures have intensified pressure on public authorities to diversify funding sources and attract additional private capital for NbS implementation.

Against this backdrop, Hudson et al. provide a systematic assessment of the financial instruments currently used to support NbS financing across the European Union.[109] Drawing on survey data and structured interviews, they demonstrate that the NbS finance market remains comparatively underdeveloped, limiting investors' ability to identify established track records, standardized performance metrics, and credible pathways to financial viability.[110] Their analysis evaluates financing instruments according to several dimensions, including standardization capacity,

[106] Catalina-Alexandra Papari, Helen Toxopeus, Friedemann Polzin, Harriet Bulkeley, Eloisa Vittoria Menguzzo, "Can the EU taxonomy for sustainable activities help upscale investments into urban nature-based solutions?" *Elsevier* (2024): 5.
[107] Marija Bockarjova, W. J. Wouter Botzen, Harriet A. Bulkeley, HelenToxopeus, "Estimating the social value of nature-based solutions in European cities," *Nature* (2022): 3.
[108] Catalina-Alexandra Papari, Helen Toxopeus, Friedemann Polzin, Harriet Bulkeley, Eloisa Vittoria Menguzzo, "Can the EU taxonomy for sustainable activities help upscale investments into urban nature-based solutions?" *Environmental Science and Policy* 151 (2024): 5.
[109] Hudson, S. Hart, and A. Verbeek, "Investing in nature-based solutions - State-of-play and way forward for public and private financial measures in Europe," *European Investment Bank* (2023): 74.
[110] Ibid.

DRAFT PENDING EC A.

implementation complexity, temporal orientation, frequency of use, and broader effects on market development.[111] Despite the fragmented and emergent nature of the NbS finance landscape, a number of principal financing mechanisms can nevertheless be identified as particularly relevant for supporting the implementation and scaling of NbS.

4.4.2 Principal Financing Instruments[112]

Grant Funding constitutes the most frequently mobilised financial instrument for NbS in the EU and is predominantly public in origin. As non-repayable funding, grants reduce the financial risk borne by implementing actors and remain the primary vehicle through which NbS projects achieve financial viability in the current institutional landscape.

Market Loans represent the second most commonly employed financing mechanism, whereby a project proponent borrows capital from a bank or other financial institution and repays the principal, together with accrued interest, over an agreed period. While accessible, market loans expose borrowers to standard commercial lending conditions that may not be well-suited to the long-term and uncertain return profiles characteristic of NbS investments.

Concessional Loans offer more favourable terms than standard market instruments, either through discounted interest rates or extended repayment periods, and may signal a financial institution's commitment to supporting the development of a particular project. Their preferential structure renders them more compatible with the extended time horizons typically associated with NbS value realisation.

Equity Instruments involve the injection of venture or private capital into NbS projects, with investors generally anticipating short-term financial returns. This expectation constitutes a structural constraint on uptake, insofar as the timescales over which NbS generate returns are typically misaligned with the short-term investment horizons that characterise private equity actors.

Guarantees involve a public institution assuming liability in the event that an NbS project loan cannot be serviced, thereby reducing the risk exposure of private financiers by the guaranteed amount. This de-risking function is particularly significant in contexts where the financial performance of NbS is uncertain or difficult to predict.

Thematic Bonds may be structured around a range of sustainability themes including the Sustainable Development Goals, climate resilience, and blue-green infrastructure and represent an instrument available to both corporate and public issuers seeking to direct capital toward NbS-aligned investments.

Sustainability-Linked Bonds and Loans differ from thematic bonds in that the financial terms of the instrument are tied to the achievement of predefined key performance indicators, thereby creating explicit incentive structures for performance delivery. This instrument has been adopted by institutions including the World Bank and the European Investment Bank. In parallel, the integration of NbS as a prioritisation criterion within public procurement frameworks, whether by giving NbS projects preferential consideration in funding decisions or by designating NbS elements as mandatory components of funding applications, would further stimulate market development. Similarly, the Intercontinental Exchange introduced the creation of NbS carbon credits, which would allow investors to purchase, sell and hedge carbon credits and create new financing opportunities on the private market.

DRAFT (PENDING EC APPROVAL)

[111] Ibid.
[112] The source of the information in this section is: Hudson, S. Hart, and A. Verbeek, “Investing in nature-based solutions - State-of-play and way forward for public and private financial measures in Europe,” *European Investment Bank* (2023): 74.

4.4.3 Supplementary and Emerging Revenue Mechanisms

Beyond the principal financing instruments outlined above, a range of supplementary mechanisms exist through which private and public NbS investments may be recouped, either through direct revenues or indirect financial advantages.

The sale of products and commodities derived from NbS areas, including timber, fruit, and dairy products, constitutes a potential source of direct revenue that may partially offset implementation and management costs. Tax and fee concessions for private NbS investments, such as reduced sewage charges in recognition of green roof stormwater retention capacity, represent a further indirect financial incentive. Conversely, value uplift accruing to private properties as a consequence of publicly funded NbS interventions manifest, for instance, in increased real estate values could appropriately be recaptured for public benefit through real estate taxation mechanisms, to also try and counteract the effects of green gentrification and citizen displacement.

Credit-based instruments are considered among the most promising emerging financial tools within the NbS financing landscape. Bloomberg projects that, under a more stringent regulatory framework, credit markets could expand by as much as 3,000% between 2023 and 2029.113 Such credits may take the form of carbon credits, biodiversity credits with additional premiums per credit reflecting biodiversity co-benefits carbon farming credits, or wetland mitigation credits applicable to wetland restoration activities.

Cost-reduction models, benchmarked against the avoided costs attributable to NbS (particularly in high-risk environments) offer a further revenue pathway: a proportion of the risk-reduction value generated could be calculated as a revenue stream accruing to institutions that benefit from reduced exposure, such as insurance providers. Ecosystem service taxes and payment for ecosystem services schemes similarly hold potential for capturing the value of ecosystem goods and services that are systematically undervalued by conventional markets, through mechanisms including direct public or private payments, tax incentives, cap-and-trade markets, and certification programmes. Insurance-based instruments targeting asset protection, liability reduction, and the facilitation of capital inflows into NbS markets represent a further avenue for financial innovation.

4.4.4 Structural Challenges

Notwithstanding the diversity of instruments available, the NbS financing landscape faces significant structural impediments. A central challenge concerns the mobilisation of blended finance, that is, the effective combination of private and public funding sources to support NbS at scale. The cultivation of public-private partnerships capable of aligning divergent risk appetites, return expectations, and governance logics remains a critical and largely unresolved challenge. At the moment, most financing for NbS comes from public institutions. Only where private actors appear to be directly benefiting from the NbS (e.g. housing developers building green facades to increase property value) are NbS actively being pursued by private actors. NbS with larger social co-benefits are yet to be frequently funded by private actors. Compounding this difficulty, regional and municipal administrations often lack the institutional capacity and technical expertise necessary to conduct rigorous economic valuations of NbS, despite the availability of a range of established valuation methodologies.114 Addressing this capacity deficit constitutes a prerequisite for the mainstreaming of economically credible NbS business cases within public investment planning.

DRAFT (PENDING EC APPROVAL)

[113] Bloomberg, “Carbon offsets price may rise 3,000% by 2029 under tighter rules,” (2025): https://www.bloomberg.com/professional/insights/commodities/carbon-offsets-price-may-rise-3000-by-2029-under-tighter-rules/.
[114] M. El Harrak, and F. Lemaitre, “European Roadmap to 2030 for Research and Innovation on Nature-based Solutions,” *NetworkNature* (2023).

5 Conclusion

Having gained increasing salience across the world, and particularly in the EU, it is important to reflect and consider the promise and limitations of NbS. As this analysis has shown, NbS should not be treated as a 'silver bullet' capable of fixing a wide variety of issues at once. However, well-designed, inclusive and environmentally just NbS can indeed bring about significant environmental and socio-economic co-benefits. This however requires a significant push for R&D in the field of assessment metrics of these co-benefits, which currently lags behind the prominence NbS is gaining. As it stands, the ability to quantify environmental, health, social, cost effectiveness, the trade-offs and benefits of NbS, particularly on a long-term scale, are still incomplete.

The paper has reviewed the ongoing discussion on definitions and knowledge gaps in the field and presented often cited critiques of NbS. It has then analysed the policy instruments at EU and MS level that could work as enablers or barriers of NbS implementation. Taken together, these findings point toward a clear path forward: NbS holds genuine potential and realising that potential demands rigour, inclusivity, and demands a critical look at the systems within which these solutions must operate.

In February 2028, an update for this Scientific Opinion paper will be completed, which will expand upon the policy instruments for NbS, to include an analysis of policy instruments for soil health at large, as well as the legal contexts in which these occur in each PHISHES test case country. These policy instruments can then also be calibrated to the findings of PHISHES, to make recommendations as specific as possible to transform the state of soil in the EU, based on PHISHES predictive long-term modelling capabilities.

DRAFT (PENDING

6 Bibliography

Anguelovski, Isabelle and Esteve Corbera. “Integrating justice in Nature-Based Solutions to avoid nature-enables dispossession.” *Ambio* 52 (2023).

Bakker, K.J. “A political ecology of water privatization.” *Studies in political economy* 70, no. 1 (2003): 35–58;

Bloomberg. “Carbon offsets price may rise 3,000% by 2029 under tighter rules.” (2025): https://www.bloomberg.com/professional/insights/commodities/carbon-offsets-price-may-rise-3000-by-2029-under-tighter-rules/.

Bockarjova, Marija, W. J. Wouter Botzen, Harriet A. Bulkeley, and HelenToxopeus. “Estimating the social value of nature-based solutions in European cities.” *Nature* (2022).

Brink, E, T. Aalders, D. Adam, R. Feller, Y. Henselek, A. Hoffmann, K. Ibe, A. Matthey-Doret, M. Meyer, N.L. Negrut, A.L. Rau, B. Riewerts, L. von Schuckmann, S. Tornros, H. von Wehrden, D.J. Abson, and C. Wamsler. “Cascades of green: a review of ecosystem-based adaptation in urban areas.” *Global Environmental Change* 36 (2016): 111 - 123.

Circularity Gap Report. “Sweden - A global standout for mineral, metal and biomass extraction.” *Circularity Economy* (n.d.): https://dashboard.circularity-gap.world/report/sweden/extraction.

Cohen-Shacham, E., G. Walters, C. Janzen, and S. Maginnis (Eds.). “Nature-Based Solutions to Address Global Societal Challenges.” *IUCN* (Gland, Switzerland, 2017).

de los Casares, Valeria, and Marc Ringel. “Nature-based Solutions for climate adaptation in the European Union: Part I Mapping EU and National initiatives.” *European Chair for Sustainable Development and Climate Transition at Sciences Po* (2023): 1 - 52.

Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A.G., Mittal, N., Feliu, E., Faehnle, M. “Mitigating and adapting to climate change: multi-functional and multi-scale assessment of green urban infrastructure,” *Journal of Environmental Management* 146, (2014): 107–115.

Dumitru, Adina, Niki Frantzeskaki, and Marcus Collier. “Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities.” *Environmental Science and Policy* 112 (2020): 107-116.

El Harrak, M. and F. Lemaitre. “European Roadmap to 2030 for Research and Innovation on Nature-based Solutions.” *NetworkNature* (2023).

European Commission. “Communication from the Commission to the Council and the European Parliament on Thematic Strategy on the Urban Environment.” *EurLex COM/2005/0718* (2005).

European Commission. “Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of the Regions: Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change.” *EurLex COM/2021/82* (2021).

European Commission. “Communication from the Commission to the European Parliament, The

DRAFT (PENDING EC APPROVAL)

Council, The European Economic and Social Committee and The Committee of the Regions: EU Biodiversity Strategy for 2030: Bringing Nature Back Into Our Lives." *Eurlex COM/2020/380 final* (2020).

European Commission. "Communication from The Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions: Green Infrastructure (GI) – Enhancing Europe's Natural Capital." *SWD(2013) 155* (2013).

European Commission. "Guidelines on Member State Adaptation Strategies and Plans." *EC* (2023).

European Commission. "National Energy and Climate Plans." *EU* (n.d.): https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-energy-and-climate-plans_en.

European Union. "Directive 2014/24/EU of The European Parliament and of The Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC." *Official Journal of the European Union* 94 (2014).

European Union. "Regulations 2021/1119 of the European Parliament and of The Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')." *Official Journal of the European Union* (2021).

European Union. "The nationally determined contribution of the European Union and its Member States." *UNFCCC* (2025).

Fini, A., P. Frangi, J. Mori, D. Donselli, and F. Ferrini. "Nature based solutions to mitigate soil sealing in urban areas: results from a 4-year study comparing permeable, porous, and impermeable pavements." *Environmental Research* 156 (2017): 443–454.

Fuss, S., W. F. Lamb, M. W. Callaghan, J. Hilaire, F. Creutzig, T. Amann, T. Beringer, W. de Oliveira Garcia, J. Hartmann, T. Khanna, G. Luderer, G. F. Nemet, J. Rogelj et al. "Negative emissions—Part 2: Costs, potentials and side effects." *Environmental Research Letters* 13, no. 6 (2018).

Girardin, C.A.J., S. Jenkins, N. Seddon, M. Allen, S. L. Lewis, C. E. Wheeler, B. W. Griscom, Y. Malhi. "Nature-based solutions can help cool the planet — if we act now." *Nature* 593, no. 7858 (2021): 191–194.

Griscom, B. W., J. Adams, P. W. Ellis, R. A. Houghton, G. Lomax, D. A. Miteva, W. H. Schlesinger, D. Shoch, J. V. Siikamäki, P. Smith, P. Woodbury, C. Zganjar, A. Blackman, et al. "Natural climate solutions." *Proceedings of the National Academy of Sciences of the United States of America* 114 , no. 44 (2017): 11645–11650.

Haase, D., N. Larondelle, E. Andersson, M. Artmann, S. Borgstrom, J. Breuste, E. Gomez-Baggethun, A. Gren, Z. Hamstead, R. Hansen. "A quantitative review of urban ecosystem service assessments: concepts, models, and implementation." *Ambio* 43, no. 4 (2014): 413 - 433.

Hudson, G., S. Hart, and A. Verbeek. "Investing in nature-based solutions - State-of-play and way

DRAFT (PENDING EC APPROVAL)

forward for public and private financial measures in Europe." *European Investment Bank* (2023).

Intergovernmental Panel on Climate Change. "Climate Change 2022: Impacts, Adaptation, and Vulnerability. Summary for Policy-Makers." *IPCC* (2022).

Immergluck, D. "Large redevelopment initiatives, housing values and gentrification: The case of the Atlanta Beltline." *Urban Studies* 46, no. 8 (2009): 1723–1745.

IUCN. "Nature-based Solutions." IUCN (2016): https://www.iucn.org/commissions/commission-ecosystem-management/our-work/nature-based-solutions (last updated on 16 Sep 2020, last accessed on 27 May 2026).

Jia, G., Shevliakova, E., Artaxo, P., Noblet-Ducoudré, N. de, Houghton, R., House, J., Kitajima, K., Lennard, C., Popp, A., Sirin, A., Sukumar, R., and Verchot, L. "Land-climate interactions." In Shukla, P. R.; Skea, J.; Calvo, Buendi, E.; Masson-Delmotte, V., Pörtner, H.-O., Roberts, D. C., Zhai, P., Slade, R., Connors, S., Diemen, R. v., Ferrat, M., Haughey, E., Luz, S.; Neogi, S.; Pathak, M. et al. (ed.): *Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (2019): 131–247.

Kassa, H., A. Abiyu, N. Hagazi, M. Mokria, T. Kassawmar, and V. Gitz. "Forest landscape restoration in Ethiopia: Progress and challenges." *Frontiers in Forests and Global Change* 5 (2022).

Kotsila, Panagiota, Isabelle Anguelovski, Francesc Baró, Johannes Langemeyer, Filka Sekulova, and James JT Connolly. "Nature-based solutions as discursive tools and contested practices in urban nature's neoliberalisation processes." *Nature and Space* 4, no. 2 (2021): 252 - 274.

Kabisch, Nadja, Niki Frantzeskaki, Stephan Pauleit, Sandra Naumann, McKenna Davis, Martina Artmann, Dagmar Haase, Sonja Knapp, Horst Korn, Jutta Stadler, Karin Zaunberger and Aletta Bonn. "Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action." *Ecology and Society* 21, no. 2 (2016).

Kabisch, Nadja, and Matilda Annerstedt van den Bosch. "Urban Green Spaces and the Potential for Health Improvement and Environmental Justice in a Changing Climate." in Kabisch et al. (eds) *Nature-based Solutions to Climate Change Adaptation in Urban Areas: Theory and Practice of Urban Sustainability Transitions* (2017).

Lennox, G. D., Gardner, T. A., Thomson, J. R., Ferreira, J., Berenguer, E., Lees, A. C., Mac Nally, R., Aragão, L., Ferraz, S., Louzada, J., Moura, N. G., Oliveira, V., Pardini, R. et al. "Second rate or a second chance? Assessing biomass and biodiversity recovery in regenerating Amazonian forests." *Global Change Biology* 24, no. 12 (2018): 5680–5694.

Marzelli, Stefan, Lilian Busse, Andrea Emmer, Claudia Schwarz, Magdalena Holzer, Wolfgang Pfefferkorn, and Sophie Mahlknecht. "Nature-based Solutions and their Governance Structures for Climate Action in the Alpine Region." *German Environment Agency* (2025).

McCarthy, J., and S. Prudham. "Neoliberal nature and the nature of neoliberalism." *Geoforum* 35, no. 3 (2004): 275–283.

Meijs, Stef, Ytsen Deelstra, Annemarieke Grinwis, Paul van Hemert, Kim van Nieuwaal, Tis

DRAFT (PENDING EC APPROVAL)

Solleveld van Helden, Hilde Westera, and Berend van Zeggeren. “Adapting with ambition: National Climate Adaptation Strategy 2016 (NAS).” *Ministry of Infrastructure and the Environment* (2016).

Ministry of Climate and Enterprise. “Sweden’s updated National Energy and Climate Plan 2021-2030.” *Government Offices* (2024).

Ministry of Economic Affairs and Climate Policy. “Update of The National Energy and Climate Plan 2021 - 2030.” *Ministry of Economic Affairs and Climate Policy* (2024).

Ministry of Infrastructure and Water Management. “National Climate Adaptation Implementation Programme: Smarter, more systemic, for all and by all.” *Ministry of Infrastructure and Water Management* (2023).

Ministerstvo životního prostředí. “Národní akční plán adaptace na změnu klimatu.” (2021).

Ministerstvo životního prostředí. “Strategie přizpůsobení se změně klimatu v podmínkách ČR.” (2021).

Nesshöver, C., Assmuth, T., Irvine, K. N., Rusch, G. M., Waylen, K. A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Külvik, M., Rey, F. et al. “The science, policy and practice of nature-based solutions: An interdisciplinary perspective.” *Science of The Total Environment* 579 (2017): 1215–1227.

Office for the Protection of Competition of the Czech Republic. “Public Procurement.” *ACT no. 134/2016* (2016).

Osaka, S., R. Bellamy, and N. Castree. “Framing “nature-based” solutions to climate change.” *WIREs Climate Change* 12, no. 5 (2021).

Papari, Catalina-Alexandra, Helen Toxopeus, Friedemann Polzin,, Harriet Bulkeley, and Eloisa Vittoria Menguzzo.“Can the EU taxonomy for sustainable activities help upscale investments into urban nature-based solutions?” *Environmental Science and Policy* 151 (2024).

Pereira, H. M., Ferrier, S., Walters, M., Geller, G. N., Jongman, R. H. G., Scholes, R. J., Bruford, M. W., Brummitt, N., Butchart, S. H. M., Cardoso, A. C., Coops, N. C., Dulloo, E., Faith, D. P. et al. “Essential Biodiversity Variables.” *Science* 339, no. 6117 (2013): 277–278.

Pettorelli, N., Graham, N. A. J., Seddon, N., da Cunha Bustamante, M. M., Lowton M. J., Sutherland, W. J., Koldewey, H. J., Prentice, H. C., and Barlow, J. “Time to integrate global climate change and biodiversity science-policy agendas.” *Journal of Applied Ecology* (2021).

Public Procurement Office. “The Public Procurement Law.” *Public Procurement Office* (2019).

Rosol, M. “Vancouver’s “EcoDensity” planning initiative: A struggle over hegemony?” *Urban Studies* 50, no. 11 (2013): 2238–2255.

Reise, Judith, Anne Siemons, Hannes Bottcher, Anke Herold, Cristina Urrutia, Lambert Schneider, Ewa Iwaszuk, Hugh McDonald, Ana Frelih-Larsen, Laurens Duin, and McKenna Davis. “Nature-based Solutions and global climate protection: Assessment of their global mitigation potential and recommendations for international climate policy.” *German Environment Agency* (2022): 1 - 81.

DRAFT (PENDING EC APPROVAL)

Reise, Judith, Cristina Urrutia, Sandra Dalfiume, Christina Ender, Ingrid Wawrzynowicz, and Pedro Pássaro. “Nature-based solutions for climate and biodiversity protection in selected national climate contributions.” *German Environment Agency* (2025).

Regeringens skrivelse. “Nationell strategi och regeringens handlingsplan för klimatanpassning.” *2023/24:97* (2023).

Roe, S., Streck, C., Obersteiner, M., Frank, S., Griscom, B., Drouet, L., Fricko, O., Gusti, M., Harris, N., Hasegawa, T., Hausfather, Z., Havlík, P., House, J., et al. “Contribution of the land sector to a 1.5 °C world.” *Nature Climate Change* 9, no. 11 (2019): 817–828.

Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., and Turner, B. “Understanding the value and limits of nature-based solutions to climate change and other global challenges.” *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 375, no. 1794 (2020).

Swedish Competition Authority. “Swedish Public Procurement Act.” *Swedish Competition Authority* (2017).

United Nations Climate Change. “Long-term strategies portal.” *UNFCCC* (2026): https://unfccc.int/process/the-paris-agreement/long-term-strategies.

United Nations Environment Program. “Overview of Nature-based solutions.” *UNEP* (last updated 4 November 2024, last accessed 27 May 2026): https://www.unep.org/topics/nature-action/nature-based-solutions/overview-nature-based-solutions.

While, A., A.E.G. Jonas, and D. Gibbs. “The environment and the entrepreneurial city: Searching for the urban ‘sustainability fix’ in Manchester and Leeds.” *International Journal of Urban and Regional Research* 28, no. 3 (2004): 549–569.

Whitehead, M. “Neoliberal urban environmentalism and the adaptive city: Towards a critical urban theory and climate change.” *Urban Studies* 50, no. 7 (2013): 1348–1367.

Widuto, Agnieszka. “Poland’s climate action strategy.” *European Parliament Briefing* (2024).

World Bank Group. “Annual Report.” *World Bank* (2008): 1 - 68. https://documents1.worldbank.org/curated/en/338051468338968060/pdf/470900WBAR0ENG00Box334114B00PUBLIC0.pdf.

Qiu, J., Game, E.T., Tallis, H., Olander, L.P., Glew, L., Kagan, J.S., Kalies, E., Michanowicz, D., Phelan, J., Polasky, S., Reed, J., Sills, E.O., Urban, D., and Weaver, S.K., “Evidence-based causal chains linking health, development and conservation actions.” *Bioscience* 68, no. 3 (2018): 182–193.

–. “Aanbestedingswet 2012.” *Wettenbank* (in force from 30 April 2026).

–. “The Ministry of Climate and Environment is working on the National Strategy for Adaptation to Climate Change, along with the Adaptation Action Plan.” *Ministry of Climate and Environment* (2026): https://www.gov.pl/web/climate/the-ministry-of-climate-and-environment-is-working-on-the-national-strategy-for-adaptation-to-climate-change-along-with-the-adaptation-action-plan.

DRAFT (PENDING EC APPROVAL)

7 Annex

Table 1: The scale at which the strategy is applicable, the document, its publication date and its legal standing.

Scale	Document	Legal Standing
International	NDC (2025)	Reporting requirement at UNFCCC, but targets are binding within EU law
EU	EU Biodiversity Strategy (2020)	Non-binding
	EU Climate Law (2021)	Binding
	EU Green Infrastructure Strategy (2013)	Non-binding
	EU Thematic Strategy on the Urban Environment (2006)	Non-binding
	EU Adaptation Strategy (2021)	Non-binding
	EU Public Procurement Law (2014)	Binding
National (applicable to all test case countries)	NECP	Submission requirement, within binding EU climate neutrality framework
	LTS	Non-binding
	NAS	Non-binding
	NAP	Non-binding
	Public Procurement Law	Binding

DRAFT (PENDING EC APPROVAL)

PHISHES

PHysically-based Integrated Soil HEalth Simulation platform

Predicting soil health to protect ecosystems

DRAFT (PENDING EC APPROVAL)

For More Information:

- Visit PHISHES website: www.phishes-project.eu/
- Follow PHISHES on LinkedIn: www.linkedin.com/company/phishes-project/

Funded by the European Union

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.