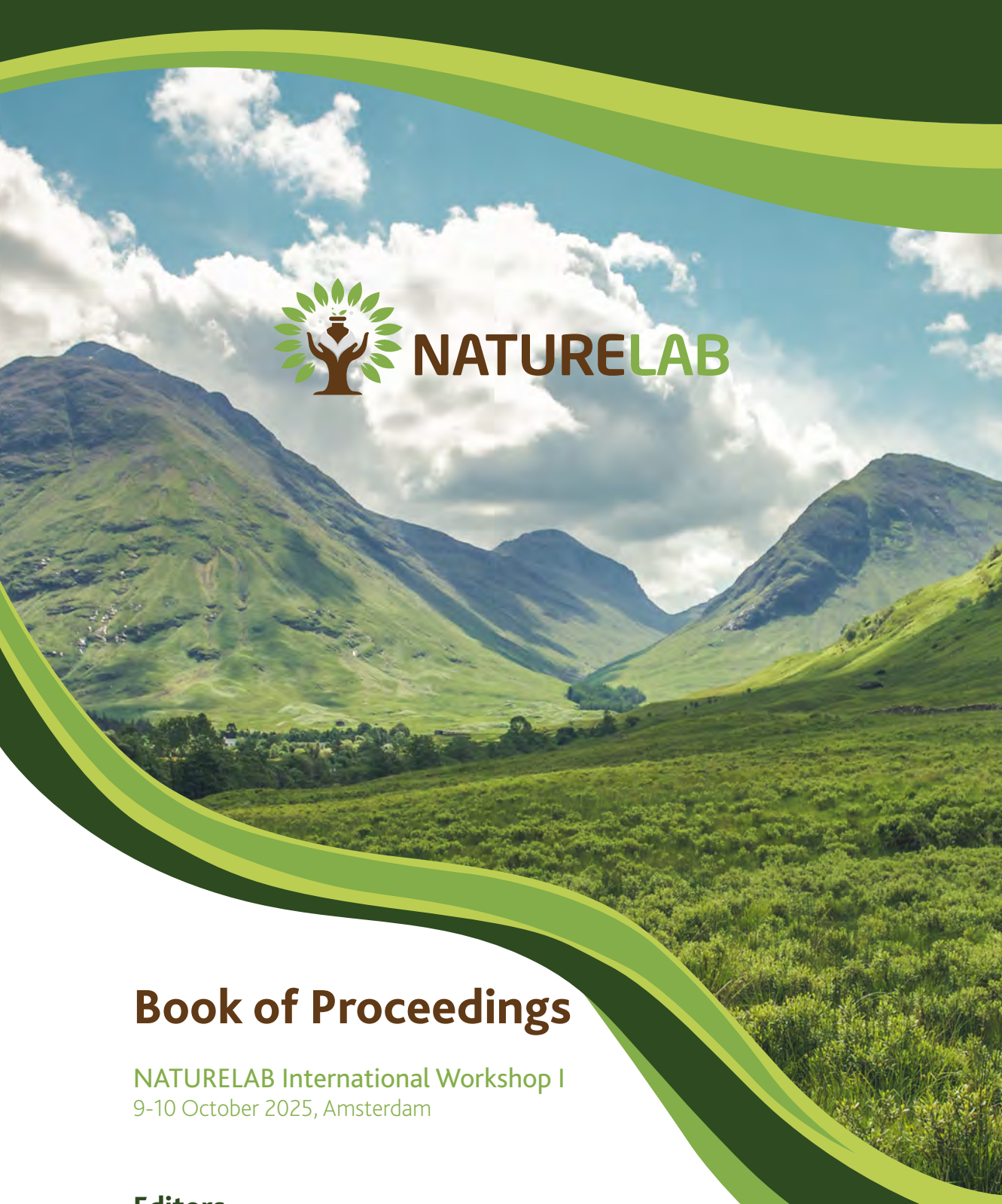

NATURELAB

Book of Proceedings

NATURELAB International Workshop I
9-10 October 2025, Amsterdam

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Acknowledgments
This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement number 101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

Divisão de Divulgação Científica e Técnica
AV DO BRASIL 101 • 1700-066 LISBOA
e-e: livraria@lnec.pt
www.lnec.pt

Publisher: LNEC

Collection: Non-serial publications

Series: NS 141

1st. edition: 2026 (pdf)

Descriptors: Urban area / Sustainable development / Public health / International Congress
Descritores: Área urbana / Desenvolvimento sustentável / Saúde pública / Congresso Internacional

CDU 502.31(063)(100)
ISBN 978-972-49-2343-7
DOI 10.34638/8zet-1n47

Preface

The **NATURELAB International Workshop I (IWI)**, held in VU Amsterdam on 9-10 October 2025, served as an international platform for joint discussion, knowledge exchange, and critical reflection within the nature-based solutions and therapies community. The IWI brought together nearly 80 participants over the course of two days, fostering a vibrant and interdisciplinary exchange of ideas. We gratefully acknowledge *Leonie Stekelenburg* and *Caroline Meier zu Biesen*, our local organisers, for their outstanding commitment to the success of this event.

IWI opened with presentations from **NATURELAB** partners, alongside contributions from the coordinators of the sister projects, RESONATE and GreenME, fostering the sharing of insights, methodologies, and early findings across complementary initiatives.

Keynote interventions addressed the intersections of health, urban sustainability, and evidence-based practice, stimulating dialogue on future research directions and implementation pathways. The programme was further enriched by parallel sessions, poster and video presentations, and experiential nature-based interventions, which together enabled participants to exchange experiences, bridge scientific and practical perspectives, and strengthen collaboration across an international community of researchers and practitioners.

In addition to the scientific programme, participants at the **IWI** engaged in nature-based intervention sessions on both days, including horticultural therapy and forest bathing at the Amsterdam Botanical Gardens. These sessions offered participants a rare opportunity for direct, embodied engagement with the restorative qualities of nature, enriching the workshop experience beyond traditional academic exchange. The sessions were facilitated by project team members *Alex Gesse* and *Daniela Silva-Rodriguez Bonazzi*, who are gratefully acknowledged.

NATURELAB IWI successfully created a space for interdisciplinary collaboration, reinforcing the project's mission to integrate nature, science, health and well-being in innovative and transformative ways. We are pleased to present this **Book of Proceedings**, which serves as a lasting record of the **IWI** and an ambassador for the increasing relevance for research, policy, and practice in the field of nature-based solutions and therapies. We are also glad to extend the reach of the event by providing access to the **keynote and panel discussion recordings**, together with the contributions collected in these proceedings, for participants and for those who wished to attend but were unable to do so.

We also wish to express our sincere appreciation to the members of *the Scientific and Technical Committee* for their commitment and rigorous work in ensuring the scientific quality, coherence, and relevance of the contributions in this volume.

Finally, we gratefully acknowledge *Rui Monteiro* and *Mariachiara Fagan*, who kindly collected notes and prepared summaries of the keynote speakers' sessions and discussions, thereby providing valuable synthesis and continuity to the outcomes of the event.

Ana Estela Barbosa, *NATURELAB Coordinator*

Margarida Rebelo, *NATURELAB Co-coordinator*

Table of Contents

Acknowledgements

The NATURELAB project coordination would like to express its sincere appreciation to all speakers, authors, reviewers, and organisers whose dedication and contributions were indispensable to the success of the NATURELAB International Workshop I. We would like to thank the coordinators of the sister projects - *Margarita Triguero-Mas* and *Helen Cole* (GreenME), and *Mathew White*, *Julia Eagger* and *Matilda van den Bosch* (RESONATE) - who, although unable to attend the IWI in person, took the time to prepare insightful videos presenting their projects' objectives and providing an overview of their main actionable outputs to date. **We also wish to highlight the importance of the ongoing collaboration among the three projects, which has been in place since their inception and has contributed to strengthening synergies and maximising impact.**

Disclaimer

The authors are solely responsible for the content of their respective contributions published in this volume. While all manuscripts underwent a review process, not all suggestions or requests made by the review committee were fully incorporated into the final versions of the works. The views and interpretations expressed herein are those of the authors and do not necessarily reflect those of the editors or the review committee.

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Keynote Speakers: Summaries and Discussion

- The City as a Tool for Health - ***Anne van Bergen***, *Healthy Cities*
- Analysing cultural ecosystem services - ***Lars Hein***, *Wageningen University*
- Implementation of lifestyle interventions in the Netherlands. A story of hope (for pioneers in 'nature and health') - ***Willem J. J. (Pim) Assendelft***, *Radboud University Medical Centre in Nijmegen*

The Keynote Speakers panel session brought together relevant personalities in research and practice from urban planning, environmental economics, and healthcare to explore how nature (and places) can become active tools for human health and well-being. Through three complementary presentations and an open discussion, the session examined the evidence linking natural and built environments to health outcomes, as well as the practical challenges of translating this knowledge into design, policy, and practice.

This section presents consolidated summaries of the three keynote speakers' interventions and the ensuing discussions. Recognising the diverse preferences and backgrounds of readers, this section is offered in two complementary formats: a Bullet-based Summary (in green box) and a Text Description.

The summaries were prepared by ***Rui Monteiro*** (Rio Neiva) and ***Mariachiara Fagan*** (VU Amsterdam) and approved by the keynote speakers.

The City as a Tool for Health- Anne van Bergen, Healthy Cities[1]

- Urban planning shapes health and well-being; 89% of health outcomes occur outside clinical settings and are influenced by the built environment.
- Rationale for healthy cities: environments strongly shape lifestyle, behaviour, and health outcomes.
- Planning and health are interlinked: the city is a tool for health, and health is a planning argument.
- Small design interventions (e.g. green space, active travel) can deliver significant health benefits.
- Evidence identifies 20 urban health determinants across density, mobility, variety, landscape, and housing:
  - Denser areas support more physical activity (+89 min/week).
  - Active mobility lowers health costs (–0.21% per +1%).
  - Green environments improve children's cognition.
- Changing environments is easier than changing mindsets; applying WHO guidance could prevent ~20% of premature urban deaths.
- Awareness alone is insufficient - urban design makes the healthy choice the easy choice.
- Poor design worsens health inequalities; good design uses community and nature-based assets for prevention.
- Urban planning is never neutral - every decision affects health; health should be central to city design, focused on creating environments that support health and well-being.
- More at: https://healthy-cities.com/

Anne van Bergen, from Healthy Cities, based in Barcelona, opened the session with a reflection on how urban design shapes the conditions in which health is produced. She stressed how cities can be tools for health by reminding the audience that almost ninety per cent of the factors determining people's health are found outside the medical system, embedded instead in everyday environments - in housing, public space, mobility patterns, and access to nature. However, van Bergen claimed that the budget allocated to people's well-being and health is almost entirely directed towards healthcare, with little investment in urban planning.

Van Bergen argued that cities should be understood not only as places where health challenges concentrate but also as instruments of prevention. Healthy Cities identified twenty urban determinants of health, grouped into five broad categories - density, mobility, variety, landscape, and housing - each influencing how people move, meet, and feel. Evidence from international studies shows that denser areas tend to encourage physical activity; that a one-per-cent increase in active mobility corresponds to a 0.21-

[1] See the video of the talk here.

per-cent reduction in health costs; and that children's memory improves when schools are surrounded by greenery.

By following World Health Organisation guidelines on healthy urban environments, cities could prevent up to one-fifth of premature deaths. A case study from Bradford, where £45 million was invested in active travel and green infrastructure, produced double that value in health-related savings, demonstrating the scale of potential returns. Van Bergen concluded that neutrality does not exist in planning - every urban design decision has health consequences, whether intended or not. Cities and nature, she suggested, should be treated as interconnected systems of preventive care.

Cultural Ecosystems for Health - Lars Hein, Wageningen University[2]

- Focus on valuing health-related ecosystem services through an economic perspective.
- Ecosystems provide multiple health benefits: well-being, stress reduction, physical activity, lower noise and pollution, etc.
- Value Ecosystems' health benefits require systematic frameworks linking ecosystems and health and focus on marginal rather than total contributions.
- Distinction between:
  - Ecosystem services: food, water, materials, climate regulation, recreation, and cognitive development.
  - Ecosystem benefits: healthy food, cleaner air, lower temperatures, reduced noise.
- Valuing direct health benefits:
  - Regulating services (e.g., air filtration) can often be valued economically.
  - Cultural services require more direct, experience-based valuation.
- Ethical and methodological questions must be addressed.
- Valuation approaches:
  - Ecosystem accounting: contribution to the economy.
  - Environmental cost-benefit analysis: marginal welfare focus
  - Non-monetary metrics: capturing welfare and well-being.
- Urgent need for interdisciplinary research (epidemiology, medicine, psychology, ecology, economics).

The second presentation, by **Lars Hein** of Wageningen University, explored the contribution of ecosystems to human health through the lens of *cultural ecosystem services*. At the core of Hein's research lies a key question: *can the value of nature and its characteristics be quantified, and if so, how?* Therefore, Hein distinguished between *ecosystem services* - the flows of ecological functions such as clean water, food, and recreation - and *ecosystem benefits*, which capture the concrete outcomes for human well-being.

[2] See the video of the talk here.

Lars Hein acknowledged that the total contribution of ecosystems to health is immeasurable, as they sustain the vastity of life, but argued that it is possible to assess *marginal changes*: how a forest, park, or coastal zone influences well-being when its condition improves or deteriorates. Also outlined three complementary valuation approaches: ecosystem accounting, cost–benefit analysis, and non-monetary well-being indicators. Each has a specific role, from informing national statistics to guiding local decision-making.

Examples from across Europe illustrated the economic magnitude of these services: air filtration in the Netherlands, valued at €171 million annually; recreation in Oslo's Marka forest, generating €1.3 billion per year; and green-space-related health benefits in Flanders, worth roughly €3,400 per hectare each year. Hein concluded that health is likely the most significant benefit that ecosystems provide to society, but one that remains undervalued because it lies between the ecological, medical, and economic domains. Unlocking its full potential requires integrated, interdisciplinary research and governance.

Lastly, according to Hein, this field of research represents just the tip of the iceberg, with the hope of uncovering further insights by addressing the challenges of integrating a broader range of disciplines beyond ecology and economics – including medicine, epidemiology, and psychology.

Lifestyle Interventions and Nature in Healthcare - Willem Assendelft, Radboud University Medical Centre[3]

- General practitioner and epidemiologist; research focus on evidence-based medicine, prevention, and lifestyle.
- What do we mean by "nature"?
- Can the effects of nature itself be separated from what people do in nature? (e.g., confounding factors).
- Observational studies show positive associations but are limited for causal interpretation-need for stronger designs.
- Even without full causal proof, most evidence points to positive effects-so why wait?
- Key challenges:
  - Targeting: entire population vs. clinical groups.
  - Financing: who should invest-insurers, municipalities, or health systems?
  - Equity: reaching people in low socio-economic situations.
- How to engage referring professionals?
  - Simplify referral systems such as "nature on prescription" (www.natuuroprecept.nl).
  - Similar initiatives exist under "social prescribing" since 2024 in the Netherlands.
- Healthcare's strength lies in the "teachable moment"- when patients are receptive to preventive actions.
- The *Lifestyle Wheel* connects health promotion with nature-based interventions.
- Building evidence and trust:
  - Involve stakeholders early and maintain personal connections (avoid only emails or newsletters).
  - Use existing structures and long-term approaches rather than isolated projects.
- "A story of hope": Nature and health align well with the shift in healthcare from disease treatment to prevention and well-being.
- Healthcare research paradigms are evolving to embrace observational, action, and qualitative studies.

Willem J. J. (Pim) Assendelft, general practitioner and epidemiologist at Radboud University Medical Centre in Nijmegen, turned attention to the healthcare sector. His presentation examined the implementation of lifestyle and nature-based interventions in the Netherlands, focusing on how prevention can be better embedded in medical practice.

[3] See the video of the talk here.

Assendelft traced the evolution of evidence-based medicine from its origins in tightly controlled clinical trials to today's broader recognition of observational and qualitative research. Complex phenomena such as the health effects of nature, he noted, cannot be understood through laboratory isolation alone. Although disentangling the influence of nature exposure from associated activities remains difficult, the accumulated evidence consistently supports its positive impacts.

He identified several structural barriers to scaling up such interventions: fragmented financing between insurers and municipalities, the difficulty of targeting at-risk populations, and limited access for lower-income groups. Effective implementation, he argued, depends on *co-creation* and *early stakeholder engagement*, along with practical referral pathways that connect healthcare providers with community initiatives - such as "nature on prescription" schemes. Healthcare encounters, he suggested, represent valuable "teachable moments" when individuals are most receptive to behavioural change. The shift from disease treatment toward health promotion aligns closely with integrating nature and lifestyle in healthcare, and though pioneering this transition is challenging, momentum is steadily growing.

Panel Discussion [4] – Moderator: Ana Estela Barbosa

The importance of daylight and solar exposure is often overlooked compared to noise or air pollution.

- Light and shade should be considered in urban design; balance between sunlight and comfort is crucial.
- Quantifying the effects of daylight remains challenging due to limited evidence.
- Discussion noted that elements such as sunlight and water are often implicit in "green and nature" debates but deserve explicit focus.

How research findings can be translated into practical design guidelines?

- Static standards (e.g., benches every certain distance) can evolve into more flexible, context-sensitive solutions.
- Health considerations and planning goals can guide design priorities.

Overlapping between ecosystem services and nature-based solutions (NBS) may create confusion.

- Emphasis on using ecosystems' inherent capacities before seeking engineered "hardware" NBS.
- Cultural perceptions highlight the importance of local context.

Trade-offs in ecosystem services were discussed, e.g., playgrounds vs. forest bathing areas.

- Different functions require different green typologies, ideally connected into a broader spatial scale.

Methodological challenges in researching nature-based interventions:

- Study design depends on the research question- proof of "added value" vs. alternative benefits.
- Need to control for contamination (participants accessing both nature and control activities).
- False negatives may result when control and intervention groups overlap in exposure.

Air pollution from domestic sources and urban density as major barriers to healthy cities.

- Urban planning should address these alongside greening initiatives.
- Discussion highlighted the difficulty of defining boundaries when valuing ecosystems:
- Some values (e.g., oxygen provision) are fundamental and non-marginal. Expressing economic values can help policymakers recognise ecosystem importance.

Considerations for different urban contexts:

- Existing dense areas vs. new developments vs. private or institutional settings.
- Innovation often lies in small-scale or temporary interventions that test and engage citizens.
- On allergenic species: while some plants produce pollen, early exposure to biodiversity may strengthen resilience and immunity, particularly in children.
- Diversity in tree species and arrangement can mitigate negative effects while enhancing air quality.
- Urban airflow should also be considered - overplanting can reduce natural ventilation.

[4] See the video of the panel discussion here.

The ensuing discussion deepened many of these themes, highlighting both conceptual clarifications and practical insights. Participants observed that **daylight and solar exposure** remain underrepresented in the discourse on nature and health, even though they are essential to mental balance or circadian rhythms. While nature-based approaches often imply the presence of sunlight and water, these factors are rarely made explicit in research or policy frameworks.

A recurrent topic was the translation of scientific evidence into design practice. The group emphasised that static norms - such as fixed distances between benches or universal ratios of green space - are insufficient. Instead, planners and architects should pursue **context-sensitive, adaptive solutions** that reflect local ecological and social dynamics.

Discussion also clarified the relationship between *ecosystem services* and *nature-based solutions (NBS)*. While both aim to harness ecological processes, NBS should prioritise using the regenerative capacity of ecosystems before resorting to engineered interventions. This distinction reinforces the idea that maintaining healthy ecosystems is itself a public-health strategy.

Participants considered the **trade-offs** inherent in multifunctional spaces. Forested areas that foster relaxation may conflict with open areas for children's play, yet both are vital. The group agreed on the need for diverse, interconnected green spaces that serve different users and purposes, forming a continuous network of well-being.

Questions were raised about the mechanisms linking nature exposure and health. Some benefits may derive directly from environmental qualities such as cleaner air and biodiversity, while others emerge from social interaction, participation, and a sense of belonging. Methodologically, researchers were urged to design studies carefully to avoid "contamination" between intervention and control groups when evaluating nature-based programs.

Urban density and air pollution were identified as two persistent barriers to healthy living. Stronger policies are needed to mitigate these pressures while ensuring equitable access to green areas. Participants recognised the potential of **economic valuation** to make ecosystem and health benefits visible to policymakers, strengthening the case for green investment.

In terms of spatial and regulatory constraints, practical strategies included above-ground or modular greening solutions where underground works are not permitted. The conversation also touched on allergens and immune health, noting that early exposure to biodiversity may enhance resilience, and that appropriate species selection and airflow design can minimise risk.

Throughout the debate, a shared understanding emerged: achieving healthier cities demands a **systemic, integrative approach** that aligns urban design, ecosystem stewardship, and healthcare innovation. By connecting the physical, social, and ecological dimensions of the urban fabric, it becomes possible to move from treating disease to cultivating health - with nature as both partner and guide.

IWI TOPIC
Indicators and methodologies for NBS/NBT research

INDICATORS TO ASSESS SUSTAINABLE AND CLIMATE RESILIENT WATER MANAGEMENT IN URBAN NATURAL SPACES

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ABSTRACT

A portfolio of key indicators and guidelines to characterise, design, protect, and manage different types of nature spaces is proposed by NATURELAB – Nature-Based Interventions for Improving Health and Well-Being, a European project aiming to enhance the benefits of natural spaces for health and well-being. The indicators address the characteristics of the nature site and its context, including the variables that can affect health and well-being and the aspects and resources that ensure comfort for people, including their basic needs. The indicators are being tested and validated in 15 experimental sites, located in Europe and Peru. The project aims to contribute to the territory's sustainability and resilience to extreme events.

This study introduces the NATURELAB indicators proposal, related to sustainable and climate-resilient water management in urban natural spaces. These indicators were developed based on prior knowledge, insights from other projects funded by the EU, and tailored to meet specific needs.

Keywords: Indicators; Natural Spaces; Resilience; Sustainability; Water Management.

1. Introduction

Water is a vital resource for people, nature and the economy. Cook and Spray (2012) identified the failure to understand the link between water and ecological health, and between the health of natural ecosystems and human well-being, as one of the most important gaps in water management.

As urbanisation progresses, the effective planning of urban growth, particularly in hazard-prone regions, is becoming increasingly important for achieving sustainable development. Conventionally, urban water systems – encompassing water supply, treatment, drainage, and wastewater facilities – have been developed and managed in an independent manner, frequently failing to acknowledge their interdependencies and the broader socio-economic ramifications (Fu & Butler, 2021). It is widely acknowledged that the role of urban water systems extends beyond the provision of water and the management of wastewater. Blue-green infrastructure, a central component of urban water infrastructure, plays a crucial role in climate change (CC) mitigation and adaptation by

mitigating the effects of urban heat islands, enhancing biodiversity, and promoting community well-being.

The European project NATURELAB aims to enhance the benefits of nature spaces for health and well-being. The project sets out an innovative approach to fostering resilient communities by enhancing the benefits of green and blue areas, including resilience to CC, promotion of biodiversity and urban water management, and the mitigation of air pollution and noise levels. Water is an essential component of human activities and of nature. It is therefore fundamental to address the sustainable and safe use and management of water in nature spaces, as well as to evaluate their contribution, as nature-based solutions (NBS), to increasing the resilience of urban areas to CC.

The main objective of the present work is to develop and pilot a cross-context indicator set for sustainable, climate-resilient water management in urban natural spaces used for Nature-based Therapies (NBT), and to report early validation insights from 15 sites in Europe and Peru.

2. Water sustainability and urban resilience in the context of climate change

Recently, the United Nations Educational, Scientific, and Cultural Organisation highlighted the importance of NBS to address water availability in urban areas (UNESCO, 2018). NBS is key to maintaining, enhancing and restoring biodiversity and ecosystems in urban areas. It is also vital for addressing societal challenges and promoting sustainable and resilient urbanisation (Wendling *et al.*, 2018, EC, 2021). They provide an excellent opportunity to address a diversity of issues associated with anthropogenic impacts on the water cycle. These include poor water quality, water availability for extraction, groundwater and surface water levels, aquifer recharge, stormwater management, water treatment, wetland habitat management, soil water management, and ecological quality (EC, 2021).

Green spaces have a positive effect on physical activity, social and psychological well-being, air quality and noise exposure. However, there is also an increased risk of injury due to increased recreational and sporting use (WHO, 2016, 2023). Studies of green space and health to date have used a variety of measures and indicators.

3. Approach to promote sustainable and climate-resilient water management in green spaces

Green spaces are vital for human activities because they determine the potential for specific activities and how long these activities can be done. It is clear that different solutions are required to ensure sustainable water management. These solutions depend on the water availability in the space (e.g., grey water, rainwater, stormwater) and the demand, needs, and respective purpose (e.g., domestic or irrigation use). These aspects will inform the infrastructure (need for water storage) and maintenance needs, respective cost, and management responsibilities, including solutions that promote community involvement (e.g., garden community maintenance).

The NATURELAB project considers the following steps towards the evaluation of the urban natural spaces to be used for NBT, and to ensure a sustainable water usage and

management (Figure 1): (i) Characterization of the context and activities to be carried out; (ii) Characterization of the water availability and needs; iii) Definition of the system to assess water sustainability management, based on indicators; (iv) Development of a diagnosis and sustainability targets definition; (v) Identification and characterization of the measures that need to be implemented.

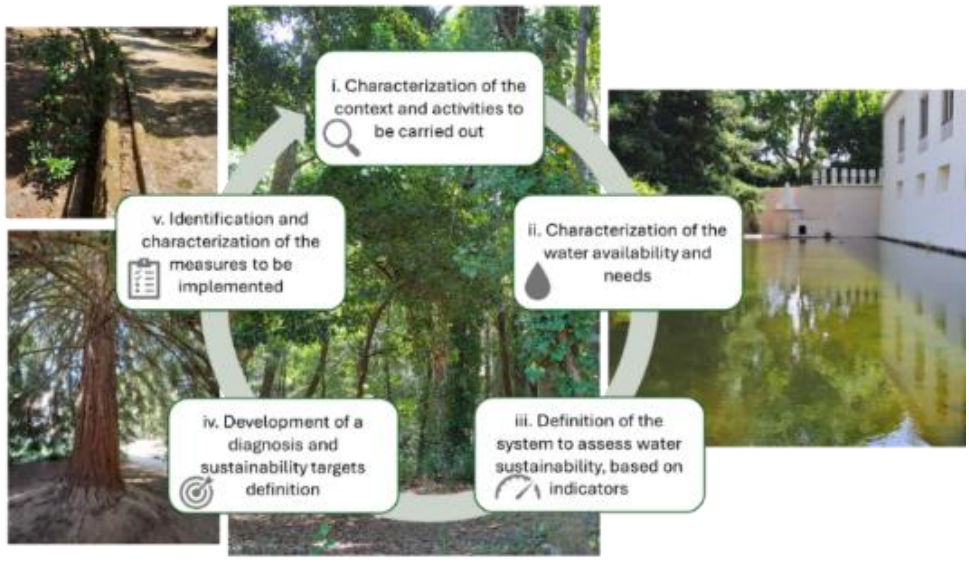

Figure 1. Approach for sustainable water usage and management of the urban natural spaces to be used for NBT.

4. Indicators to assess sustainable and climate-resilient water management in green spaces

A set of indicators to promote sustainable and climate-resilient water management at urban natural spaces (along with "Physical characteristics and infrastructures", and "Natural features related to health and well-being") was developed in NATURELAB (Cardoso *et al.*, 2024, Fernandes *et al.*, 2024, Barbosa *et al.*, 2025). It is based on previous developments and knowledge, like other European projects as RESCCUE (Cardoso *et al.*, 2020) and B-WaterSmart (Silva *et al.*, 2023), mainly addressing water-related aspects. Where needed, they were complemented by other indicators identified from literature review (Fernandes *et al.*, 2024). The set of indicators is presented in Table 1, regarding the description, ease of determination, related recommendations, and source. The risk is considered through a subset of indicators, which assess the frequency of certain hazards (e.g. flooding or water supply interruptions). Most indicators are qualitatively assessed (e.g., yes/partially/no, major/moderate/low) to encourage their use by the urban natural spaces' managers. In a later stage, they allow providing a quantitative assessment, increasing reliability.

Table 1. Indicators to assess sustainable and climate-resilient water management (Fernandes et al., 2024)

Indicator	Description	Metrics and ease of determination	Recommendations
Water sources available	Water availability in the site	Identify types of water supply sources (e.g. surface water, rainwater, reclaimed water)	Explore lakes, rivers, abundant nature, serene water
Impervious area	Surface imperviousness	Percentage of impervious area (%)	Minimise concrete, prioritise green spaces; foster biodiversity, preserve natural drainage.
Water needs	Water-related facilities availability and needs	Water supply needs (total, toilet equipment, water supply points, irrigation, washing)	Assess water needs; enhance facilities for conservation and access
Physical access to water supply	See Silva *et al.* (2023)	N. of operational physical access points to water supply in the area (No./km^2)	Ensure easy access; promote safety around water bodies
Wastewater disposal	See Cardoso *et al.* (2020)	Wastewater disposal exists and is adequately used?	Monitor, maintain wastewater systems for environmental and public health
Stormwater management		Are solutions for stormwater management adequately used?	Invest in green infrastructure; mitigate floods, protect ecosystems.
Drinking water consumption	B-WaterSmart Silva *et al.* (2023)	Level of water supply consumption	Promote conservation; ensure safe, sustainable drinking water practices.
Drinking water in non-potable uses	See Cardoso *et al.* (2020) and Silva *et al.* (2023)	Is drinking water being significantly used for non-potable uses?	Implement greywater systems; optimise non-potable water usage wisely.
Water use from alternative sources		Is being used for non-potable uses?	Explore diverse sources; reduce reliance, ensure sustainable water use.
Redundancy in Water supply sources	See Cardoso *et al.* (2020)	Which types of water supply sources are being used?	Establish backup sources; ensure resilience for water supply.
Redundancy in stormwater storage capacity		Is there a volume to store rainwater or stormwater?	Increase storage capacity; bolster resilience against fluctuating precipitation levels.

Indicator	Description	Metrics and ease of determination	Recommendations
Risk of Water supply interruption		Water supply interruptions occurrence	Assess risks, diversify sources, ensure contingency plans for interruptions.
Risk of Flooding		Flooding incidents	Implement floodplain management; safeguard areas prone to inundation
Risk of Wastewater discharges		Wastewater discharges to ecosystem services	Monitor, regulate wastewater discharge; protect ecosystems from harmful contaminants
Risk of Water quality compliance		Is the water quality compliant with the legal requirements for its use?	Ensure standards met; monitor, maintain water quality for environmental health.

5. Final remarks

Sustainable cities must encourage purer water and air, lower exposure to contaminants and unfavourable environmental circumstances. Sustainable communities and green and blue areas are linked to better mental health. Therefore, access to green spaces, biodiversity, and well-kept settings is key to improving general well-being by lowering stress, anxiety, and depressive symptoms. Mitigating and adapting to extreme precipitation and temperature linked to climate change can be achieved by reducing environmental hazards and implementing water management strategies. These actions will enhance biodiversity and greenness, and help create sustainable, inclusive, resilient living spaces and communities (Fernandes *et al.*, 2024).

The first validation across the experimental sites revealed considerable variation in conditions. The impervious area was generally modest (below 20%), though in several urbanised sites it exceeded 50%. Approximately 40% of sites reported some form of stormwater storage or retention solution. Non-potable water reuse practices (e.g., rainwater or greywater) were identified only in a few sites, with potable water still the predominant source for irrigation and sanitary uses. In parallel, several sites documented temporary water supply interruptions or localised flooding episodes.

It is essential to recognise the intrinsic value of each indicator during the testing and validation process. This will allow to measure or establish each indicator more easily and effectively, as well as monitor and update them. This, in turn, will help to develop future tools.

Acknowledgements

This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement number 101083857 and co-funded by the UK Research and Innovation Grant Award No. 10067111.

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THE IMPORTANCE OF ASSESSING AIR QUALITY IN NATURE-BASED SOLUTIONS WITH A FOCUS ON HEALTH AND WELL-BEING

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ABSTRACT

Understanding the full potential of Nature-Based Solutions (NBS) is crucial in facing many societal and environmental challenges. The NATURELAB project promotes NBS for health and well-being and acknowledges the relevance of air quality within this context, which aligns with existing evidenceand EC directions. Air quality is key for enhancing urban population health and protecting vulnerable participants in Nature-Based Interventions (NBI), such as those with respiratory or cardiovascular conditions. NATURELAB selected, from the proposal stage, NO_2; PM_{10} and $PM_{2.5}$ as the air quality parameters to be assessed at some of the experimental sites where NBI will take place. Compared to the Directive 2008/50/EC, the WHO's air quality standards for the three selected air quality parameters are more aligned with the motivation and purposes of the project.

Keywords: Air Quality; Nature-Based Solutions; Nature-Based Interventions; Urban Population; Health; Well-Being; Particulate Matter; Dioxide Nitrogen.

1. Introduction

The NATURELAB project deals with Nature-Based Solutions (NBS) located in 15 experimental sites, from 5 countries. These NBS represent very distinct nature and climate contexts and are the foundation for research activities aiming at promoting health, well-being and environmental sustainability. Understanding the full potential of NBS is crucial in a world facing so many societal and environmental challenges. NBS are interventions that harness the functions of healthy, natural or restored ecosystems to address societal challenges in an integrated way. Notably, the EC (2024) list of NBS projects includes NATURELAB in the list of cross-cutting projects, with a focus on "health and well-being".

According to the European Union (EU), NBS are defined as: "*solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more*

diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions" (EU, 2021). The International Union for Conservation of Nature (IUCN, 2020) defines NBS similarly but with greater emphasis on ecosystem integrity as: "*actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature.*"

Together, the two definitions agree that NBS should be cost-effective, multi-benefit, and adaptive, with the EU stressing policy, design, and systemic interventions, and the IUCN emphasising ecological health and the linkage to human well-being and biodiversity.

NBS air quality is a key topic, both from the perspective of co-benefits for the health and well-being of the urban population living nearby, and for specific cases, such as Nature-Based Interventions, where participants with health issues (e.g., respiratory or cardiovascular issues), likely to be directly affected by air quality, must be protected. The vegetation cover in urban areas directly influences air pollution levels in an indirect manner (Zhan *et al.*, 2022), reinforcing the imperative of enhancing natural environments to significantly improve air quality.

The Commission's handbook for practitioners complements NBS definition with an operational impact-assessment framework that lists air quality among twelve societal and environmental dimensions (*c.f.* Figure 1) and provides indicators and methodologies to measure NBS effects on air quality and microclimate (EU, 2021). The IUCN's core definition (IUCN, 2024) embeds air quality within the wider suite of ecosystem services and human-health co-benefits; IUCN guidance and urban tools (for example, the Urban Nature Indexes) operationalise this by including air-quality-related indicators when assessing urban NBS.

2. Objectives

This work aims at enhancing the relevance of air quality assessment in NBS with a focus on the promotion of the health and well-being of urban populations.

3. Air Quality in Urban Areas

The increase in air pollution levels in urban areas affects the quality of city residents' everyday life, endangers human health, and harms the environment. Air quality is a major concern worldwide, particularly in urban areas, due to its direct consequences not only for life (humans, fauna and flora) but also on infrastructure and buildings, including historic ones (Barbosa *et al.*, 2025). In the political agenda, air quality issues are related with climate change mitigation, since many actions towards air quality improvement contribute to the reduction of greenhouse gas emissions.

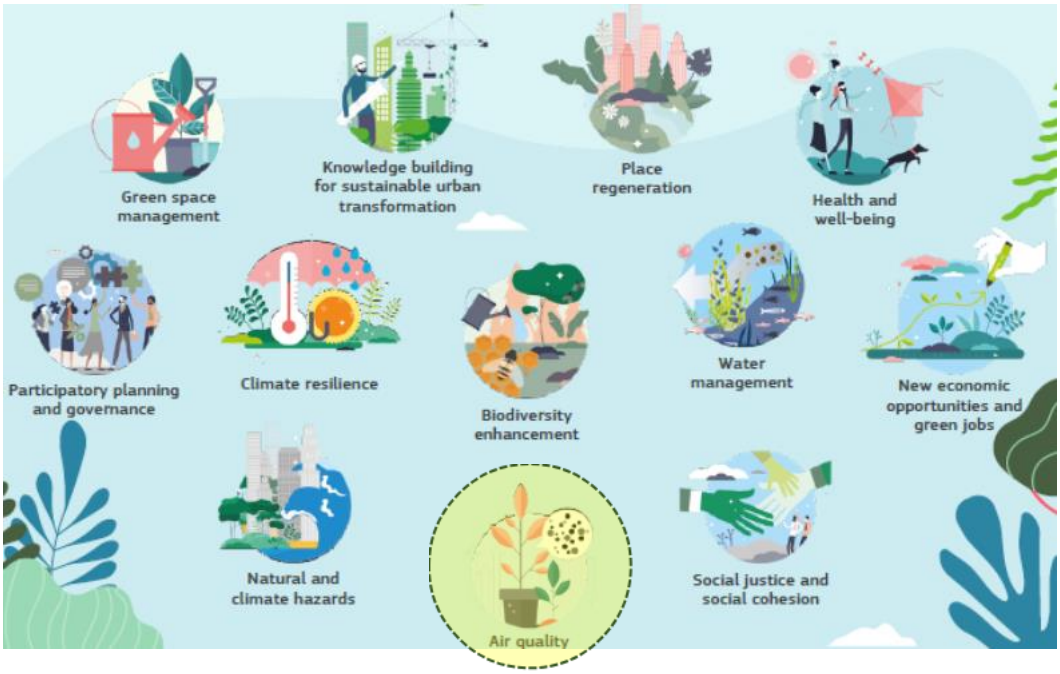

Figure 1. The air quality among the dimensions of Nature-Based Solutions, according to the European Commission. Image extracted from the front cover of EC (2021).

Traffic emissions, a bigger number of vehicles, road-traffic density, industrial areas, as well as anthropogenic activities, are some of the dominant factors that contribute to the increase in the concentration of pollutants in ambient air, leading to the deterioration of air quality (Antonopoulou *et al.*, 2023). Around 90% of city dwellers in Europe are exposed to pollutants at higher concentrations than the air quality levels deemed harmful to health. For example, fine particulate matter ($PM_{2.5}$) in air has been estimated to reduce life expectancy in the EU by more than eight months (EC, 2021). The scientific community has developed an array of air quality indices that describe the potential impact of pollution levels on human health, to research the air quality and its related effects. In general, these indices are a metric for a population health risk assessment (Antonopoulou *et al.*, 2023; Cairncross *et al.*, 2007; WHO, 2021).

The distribution of air pollutants in urban settings results from complex interactions between factors such as street morphology (*e.g.*, building volume, roof shape), green spaces (*e.g.*, street trees, vegetation barriers, type of leaves), microclimatic factors (*e.g.*, humidity, wind direction and intensity, temperature), traffic emissions, background pollutant concentrations, pollution sources, physical processes, and photochemical reactions (Khan *et al.*, 2022; Miao *et al.*, 2023).

It is known that air pollution impacts particularly sensitive population – children, the elderly, and people with respiratory and cardiovascular conditions. Exposure to fine particulate matter ($PM_{2.5}$), a dominant air pollutant, is associated with adverse health effects such as respiratory and cardiovascular diseases and premature mortality (*e.g.*, Anderson *et al.*, 2012; Zhan *et al.*, 2023).

4. Air Quality Guidelines and the NATURELAB Approach

The Directive 2008/50/EC sets air quality assessment and air quality management, with the purpose of ensuring ambient air pollution assessment. The framework is based on the need to manage sources of pollution and ensure that exposure, even in the long term (yearly basis), is below acceptable guidelines and thresholds. The NATURELAB project selected three representative air quality parameters to be assessed at ES where the therapeutic programmes will take place, namely: NO_2; PM_{10} and $PM_{2.5}$. It was understood that, compared to the Directive 2008/50/EC, the WHO's air quality standards are more aligned with the motivation and purposes of NATURELAB. Table 1 reports the WHO most recent standards for these parameters, and the previous one, dated from 2005. It is observed from the comparison of the 2005 and the 2021 guidelines that the updates in research and practice have pushed the concentration levels to reduced values.

Table 1. Ambient air quality standards based on WHO (2021)

Pollutant	Averaging time	WHO 2005 air quality standards	WHO 2021 air quality guidelines
Nitrogen Dioxide (NO_2)	24h[a)] Annual	[b)] 40 µg/m^3	25 µg/m^3 10 µg/m^3
Particulate Matter: PM_{10}	24h[a)] Annual	50 µg/m^3 20 µg/m^3	45 µg/m^3 15 µg/m^3
Particulate Matter: $PM_{2.5}$	24h[a)] Annual	25 µg/m^3 10 µg/m^3	15 µg/m^3 15 µg/m^3

[a)] 99th percentile, *i.e.*, 3-4 exceedance days per year.
[b)] NO_2 standard for 24h was not established. A 1h-average of 200 µg/m^3 was proposed.

The portable AEROQUAL™ portable air quality series 500 equipment was selected for use at project ES due to its suitability for use on-site. A straightforward methodological approach was established for measuring local air quality data by non-experts at the NATURELAB ES (*c.f.*, Fernandes *et al.*, 2024). Note that this information is to be used as a site-specific characteristic that may inform on ambient NO_2; PM_{10} and $PM_{2.5}$ levels vis-à-vis participants' needs and is not intended to describe the local air quality. Delgado-Saborit (2012) informs that assessing instantaneous peak personal exposure enables researchers to examine the relationship between short-term exposure events and corresponding health effects. NATURELAB aims to keep air quality data as an additional indicator that may support an improved understanding of the success of NBI.

5. Final Remarks

Air quality in urban areas requires significant attention and care. The NATURELAB project focuses on raising awareness and assessing this important aspect, which is crucial for the health and well-being of the population. It also ensures a safe environment for nature-based interventions involving individuals who are sensitive to air pollution. All project activities are grounded in the understanding that nature plays a vital role in improving air quality.

Acknowledgements

The NATURELAB project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

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TOWARDS HUMAN HEALTH, WELL-BEING AND SUSTAINABILITY: ESTABLISHING AND TESTING A KEY INDICATORS FRAMEWORK TAILORED FOR DIFFERENT TYPES OF GREEN SPACES

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ABSTRACT

The NATURELAB project aims to enhance green and blue spaces, strengthening climate resilience, biodiversity, and water management while promoting environmental, health, and societal benefits for a sustainable future. The type and quality of green spaces strongly influence health and well-being of the users, which is significant for the case of nature-based interventions (NBI). NATURELAB developed a *Framework of Key Indicators* to address this therapeutic potential and assess different nature spaces, namely i) forests and protected areas, ii) urban parks and healing gardens, and iii) horticultural or gardening spaces. The framework integrates cultural ecosystem services (CES) and resilience dimensions. It distinguishes indicators by complexity (Levels 1–3), and suitability for each of the nature contexts typologies. This work presents the framework as well as the results of its application to 14 project experimental sites (ES). This methodology can support city planners to implement nature-based solutions with high impact in the population's health and well-being.

Keywords: Forest; Urban Park; Health Status; Well-Being; Sustainability.

1. Introduction

Green spaces are increasingly recognised as essential for both public health and climate resilience (Hunter *et al.*, 2023; van den Bosch & Ode Sang, 2017; WHO, 2016). They provide ecosystem services, such as cooling, air purification, and noise reduction (Bratman *et al.*, 2019), and reduce risks of mental and physical illness while promoting human health (Hartig *et al.*, 2014). These benefits are associated with characteristics such as biodiversity, accessibility, and aesthetics (Barnes *et al.*, 2019; Felappi *et al.*, 2020; Nguyen *et al.*, 2021). Expanding health-specific outcomes, nature spaces enrich everyday life through cultural ecosystem services (CES), e.g., fostering education, social connection, and personal identity (Yang & Cao, 2022). Nature-based interventions (NBI; e.g., forest therapy, horticultural therapy) draw on the "nature–health link," though their effectiveness for promoting health and well-being varies by context and site characteristics (Shrestha *et al.*, 2025), as well as by the type of activity undertaken in green spaces (e.g., active vs. passive) (e.g. Ihle *et al.*, 2024).

2. Objective

The NATURELAB project addresses these challenges by developing a comprehensive Framework of Key Indicators to assess i) forests and protected areas, ii) urban parks and healing gardens, and iii) horticultural or gardening spaces. As a comprehensive approach linking environmental conditions, human health, and social impact, the framework also integrates sustainability and resilience, distinguishes between simple and complex measurements, and adopts a CES perspective. One of the project's objectives is to design, test and validate this indicator framework, based on comparative insights across 14 sites.

3. Methods

3.1. Framework development

An extensive literature review (Web of Science, PubMed, Google Scholar) informed the framework (Figure 1). Domains and dimensions were synthesised from systematic reviews, with indicators defined and linked to metrics and assessment methods. Expert validation was conducted by initialising several rounds of feedback on the framework at different stages of its development, conducting internal reviews along the process and external reviews after its completion.

The preliminary *Framework of Key Indicators* contains three overarching domains with multiple dimensions (Fernandes *et al.*, 2024). The first domain covers green space characteristics, including spatial, natural, and infrastructural properties, while the second addresses cultural ecosystem services. The third domain emphasizes sustainability and resilience, incorporating indicators such as water management, daylight exposure, thermal comfort, air quality, and soundscapes.

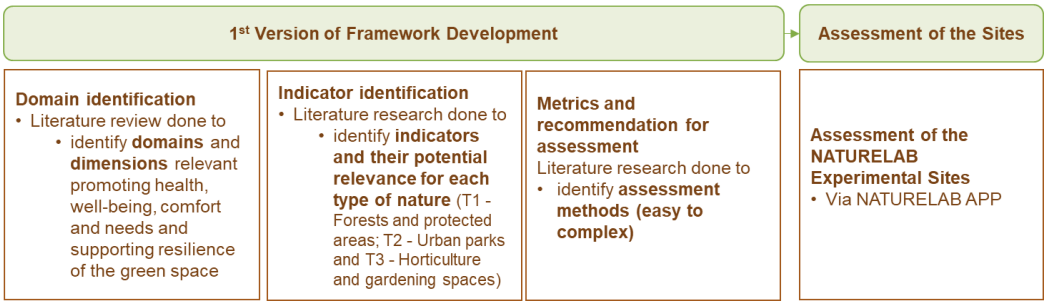

Figure 1. Flow-chart on the progress of the Framework of Key Indicators

3.2. Implementation

Fourteen experimental sites (ES) were selected. Data collection was supported by the NATURELAB App (ArcGIS Survey123). Each site was assessed in summer 2024 using the first framework version. The data collection ended in November 2024. Data was assessed across all sites. We grouped the ES (n = 14) by type (Type 1: n = 3; Type 2: n = 9; Type 3: n = 2). The cross-site data analysis provides insight into the relationships between sub-dimensions across types.

4. Results

This section presents key findings that highlight the framework's strengths and weaknesses.

4.1. Size

Heterogeneity across ES is evident, with ES1 being considerably larger than the other sites. Size of forests and protected areas (Type 1) ranged from 6.46 to 23,280.00 ha, urban parks (Type 2) from 0.04 to 45.00 ha, and horticultural/gardening spaces (Type 3) from 0.25 to 0.52 ha.

4.2. Green space characteristics

This part of the framework allows for a structured overview of site characteristics accompanied by quality ratings. Therefore, we used several sub-dimensions (e.g. facilities, accessibility, safety, maintenance, amenities, and attractiveness) of the RECITAL Assessment Tool (Knobel *et al.*, 2021). Notably, the framework allows to compare ES by their basic facilities as shown in Figure 2. Half of the ES provide grass pitches, Type 1 ES provide water-related features and most ES provide open multi-use spaces in good quality. Notably, disability adaptations score low overall (except for ES05 and ES07). Space entrances are generally adequate (except ES05, ES07), and walking paths meet standards in most locations (except ES12 and ES14). Safety features show the greatest dispersion: street lighting is consistently present at the Greek sites ES10–ES12); protection from car and bikes are uncommon (except ES07 and ES09). Cleanliness is high overall, though moderate litter is reported at ES07 and ES13. Problematic behaviors (e.g., vandalism) are rare, whereas noise and odors vary more, particularly in Peru (ES13, ES14), Portugal (ES02, ES03, ES04, ES06), and the Netherlands (ES07). Because RECITAL

(Knobel *et al.*, 2021) was designed for urban parks, results for Type 1 and Type 3 sites should be interpreted with some caution.

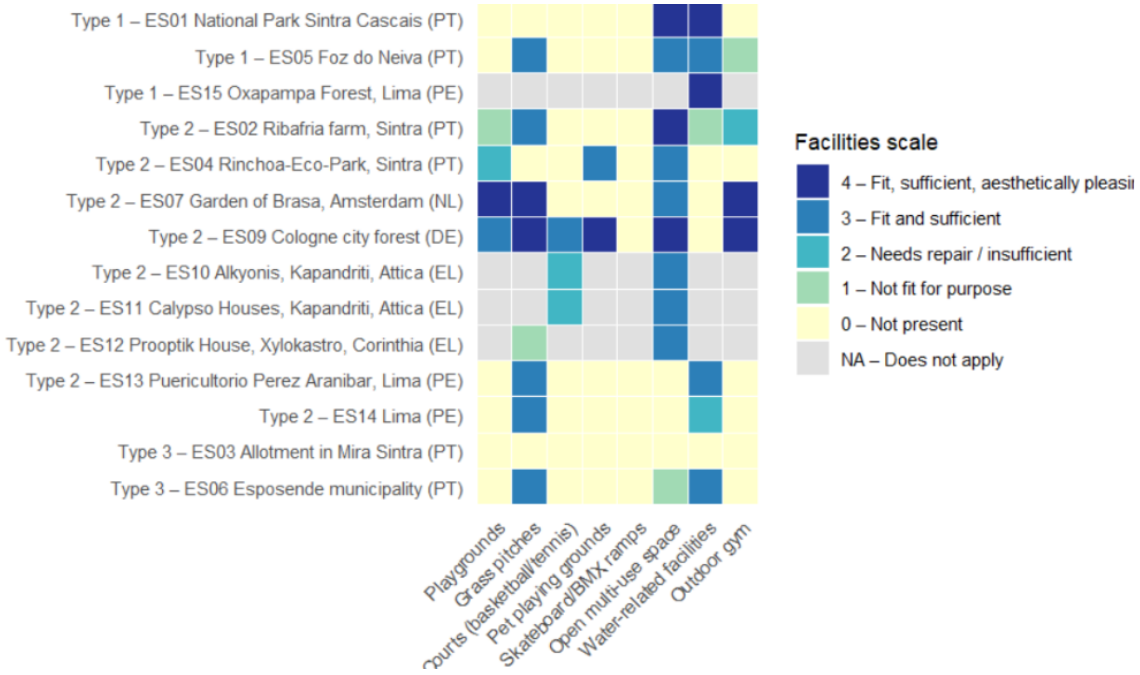

Figure 2. Presence and Quality of Facilities across all Sites

4.3 Cultural Ecosystem Services

The potential of sites to provide a range of cultural ecosystem services was assessed using the TESSA method "free listing tool" (based on TESSA method Cultural M1.C; Peh *et al.*, 2022). For Type 1 sites, benefits were more evenly distributed across categories, whereas for Type 2 sites, the most frequently reported benefits included mental and physical health, as well as a sense of place (feeling connected). The CES assessment also captured the main reasons for visiting the site, number of educational visitors, therapeutic use and social interaction for all sites.

4.4. Geophysical indicator

This section of the framework contained water management, daylight and solar radiation, climate context, air quality and sound measurements. The assessment required specialized equipment and technical expertise. This part of the framework also allowed for monitoring the sites and compare the data with common quality standards. Details on the approach, measurements and preliminary data related to the six ES Portuguese can be found in Barbosa *et al.* (2025).

5. Discussion

The preliminary evaluation of the framework demonstrates the value of integrating human health, climate resilience, and sustainability perspectives into the assessment of diverse types of green spaces. Its application across different ES highlighted both strengths and challenges. On the one hand, the framework proved effective in capturing multidimensional benefits of nature, from ecological resilience to cultural ecosystem services. On the other hand, initial testing revealed the need to distinguish indicators according to their relevance, measurability, and sensitivity to specific conditions of local contexts. Ultimately, developing a flexible and adaptive framework is critical for advancing evidence-based nature-based interventions and for supporting policies that link human health, well-being, and sustainability.

6. Conclusion

The NATURELAB project developed and tested a Framework *of Key Indicators* to evaluate forests, parks, and gardens in terms of health, well-being, and resilience. Ongoing refinement will ensure that it becomes a practical and scientifically sound tool to guide sustainable NBIs that can be used beyond the scope of the project.

Acknowledgements

The NATURELAB project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

We would like to express our sincerest gratitude to our external reviewers and internal reviewers (Stefanie Frech, Lars Hein) of the framework document.

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IWI TOPIC
Monitoring NBS for sustainability, health and well-being

DAYLIGHT AND SOLAR RADIATION ON-SITE EVALUATION IN THE SCOPE OF NATURELAB PROJECT

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ABSTRACT

Daylight and solar radiation are essential factors that influence the quality of life of all living beings. In the scope of NATURELAB project, the main objectives of the daylight and solar radiation (DSR) evaluations are the assessment of how both daylight and solar radiation can contribute to the health, comfort, and well-being of individuals in outdoor spaces. Additionally, the potential positive effects of those factors are also evaluated as part of therapeutic programs. For this purpose, a set of indices and indicators are proposed based on on-site evaluation of the luminous environment and also based on the statistical analysis of groups of individuals regarding the before mentioned outdoor luminous environment. This paper presents the main on-site procedures for the characterisation of the daylight and solar radiation components of the outdoor environment. The preliminary results indicate the influence of natural light and solar radiation in improving the health, well-being, and comfort of individuals in leisure and healing contexts.

Keywords: Daylight; Solar Radiation; Monitoring; Health and Well-being.

1. Introduction and state-of-the-art

Most of the scientific knowledge regarding the daylight and solar radiation components of the outdoor environment quality (OEQ) derives from previous studies and findings related to the indoor Environment Quality (IEQ) in buildings. There are still very few research studies that deal with the DSR components of the outdoor environment and in almost all of them the DSR is only included as a small part of the outdoor environment domains associated with other areas of the outdoor environment (Wang *et al.*, 2024; Han et al, 2022).

2. The monitoring methodologies

As stated in (Fernandes et al, 2024), the methodologies used in the characterization of the Daylight and Solar Radiation (DSR) components of the outdoor environment, in the framework of the NATURELAB project, are based on on-site characterizations and complementary analysis of the Experimental Sites (ES) selected as case studies. A set of systematic measurement procedures (monitoring) were defined, including a validation stage applied to two ES, followed by the application of the methodology to five of the six

ES (ES3 was replaced during 2024, and no further information is available, currently, on a replacement ES – see also Table 1).

The recommendations regarding the assessment of DSR are essentially based on the measurement of illuminance (in lux) values in reference planes, and, sometimes, also based on irradiance values (in W/m^2) (Santos, 2002). An outline of the methodology used for outdoor DSR characterization, based on on-site assessment and complementary analyses, is presented in Figure 1.

As referred, a set of systematic measurement procedures (monitoring protocols) were defined, applied, analyzed, modified and validated to be used in the selected Portuguese ES. The results obtained are briefly described in the "Monitoring" section and they are the initial basis for the development of "key proposed indicators" in the domains of DSR.

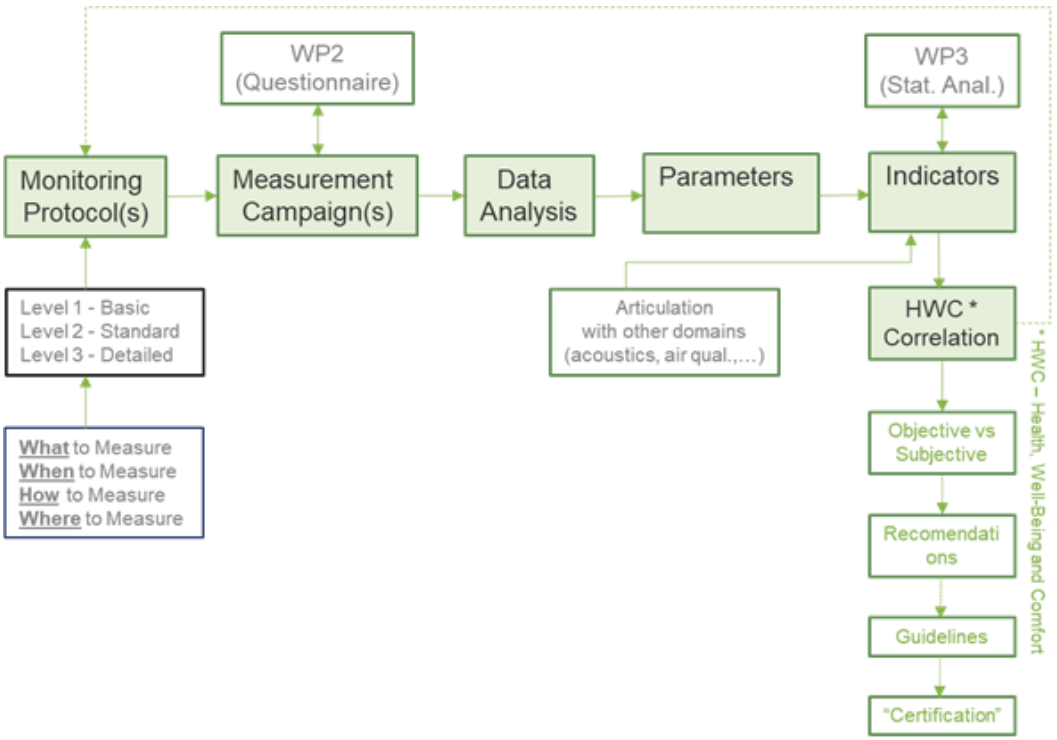

Figure 1. Methodology used in the in the characterisation of the DSR components of the outdoor environment in the context of the NATURELAB project (Fernandes et al, 2024).

3. On-site monitoring

From January 2024 to September 2025 different monitoring campaigns were performed to assess the exterior DSR conditions in the Portuguese ES: i) Quinta da Ribafria (QRF), ii) Rinchoa's Urban Park - Eco-Park and iii) National Park Sintra-Cascais both in the region of Sintra near Lisbon and iv) Foz do Neiva and v) Esposende Municipality. Table 1 summarizes the present state of the referred DSR evaluations.

The referred evaluations included: i) the definition of a preliminary monitoring protocols (for each ES); ii) the definition of the locations of the measurements; iii); the measurement of the relevant luminous and radiative quantities [Eg,h - Global horizontal illuminance (lux); Ediff,h - Diffuse illuminance (lux); Ig,h - Global horizontal irradiance (W/m2) and Idiff,h - Diffuse irradiance (W/m2)]. The measurements were performed under clear and overcast skies and will be completed during 2025/2026 (see Table 1).

The quantities previously referred were measured during certain periods (roughly coinciding with the Solstices and the Equinoxes and at least during three periods of the day - 9:00 True Solar Time - TST; 12.00 TST; 15:00 TST) (Santos, 2002).

The observations included: photographic reports of the different ES, including the characteristics of the vegetation, relevant obstructions and type of cloud cover during the measurements, identification of the most relevant locations for fixed measurements, identification of the type of usage by users (when, where and how).

4. Main difficulties and challenges

The main difficulties/limitations observed during the monitoring campaigns were the following:

- *Difficulty in predicting the exact weather conditions in the ES locations*. It was/is not possible to perform measurements under rainy conditions and whenever the ground is wet and/or muddy. These situations led to the need to make several rescheduling of the on-site measurements.
- *Strong random fluctuations of the nebulosity*, especially during overcast and intermediate skies and medium/strong windy conditions also have a strong influence on the quality and reliability of the measurements due to the influence of changes and inadequate nebulosity conditions and due to "moving vegetation" on the measured values. In particular, Sintra is known for having a very special microclimate with the development of very dense cloud formations, especially during the morning periods, all year round which often makes measurements impossible under clear sky conditions.
- *Selection of feasible and adequate measurement locations within each ES*. In some of the ES the most interesting and adequate locations for the measurements were not accessible, due to various reasons (safety, presence of users, etc.) so, some not foreseen simplifications and alterations had to be made on site.
- *Disturbances caused by people using the spaces* on the quality of the measurements (obstruction, random variability, etc.).
- *Impossible assessment routes* due to the characteristics of the floors and terrains under certain conditions (meteorological, safety characteristics, orography, etc.).

Table 1 - Status of the DSR assessment at the Portuguese ES (September 2025)

ES	2024							2025					
	Valid.	Summer		Autumn		Winter		Spring		Summer		Autumn	
	C/O	Clr.	Ovc.	Clr.	Ovc.	Clr.	Ovc.	Clr.	Ovc.	Clr.	Ovc.	Clr.	Ovc.
ES1 – Sintra Cascais Natural Park (Forest)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
ES2 – Quinta da Ribafria (Healing Gard.)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
ES3 – Allotment in Rinchoa (Hort.Gard) *	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY	NRY
ES4 – Parque Urbano Rinchoa (Eco Park)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
ES5 – Foz do Neiva **	Yes	**	**	**	**	**	**	**	**	Yes	No	No	No
ES6 – Esposende **	Yes	**	**	**	**	**	**	**	**	Yes	No	No	No

LEGEND: **ES**: Experimental Sites; **Valid.**: Reconnaissance of ES and Validation of the Methodology under clear and/or overcast sky conditions; **Clr.**: Assessment under Clear Sky conditions; **Ovc.**: Assessment under Overcast Sky conditions; ****** - Monitoring campaigns started on the Summer of 2025; *****: ES replaced during 2024 - no further information available yet.; **NRY**: No Visit/Reconnaissance Yet

A more detailed analysis of the DSR assessments was included in the report by Barbosa *et al.* (2025).

5. Preliminary findings and further work

Regarding the daylight and solar radiation components of the outdoor environment and their influence on the health and well-being of individuals, there are still no definitive findings since the measurement campaigns are not finished yet. Nevertheless, the preference of individuals regarding the natural environment is well known and documented (Santos, 2002), and it was proven, so it is not surprising that some of the key findings, so far, highlight the potential expected influence of natural light and solar radiation in improving the health, well-being, and comfort of individuals in leisure contexts. More concrete findings are expected in the next months with further results expected as more measurements are carried out and new indicators proposed and developed.

Figure 2. Illustration of sunlight filtering by vegetation in ES4 – Eco Park - Rinchoa.

The next steps in the DSR assessment are the completion of monitoring campaigns in all ES, with the application of adjusted monitoring protocols to the selected case studies and the proposal of additional relevant indicators, when justified. From the work completed so far, horizontal and vertical illuminances (either diffuse or global) certainly play a major role in the definition of the DSR indicators. Luminance, views, and obstructions also seem to be important in the DSR characterisation of the ES's and they will certainly be part of the complete set of DSR indicators.

Acknowledgements

This work was financed in the scope of NATURELAB project funded by the European Union under Grant Agreement No. 101083857. The author would also like to acknowledge Eng. Pedro Ramos for his assistance during the experimental campaigns.

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METHODOLOGIES FOR ENVIRONMENTAL SOUND ASSESSMENT: CHARACTERISATION AND MEASUREMENT APPROACHES AT SIX ES SITES IN PORTUGAL

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ABSTRACT

Environmental sound assessment can be carried out in different ways, depending on the measurement goals, the sampling techniques used (both spatial and temporal), and the effort required to obtain representative results. A major challenge is the development of sound assessment methods that go beyond traditional "noise mapping" to capture the complexity of acoustic environments, which include both natural and anthropogenic sounds. This is particularly relevant in the context of environmental sustainability and biodiversity conservation, where sound plays a crucial role in ecological processes and human well-being. The NATURELAB project addresses this challenge by creating an integrated framework for classifying different natural spaces (such as forests, urban parks, and gardens) based on their potential to promote health. Within this framework, the present study contributes by collecting and analysing acoustic data from six Experimental Sites (ES) in Portugal. These data, along with on-site visits and short-term measurements, provide the foundation for defining robust measurement strategies in the next phase of the project. This study presents information collected on the acoustic environment of six Experimental Sites (ES) in Portugal. This information, combined with on-site visits and short-duration measurements, has supported the identification of appropriate measurement types to be implemented in the following project phase.

Keywords: Environmental Sound; Noise; Monitoring Methodologies.

1. Introduction

1.1. Environmental sound assessment: From regulatory frameworks to perceptual approaches

Environmental noise represents a major public health concern and is recognized among the top environmental risks to human health. Its adverse effects on health and well-being have raised increasing concern among the general population as well as European policymakers. In response, the European Union issued the Directive 2002/49/EC (EU, 2002), to establish a common framework for the assessment and management of environmental noise. This directive, known as the Environmental Noise Directive (END), mandates that all Member States develop strategic noise maps for major transport infrastructure - namely roads, railways, airports - as well for agglomerations. Following the development of these maps, Member States are also required to prepare action plans aimed at mitigating noise exposure and its associated effects. Furthermore, national

legislations have been established to define limit values for the noise indicators L_{den} (day-evening-night noise indicator) and L_n (night noise indicator). Standardised methodologies for assessing urban environmental sound predominantly rely on quantitative measures based on long-term A-weighted equivalent sound pressure levels, typically expressed for daytime (L_{day}), evening ($L_{evening}$), and nighttime (L_{night}) periods, in accordance with ISO 1996-2 guidelines (ISO, 2017).

In parallel, the World Health Organisation (WHO) Regional Office for Europe has issued guidelines to protect public health from exposure to environmental noise from various sources (WHO, 2018). These guidelines detail the health impacts of noise exposure, including noise-induced hearing loss, sleep disturbance, cardiovascular and psychophysiological effects, as well as impacts on cognitive performance, speech intelligibility, and social behaviour. Recommended threshold values for L_{den} are 53 dB for road traffic noise, 54 dB for railways, 45 dB for aircraft, and 45 dB for wind turbines. Exposure above these thresholds is associated with well-documented negative health outcomes (WHO, 2018).

Traditional approaches to environmental noise control have predominantly focused on minimising undesirable sounds, with limited attention given to the potential health and psychological benefits of positively perceived sounds. However, empirical studies conducted in urban open spaces suggest that when sound levels remain below 65–70 dBA, individuals' assessments of acoustic comfort are influenced not only by sound intensity but also by the nature of the sound, user characteristics, and contextual factors (Yang & Kang, 2005). Consequently, there has been a paradigm shift from a purely quantitative noise assessment to a more holistic and perceptual-based framework.

2. Objectives

A detailed description of the methodology employed in this project is available in NATURELAB D1.1 (Fernandes *et al.*, 2025). This study presents the basic level methodology applied for characterising the sound environment of ES in Portugal, acknowledging the dual nature of sound sources—ranging from anthropogenic noise with the potential to cause annoyance to natural sounds which can have positive health effects.

3. Methods and Results

3.1 ES monitoring methodologies

Within the scope of the NATURELAB project, and to characterise environmental sound in both quantitative and qualitative terms, three monitoring strategies will be employed: basic, intermediate, and high. Each strategy is aligned with specific objectives and indicators.

The basic-level monitoring strategy involves collecting all available information on the characteristics of sound sources associated with human activities at each Experimental Site (ES) - for example, train schedules, noise maps, or noise action plans. This level is more closely related to the characterisation of the potential adverse effects of noise (or its absence). The data gathered during this phase will support the optimisation of the

design and implementation of more advanced monitoring strategies, following preliminary measurements. Intermediate-level monitoring will be conducted over a one-year period, when necessary, and will consider different source emission and sound propagation characteristics. The high-level monitoring strategy, which is more closely related to the assessment of sound perception, complements the previous strategies. It involves the measurement of more complex indicators in addition to sound levels (e.g., Loudness), as well as binaural audio recordings and soundscape characterisation along the therapeutic pathways (see Fernandes *et al.*, 2024, for more details).

1.2. Results from basic level monitoring methodology strategy in Portuguese ES

At this level, all available acoustic data was gathered. This included municipal noise maps (*Sintra*, *Esposende*, and *Viana do Castelo*), major road noise maps (A28), and railway noise maps (*Linha de Sintra/Lisboa* and *Linha do Oeste*). This information was complemented by site visits to each experimental location and very short-term measurements (5 minutes each). The information collected during the basic monitoring phase for the Portuguese ES is presented in Table 1 (further details are available in Barbosa *et al.*, 2025).

Table 1. Basic level monitoring for the Portuguese ES

Experimental Site	Main anthropogenic sound source	Available Information	Observations
ES1 - National Park Sintra Cascais	Local road (N 375) and car park at the entrance	No more information available. Sound levels below 50 dB(A)	Due to the local topography, the sound of road traffic is not perceptible inside the park. In this ES, natural sound sources are dominant.
ES2 - Ribafria Farm	Local road (*Estrada da Varzea*)	Noise map of the municipality of Sintra (July 2020)	Indicator (L_{den}) range between 50 and 55 dB(A). Depending on the distance to the road and terrain elevation, road traffic noise can be noticeable.
ES3 - Horticulture Allotment in Mira Sintra	Railway traffic derived from trains of *Linha do Oeste*	*Linha do Oeste* noise map (Bifurcation *of Meleças and Mira Sintra*), published in 2017.	Indicator (L_{den}) range between 45 and 55 dB(A). Due to local topography, noise from trains *Linha de Sintra*/Lisboa are also perceived and road traffic noise from nearby roads. In this ES traffic noise is dominant.
ES4 - Rinchoa Eco Park Sintra	Railway traffic from trains of *Linha do Oeste*	*Linha do Oeste* noise map (Bifurcation of *Meleças and Mira Sintra*), published in 2017.	Indicator (L_{den}) range between 50 and 65 dB(A) throughout the park depending on the location. Natural sound sources are dominant, except when a train passes on *Linha do Oeste*

Experimental Site	Main anthropogenic sound source	Available Information	Observations
ES5 - Foz do Neiva	Road traffic noise from local road (*Foz do Neiva* street)	Noise map of the municipality of Esposende (January 2008)	Indicator (L_{den}) range between 50 and 55 dB(A), depending on the distance to the local road. Nearby the riverside natural sources are dominat.
ES6 - Esposende Municipality	Road traffic noise from A28 motorway	A28 noise map (February 2025)	Indicator (L_{den}) -range between 50 and 60 dB(A),

4. Preliminary findings and next steps

The acoustic environment of Ribafria Farm, Rinchoa Eco-Park Sintra, Horticulture Allotment in Mira Sintra, and Esposende Municipality is influenced by anthropogenic noise sources, primarily from road traffic (in the case of Ribafria Farm and Esposende Municipality) and railway traffic (impacting Rinchoa Eco-Park Sintra and Horticulture Allotment in Mira Sintra). Preliminary noise measurements (based on very short sampling periods) revealed variations in sound levels: 44–47 dB(A) at Ribafria Farm, 40–47 dB(A) at Rinchoa Eco-Park Sintra, and 54 dB(A) at Horticulture Allotment in Mira Sintra (only one location was selected for this site, as this ES is still under construction). These initial values should be regarded as indicative, serving to guide the selection of measurement locations for future monitoring campaigns.

In terms of noise source assessment and based on the data collected during the basic level monitoring phase, three measurement locations were selected within Ribafria Farm for the purpose of approximately 90 minutes of sound data collection. For Rinchoa Eco-Park Sintra, five measurement locations were identified, with each location being monitored for approximately one hour. These monitoring campaigns will be repeated in both the Autumn/Winter and Spring/Summer seasons. For Esposende Municipality, the strategy involved measuring at a location close to the motorway throughout the entire day, while simultaneously conducting brief measurements at four additional locations within the ES area.

However, the evaluation of the acoustic environment at these sites extends beyond mere sound level assessments. Other factors, such as the qualitative assessment of the sound environment, the types of activities conducted at each site, and the proximity to residential areas (particularly relevant for Rinchoa Eco-Park Sintra), must also be considered.

Furthermore, audio recordings of the sites will be analysed to differentiate the natural sounds present, using physical descriptors. This dual approach is essential for environmental sound assessment, as many naturally occurring sound sources can have beneficial effects on human health.

Acknowledgements

The author would like to thank colleagues Mariana Neto, Pedro Ramos and Ari Reis for their support in carrying out measurements in ES. The work carried out was financed within the scope of the NATURELAB project funded by the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

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IWI TOPIC
Research and implementation of NBS/NBT interventions across the health continuum (prevention, promotion, treatment, rehabilitation)

FOREST-BASED THERAPIES FOR ADOLESCENT MENTAL HEALTH RECOVERY

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ABSTRACT

Adolescent mental health needs are rising across North-West Europe while conventional services are saturated. From 2025 to 2028, Forest4Youth (NWE0400643) addresses this gap by developing a transferable, evidence-informed model of forest-based care for young people. The project brings together a multi-country, multi-sector consortium of mental health providers, forestry bodies, public authorities, and universities to co-design a joint protocol that integrates real-world forest immersion with a complementary virtual reality (VR) component. Methods combine a structured mapping of existing practice, participatory co-design with adolescents and families, and multi-site pilots in peri-urban and rural settings, supported by cross-sector training and policy-oriented guidance. Evaluation focuses on feasibility and acceptability, equity of access, implementation determinants, and indicative pre–post changes in psychosocial outcomes. Planned outputs include pilots across eight therapeutic forest sites (plus VR), mixed-discipline training, and guidance for public authorities, underpinned by national reference centres to sustain practice. By coupling participatory design with cross-sector implementation, Forest4Youth aims to offer a credible pathway for integrating nature-based activities into adolescent mental-health care across heterogeneous systems in NWE.

Keywords: Adolescent Mental Health; Forest Therapy; Nature-Based Intervention; Virtual Reality; Implementation; Interreg NWE.

1. Objective

Forest4Youth (https://forest4youth.nweurope.eu/) aims to:

1. Co-design a joint forest-based care protocol integrating real-forest and VR experiences for adolescents (12–18) in psychiatric care.
2. Deploy pilots by establishing therapeutic forests and implementing clinical protocols that include adolescents regardless of condition.
3. Build cross-sector capacity (mental-health and forestry) and produce guidance for authorities to support scale-up and integration.

The project addresses high adolescent prevalence rates in partner countries (≈16–20%) and the EU average (≈17.5%), leveraging NWE's woodland asset while services remain saturated.

2. Methods

Design and Work Packages.

- WP1 – Identification & assessment; protocol co-design. State-of-the-art mapping of forest-based practices; definition of the therapeutic protocol; preliminary guidance. Participatory co-design uses Patient and Public Involvement (PPI) principles developed within the RCSI's Centre for Positive Health Sciences publication: "Positive Health: 100+ research-based positive psychology and lifestyle medicine tools for enhancing wellbeing" (Burke *et al.*, 2022) to convene researchers with representatives of adolescents and families, professionals from the mental health and forestry sector, public authorities and VR experts from several NWE countries.
- WP2 – Implementation of pilots. Joint method to identify 8 sites; pilots for ~400 adolescents over two years; VR protocol as complement/alternative; medium- and long-term evaluations using the Framework for Developing and Evaluating Complex Interventions (Skivington *et al.*, 2021); establishment of reference centres. Local PPI focus groups (users, families, clinicians, foresters, public authorities) validate and refine tools.
- WP3 – Capacity building & uptake. Joint training (hybrid), technical guide for practitioners, tailored guidelines for public authorities; mid-term and final conferences; transnational study visits. Training cohorts intentionally mix professions and countries to foster shared standards and mutual recognition.

Governance & Consortium. The partnership combines mental-health care providers, national and regional forestry organisations, public environmental authorities managing peri-urban forests, and universities/research and training bodies across multiple NWE countries. This multi-country, multi-sector composition is deliberate to embed integration and transferability without relying on any single institutional model.

3. Results

The forest-based care protocol will be co-designed in WP1 as a practical package - combining session plans, safeguarding checklists, a joint method for designating suitable forest sites, VR usage guidelines, and ready-to-use implementation tools. Cross-sector teams (mental health services, forestry organisations, public space authorities) will then apply the protocol across diverse pilot sites to generate comparable evidence on feasibility, acceptability, and real-world implementation, while adapting delivery to local care pathways and environmental conditions. A complementary VR component will widen access for adolescents who face mobility, anxiety, or distance barriers and will be used to prepare, reinforce, and extend in-forest sessions.

Core elements:

- A co-designed protocol with common metrics and adaptable session plans (translated into EN/FR/DE)
- A standardised site-selection and preparation method for therapeutic-forest delivery, followed by identification of 8 pilot forest sites across participating regions
- Multidisciplinary local teams coordinating care, nature stewardship, and public-space management
- VR-supported participation to broaden access and scaffold learning before and after sessions
- A network of national reference centres (one per participating country; total 5) to anchor training, supervision, materials, and data stewardship, supported by an implementation plan and pilot centres
- Consolidated outputs: a joint strategy and action plan, a technical guide for practitioners, and policy-ready guidance for authorities
- A mixed-discipline training offer to seed capacity across countries and sectors, complemented by study visits, regional workshops, and milestone conferences

4. Discussion

Why transnational? Diverse forest ownership/management and health-system structures across NWE require joint standards, shared learning, and context-sensitive pathways to scale. Partner roles exemplify this: Brussels Environment aligns peri-urban access (e.g., Sonian Forest) and staffing; LFoA brings "healing forest" know-how from DE; RCSI contributes positive-psychology and outcomes expertise; ULB leads VR design/assessment.

Access & equity. VR broadens inclusion for adolescents unable or unwilling to access forests and can prepare or extend the effects of real immersion; real-world constraints (transport, safety, weather, stigma) are addressed through site-selection, logistics, and facilitator competencies.

Sustainability. Reference centres (one per country) act as hubs for training, materials, datasets, and liaison between families, services, foresters, and authorities.

Limitations & Mitigation. Heterogeneity of sites and service pathways is anticipated; the project mitigates via a standardised site method, user-involved focus groups, and a cross-sector training/guide suite to improve fidelity and transferability.

5. Conclusion

Forest4Youth will deliver a co-designed protocol, piloted therapeutic forests, a VR complement, and a capacity-building ecosystem (training, guidance, reference centres) to integrate nature-based care into adolescent mental-health services across NWE. The combination of pilots, standards, and durable infrastructure is designed for uptake by providers and public authorities beyond the project's lifetime.

Acknowledgements

The project is supported by Interreg North-West Europe and co-funded by the European Union. Project ID: NWE0400643; Acronym: Forest4Youth; Duration: 48 months, from 2025 – 2028. Priority: Transition towards a socially inclusive and resilient society. Funding. Total €5,538,079.80; ERDF €3,322,847.88 (60%).

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COMMUNITY PROJECT "AROMATIC PLANTS: WELL-BEING FOR OLDER NEIGHBORS" HORTICULTURAL THERAPY, ART, AND MOVEMENT. SANTIAGO, CHILE

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ABSTRACT

The community project "Aromatic Plants: Well-being for Older Neighbours, implemented in the Pedro de Valdivia Norte neighbourhood in Providencia, Santiago, Chile, aimed to enhance the quality of life of older adults through horticultural therapy and outdoor social activities. Led by the Neighbourhood Association and funded by Santiago's Active Community Fund, the project offered workshops that combined gardening, art, aromatherapy, and movement, guided by professionals in horticultural therapy, art therapy, and yoga. Activities took place at the CIDES centre, a safe and accessible space with green areas. Over 30 seniors participated, engaging in planting, learning about the therapeutic uses of herbs, practising relaxation techniques, and expressing creativity through art. The initiative led to the creation of a community aromatic garden, which became a therapeutic and educational space for the whole neighbourhood, fostering a strong sense of belonging and collective care. Results showed significant emotional and social benefits for participants, with no adverse effects, and high satisfaction. The project proved to be a successful non-pharmacological strategy to support active ageing, especially relevant in Providencia, where older adults make up over 27% of the population. It highlights the value of nature-based interventions to promote well-being and community connection in ageing societies.

Keywords: Horticultural Therapy; Emotional Well-Being; Older Adults; Community Projects; Chile.

1. Introduction

The community project "Aromatic plants: Well-being for older neighbours" was implemented in the Pedro de Valdivia Norte neighbourhood, Providencia district in Santiago, Chile, to promote the integral well-being of older adults through outdoor activities and community socialisation spaces.

The initiative, conceived by a group of neighbours as part of a participatory process led by the Neighbourhood Association in 2023, focused on horticultural therapy (HT), a complementary therapeutic approach that utilises gardening and contact with nature as tools to achieve set therapeutic goals.

Various international scientific studies have shown that HT is effective in improving mental health, reducing symptoms of depression and anxiety, and slowing cognitive decline in older adults, providing solid evidence of its positive impact on their well-being and quality of life (Xu *et al.*, 2023, Chan *et al.*, 2017, Wichrowski *et al.*, 2024, Wang *et al.*, 2025, Chana *et al.*, 2022, Shiue *et al.*, 2016, Detweiler *et al.*, 2012).

Funded by the Santiago Government's Active Community Fund, the project developed workshops in three main areas: planting and knowledge of aromatic plants; art and nature; and movement and relaxation guided by aromas. Activities took place at Los Misioneros Integrated Social Development Centre (CIDES), a space that offered optimal conditions for safety and access to green areas.

2. Objectives

The general objective of the project was to promote and improve the quality of life, physical health, mental health, and well-being of older adults in Providencia through horticultural therapy activities with aromatic plants at CIDES.

Specific objectives included:

- Promoting physical activity
- Boosting cognitive abilities
- Promoting sensory stimulation
- Fostering socialisation
- Boosting emotional well-being

3. Methods

The project was designed based on the principles of horticultural therapy, art therapy, and yoga and was facilitated by a horticultural therapist, an art therapist, and a yoga instructor. A total of ten workshops and three guided tours were held, targeting individuals over 60 years old with a connection to CIDES. Each workshop consisted of four 60-minute sessions, one per week, for groups of 8 to 12 participants. Four types of workshops were implemented:

1. **Sowing and Planting Workshop:** the main goal was to promote well-being and social inclusion through gardening activities such as preparing soil, sowing aromatic herbs and vegetables, pruning, and transplanting.
2. **Knowledge and Use of Aromatic Plants Workshop:** Focused on sensory stimulation and fine motor skills, teaching participants about the cosmetic and therapeutic properties of herbs, such as creating a herb blend and a sea salt and lavender scrub.
3. **Relaxation and Body Movement Guided by Aromas Workshop:** Combined breathing exercises and body movement (yoga) with aromatherapy to cultivate inner peace and vitality. This workshop was adapted to each participant's abilities.
4. **Art Therapy Based on Aromatic Plants Workshop:** Allowed participants to explore their creativity and artistic expression through appreciating herbs and nature.

The program was executed over the period from November 2024 to August 2025. The Sowing and Planting Workshop was done in November 2024, Knowledge and Use of Aromatic Plants, Relaxation and Body Movement Guided by Aromas and Art Therapy Based on Aromatic Plants Workshops, were repeated three times between November 2024 and July 2025, and the guided tours were conducted during August 2025.

At the Los Misioneros Integrated Social Development Centre, there are two main green areas: the entrance/front garden and the back patio. For this program, we used the back patio. This area faces northeast, making it suitable for a future vegetable garden. It includes an approximately 40 m^2 hard-surface terrace attached to the centre's library, a 25 m^2 lawn in the middle, and a large eucalyptus that provides a pleasant scent. Along the perimeter, next to the property lines, there are very old shrubs that have not been pruned for years; even so, they create a green, welcoming setting for workshops. Some yoga classes were held on the lawn when the weather allowed. Most art and gardening sessions took place on the terrace, where we set up two folding tables and chairs. We also brought in four raised wooden planters and planted a variety of herbs and vegetables during the workshops.

4. Results

The project generated significant results for the elder community in the Pedro de Valdivia Norte neighbourhood. Active participation in the workshops was achieved, with over 30 people enrolled. The creation of an aromatic garden not only promoted neighbour participation but also became a therapeutic and educational space for other community members, including children. This space fostered a sense of belonging and responsibility through a communal plant-care system. Additionally, the project's execution contributed to the completion of two key activities from the 2023-2025 work plan of the Pedro de Valdivia Norte Neighbourhood Association, which was based on community proposals. The project, as a whole, provided a safe and protected space for older adults to connect with nature and with each other.

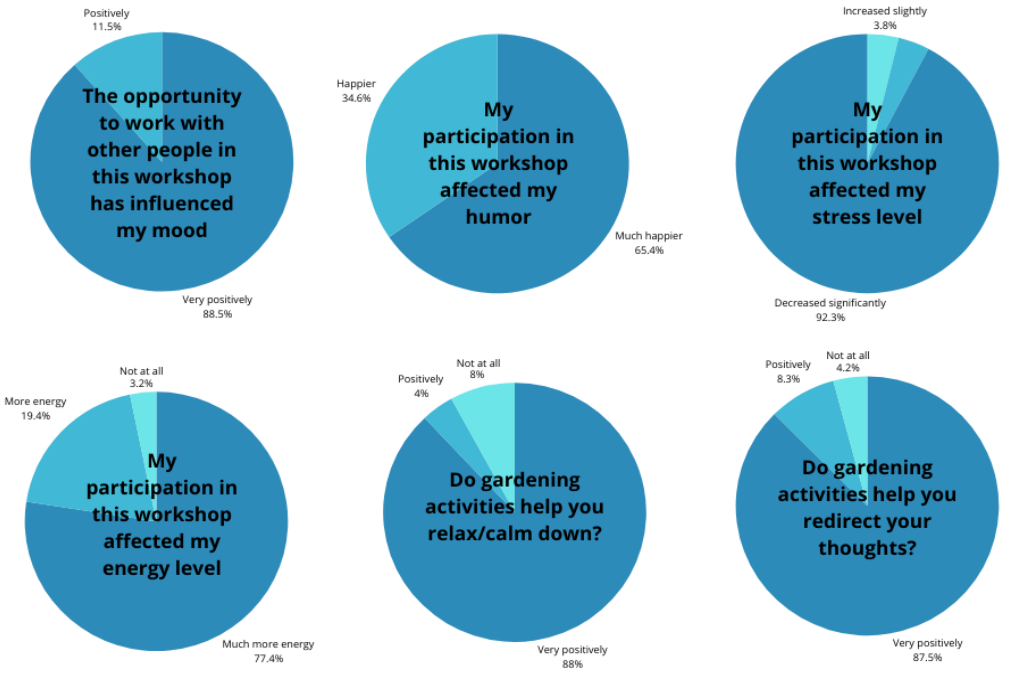

Figure 1. Survey's Results

To measure the impact of the interventions on users, they were asked to complete a customer satisfaction survey consisting of 7 self-administered questions aimed at measuring emotional well-being (see Fig. 1).

5. Discussion

The implementation of this horticultural therapy project aligns with the growing need to address the ageing population in Chile. Providencia has one of the highest concentrations of older adults in the capital, with 27.55% of its population consisting of older adults. The project proved to be an effective and non-pharmacological alternative for improving the quality of life and emotional well-being of this population. HT has no risk of adverse effects and generates a clear set of benefits for participants. The use of the Los Misioneros Integrated Social Development Centre (CIDES) was a crucial factor in the project's success, as it is a space designed to improve the quality of life for residents and features adequate facilities for plant cultivation and workshops. The integration of various disciplines, such as art therapy and yoga, broadened the benefits of horticultural therapy, allowing for a holistic approach that stimulates not only the senses and motor skills but also creativity and relaxation. The project also addressed one of the primary needs identified by the Neighbourhood Association, utilising CIDES for community activities and supporting older adults.

Figure 2. Project Activities

The enrolled neighbours showed great interest in each activity and expressed an energetic and enthusiastic desire for the workshop to continue (see Fig 2). Here are some of the words from the satisfaction survey:

> *"I loved participating in these workshops. Learning and connecting with plants, as well as my neighbours, has been wonderful. It is an oasis of tranquility, joy, and learning. These activities remind me and awaken the connection we have with nature." C.D 61 years.*
>
> *"It's a delicious mix of technical knowledge, relaxation therapy, and applying and practising in the soil. The workshop is incredible emotionally, and the learning can be totally applied at home." C.B 64 years.*
>
> *"I ask that the well-being workshops be permanent, for all the contributions to mental health. I am an older adult, and it is crucial for our mental health and socialisation to meet our neighbours. I ask that they continue." A.G 67 years.*

6. Conclusions

The project "Aromatic plants: Well-being for older neighbours" proved to be a successful strategy for improving the quality of life of older adults in the Pedro de Valdivia Norte neighbourhood. Horticultural therapy activities fostered physical activation, cognitive and sensory stimulation, emotional well-being, and socialisation. The creation of a community garden not only provided a therapeutic and educational space but also strengthened community ties and a sense of belonging among participants. This type of initiative holds great social, ethical, and practical value, especially in an ageing society, and offers a sustainable approach to promoting active and healthy ageing.

The workshop was so successful that the participants asked for it to be continued. Since the allocated funding has ended, the possibility of moving forward with municipal funding from the centre itself is currently being evaluated. This proposal is still under review.

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NATURELAB ASSESSMENT MODEL: A PILOT FRAMEWORK FOR EVALUATING THE IMPACT OF NATURE-BASED INTERVENTIONS AND NATURE QUALITIES ON HEALTH AND WELL-BEING

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ABSTRACT

To scientifically validate the health benefits of nature-based interventions, the NATURELAB project developed an assessment model to evaluate participants and natural intervention sites across four guiding principles: WHAT, WHEN, HOW, and WHO. The Nature-based Interventions (NBI) participants' assessment comprises psychological health, well-being, connection to nature, ecological identity, perceived quality of natural areas, health information, and socio-economic background. The assessment framework for the Experimental Sites (ES) covers ten dimensions, including natural characteristics, infrastructure, ecosystem services, and environmental conditions. Supported by the NATURELAB dual app, the model harmonises subjective and objective measures while ensuring ethical and secure data management. This pilot framework provides the foundation for generating evidence-based insights into associations linking NBI to improved health outcomes.

Keywords: Assessment; Health; Well-Being; Nature Characteristics; Nature-Based Interventions.

1. Introduction

Nature-based interventions (NBI) are increasingly recognised as effective tools to improve physical and mental health, foster social cohesion, and enhance resilience to stress and chronic conditions (Wilkie & Davinson, 2021). Engagement with natural environments has been associated with reduced symptoms of depression and anxiety (Bratman *et al.*, 2019), improved cognitive functioning (Berman *et al.*, 2008), and strengthened social relationships (Twohig-Bennett & Jones, 2018).

Despite this growing body of evidence, the field still lacks standardised methodologies to evaluate the effectiveness of nature-based interventions. Existing studies vary widely in design, measures, and contextual factors, which limits their comparability and scalability (Nguyen *et al.*, 2021; Shrestha *et al.*, 2025).

Table 1. Target age groups, number of participants and health conditions by country and ES

Country	ES	Target age groups	Nr of participants	Health conditions
PT	ES#1 – ES#3; ES#6	Adults	192	Individuals with health conditions that could benefit from NBI (e.g., anxiety, depressive mood, and stress-related issues)
	ES#4; ES#5	Adolescents	96	Individuals with health conditions that could benefit from NBI (e.g., attention and self-esteem deficit, and behaviour issues)
NL	ES#7	Children Adolescents Adults	66	Individuals reporting poor mental well-being
DE	ES#9	Adults	90	Individuals self-reporting emotional eating
EL	ES#10 – ES#12	Adults	45	Individuals institutionalised with mental health disorders.
PE	ES#13	Children Adolescents	39	Individuals institutionalised without a mental health diagnosis who could benefit from NBI
	ES#14	Adults	33	Individuals institutionalised with mental health disorders
	ES#15	Adolescents	84	Individuals without mental health diagnosis who could benefit from NBI

The Horizon Europe project NATURELAB is testing and validating NBI across 14 Experimental Sites in 5 countries, in Europe and Latin America (Portugal, Greece, the Netherlands, Germany, and Peru), involving a diverse range of participants across different age groups, institutional settings, and health conditions (Table 1).

For this purpose, a comprehensive assessment model has been developed, integrating subjective, clinical, environmental, and socio-economic dimensions. This abstract presents the pilot version of the NATURELAB Assessment Model. Notably, the project developed a framework with key indicators to assess and categorise different types of nature spaces and their impact for therapeutic indications (Fernandes *et al.*, 2024).

The model is structured around four guiding principles: 1) WHAT to be assessed, 2) WHEN the assessments take place, 3) HOW assessments are conducted, and 4) WHO is responsible for implementing the assessment. This systematic framework was developed to ensure consistency across diverse contexts and populations, enabling the production of robust, comparable evidence on the effectiveness of NBI.

2. Structure of the Assessment Model

2.1. Assessment of NBI Participants

The participant assessment protocol integrates multiple dimensions, such as the following:

1. **Perceived psychological health and well-being**: including WHO-5 Well-Being Index (WHO, 1998), Patient Health Questionnaire (PHQ-9) (Kroenke *et al.*, 2001), Generalised Anxiety Disorder Scale (GAD-7) (Spitzer *et al.*, 2006), Depression, Anxiety and Stress Scale – Youth version (DASS-Y) (Szabo & Lovibond, 2022), Perceived Stress Scale (PSS-10) (Cohen *et al.*, 1983), Rosenberg Self-Esteem Scale (RSES) (Rosenberg, 1965), abbreviated version of WHO Quality of Life Instrument (WHO-QOL-BREF) (World Health Organization Quality of Life Group, 1998), the health-related quality of life KIDSCREEN-10 (KIDSCREEN Group Europe, 2006) and other specific health measures for institutionalised people.
2. **Connection to nature and ecological identity**: assessed through the Nature Connection Index (NCI) (Richardson *et al.*, 2019), Revised Environmental Identity Scale (EID-R) (Clayton, 2003; Clayton *et al.*, 2021), Ecological Identity (Harper, 2019) and nature visits and appreciation (Alcock *et al.*, 2020).
3. **Perceived quality of natural areas**: using the Perceived Sensory Dimension Qualities (PSDQ) scales (adapted from Grahn & Stigsdotter, 2010, He *et al.*, 2024, and Stoltz *et al.*, 2024), the Restoration Outcome Scale (ROS) (Korpela *et al.*, 2008), and the impact of perceived natural elements on well-being (sounds, colours, textures) (Subirana-Malaret *et al.*, 2023).
4. **Clinical and health information**: covering physical, metabolic, and cognitive indicators, as well as previous diagnoses.
5. **Socio-economic background**: including demographics, education, employment, family structure, and income.

Assessments occur at five moments in time across the 12-week NBI implementation: baseline (pre-NBI), mid-programme (6 weeks after the start), post-programme (12 weeks after the start), and two follow-ups (4 and 12 weeks after the NBI completion). Additional physiological measures (e.g., heart rate and blood pressure) will be collected cross-cuttingly at different time points.

2.2. Assessment of Experimental Sites

The ES assessment protocol covers ten dimensions: 1) general information, 2) spatial and design characteristics, 3) infrastructural features, 4) natural features, 5) cultural ecosystem services, 6) sustainable water management, 7) daylight and solar radiation, 8) climate context, 9) air quality, and 10) sound environment. Data collection was done through in situ observations (ES).

2.3. Implementation Procedures

The study's design follows a randomised controlled study format. Recruitment takes place through local institutions from various sectors and partner organisations. The assessment's implementation relies on three key roles: ES Coordinators, who oversee global implementation and communication; Local Liaisons, who connect researchers with communities and manage local project activities; and NATURELAB facilitators/therapists, who guide participants through the NBI programme and assessments. The NATURELAB dual app supports secure, pseudonymised data collection online and offline. Ethical protocols are aligned with EU standards, the Declaration of Helsinki, and national regulations.

3. Expected Outcomes and Impact

Expected outcomes include a harmonised assessment model adaptable to varied contexts, the integration of subjective and objective measures for comprehensive evaluation and methodological robustness. The NATURELAB Assessment Model represents a significant step towards minimising the lack of consistency noted in the literature, specifically regarding how NBIs are defined, categorised, and evaluated (Kaleta *et al.*, 2025), which limits comparability across contexts. By integrating psychological, environmental, and socio-economic assessments, it unifies fragmented approaches. It also selects robust, cross-validated measures (e.g., health measures) to address common characteristics across distinct populations, health issues, and cultural contexts, without, at the same time, losing the specificity of the target populations involved in the NATURELAB NBI.

Acknowledgements

The NATURELAB project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

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NATURE-BASED INTERVENTIONS FOR MENTAL HEALTH: A STUDY PROTOCOL FOR A RANDOMISED CONTROLLED TRIAL IN A COMMUNITY HORTICULTURAL GARDEN IN AMSTERDAM

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ABSTRACT

This study protocol describes an effectiveness study which examines how nature-based interventions (NBI) can support health and well-being by using green and blue spaces as complementary care settings. The present study is based in the Netherlands at the Gardens of Brasa, a community horticultural garden located in a multi-ethnic, economically disadvantaged neighbourhood of Amsterdam South-East, where levels of psychological distress and loneliness are substantially higher than the national average. The main objective is to assess whether a structured, contextually adapted NBI improves self-reported mental health more effectively than enhanced care as usual (eCAU). Using a single-blind randomised controlled trial design, participants with poor mental wellbeing will be assigned to either an NBI plus eCAU or eCAU alone. The intervention consists of facilitator-led group sessions delivered over 12 weeks and guided by five core NBI components, including nature connection and sensory engagement. Psychological distress is the primary outcome, measured through validated scales. Alongside the trial, a mixed-methods process evaluation will explore implementation, mechanisms of impact, and contextual influences. The study aims to strengthen evidence on NBIs while addressing challenges related to engagement, trust, and long-term integration into healthcare systems.

Keywords: Study Protocol; Randomised Controlled Trial; Nature-Based Therapies; Urban, Mental Health.

1. Introduction

This abstract presents the protocol of an effectiveness study and is based on a journal article in preparation for peer-review. This study is part of the NATURELAB project, which aims to increase the recognition, promotion and use of green and blue spaces as care

providers by investigating the benefits of nature-based interventions (NBIs) on health and wellbeing. NATURELAB focuses on nature exposure and experiences provided by i) forests and protected areas, ii) urban parks, and iii) horticulture and gardening contexts. NATURELAB works at 15 experimental sites in five countries (i.e. Peru, Portugal, Greece, Germany, and the Netherlands).

This study protocol is for an experimental site in the Netherlands, located in the Gardens of Brasa – a community horticultural garden – at the outskirts of Amsterdam. The gardens lie within a multi-ethnic, economically disadvantaged neighbourhood. Reported psychological complaints, stress, and risk of anxiety and depression were around 50% higher in this neighbourhood compared to the Dutch average (RIVM, 2025). Also, higher levels of loneliness (including overall, social, and emotional loneliness) were reported in this location (RIVM, 2025). *Could NBIs be a solution to the high levels of psychological distress experienced by this disadvantaged community in Amsterdam?*

2. Objective

The main study objective is to investigate whether a contextually adapted NBIs improves the self-reported mental health of individuals living near an urban park and community horticultural garden in Amsterdam South-East, the Netherlands. More specifically, this study will evaluate whether structured and contextually adapted NBIs – i.e., interventions adjusted to local ecological conditions, community needs, and existing care pathways – are more effective than usual care (enhanced with local outdoor and community-based activities) in reducing psychological distress (i.e., symptoms of anxiety, depression, and stress) among individuals reporting poor mental wellbeing living around Brasapark, an urban park and community horticultural garden in Amsterdam South-East.

Also, this study will examine mechanisms of impact, i.e. how core NBI components link to other health and human-nature related outcomes, socio-demographic variables, and the broader context.

3. Methods

3.1. Study design and process

A single-blind, individually randomised group treatment trial design. This randomised controlled trial (RCT) has two arms comparing enhanced care as usual with NBI (eCAU/NBI; intervention arm) to eCAU alone (control arm). Participants will undergo multiple measurements at six time points. Figure 1 displays a flow chart of the study design.

Several multi-stakeholder consultation and co-design sessions were held to inform the study design, outcome measures, target population, and recruitment materials. These employed various qualitative research methods (i.e. key informant interviews (N=21), focus group discussions (2 groups; N=8), co-creation workshops (2 workshops; N=33) and took place from October 2024 to July 2025.

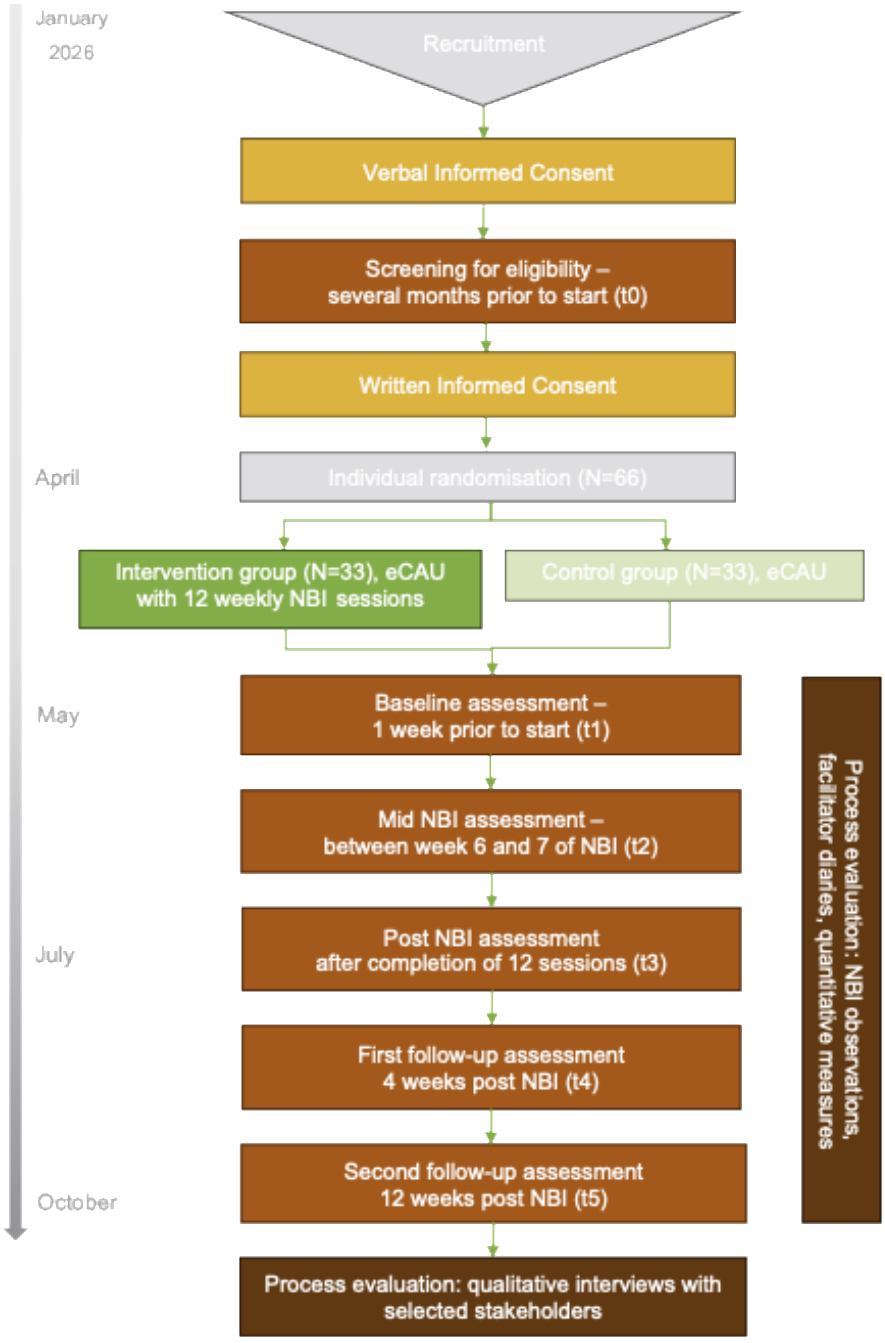

Figure 1. Flow chart of the study design.

A mixed-methods process evaluation will be conducted alongside and after the RCT, following Medical Research Council guidance on the evaluation of complex interventions (Moore *et al.*, 2015; Skivington *et al.*, 2021). Quantitative methods cover fidelity

checklists, green space observations, and qualitative methods facilitator diaries and stakeholder interviews.

3.2. Participants: selection criteria

Inclusion criteria: individuals (age > 10 years) living in the vicinity of the Gardens of Brasa in Amsterdam South-East reporting poor mental well-being (i.e., a score below 50% (equals raw score <13) on the WHO-5 wellbeing scale will be used as a cut-off (WHO, 2024).

Exclusion criteria: individuals with severe cognitive impairment (e.g., advanced dementia), acute medical conditions, who exhibit disrespectful behaviour (e.g., racism), or pose a risk of harm to themselves or others. Also, excluded are those who started a new psychopharmacological or psychotherapeutic intervention (< 2 months) or expect dosage changes during the study period.

3.3. Interventions

NATURELAB partners Forest Therapy Hub (FTHUB) and the Peruvian Association for Therapeutical and Social Horticulture (APHTS) identified five core components of NBIs: i. nature connection; ii. sequencing of sensory engagement; iii. noticing; iv. artistic expression; v. integration into daily life. These components will guide NBI programmes across NATURELAB's experimental sites, including the Netherlands. Therapeutic programmes as part of NATURELAB will be facilitator-led and carried in small groups of 8-12 people with similar health conditions, over a period of 12 weeks, one session per week of 1,5 to 2 hours per session.

Care-as-usual (CAU) covers all (mental) health services available to individuals living in the Netherlands (ranging from care provided by health providers in primary care to specialist healthcare). Enhanced care-as-usual (eCAU) in this study involves five sessions of outdoor group activities in the local community, over a period of 12 weeks (roughly one session every other week; 1-2 hours per session). Additionally, eCAU participants receive a nature-activity information package (with local walking routes and local nature events and activities).

3.4. Outcomes and measures

Around twenty different measurement scales and tools will be used to assess various primary and secondary outcomes (i.e. mental health, quality of life, clinical and health, and human-nature connection). Most will be applied across all NATURELAB's experimental sites, and some are site-specific.

Psychological distress is the primary outcome measure. For adults (18+), this outcome is a composite measure (PHQ-ADS) of the Generalised Anxiety Disorder (GAD-7) scale and the Patient Health Questionnaire (PHQ-9). For children and adolescents (<17), the Depression, Anxiety and Stress Scale Youth (DASS-Y) scale will be used.

3.5. Data analysis

Based on findings from previous relevant systematic reviews and meta-analyses, we anticipate a moderate to strong effect size (Soga *et al.*, 2017; Coventry *et al.*, 2021; Tu 2022; Shresta *et al.*, 2025). An adequate sample size (N=52) was estimated using G*power version 3.1. software using Cohen's f-test (assuming a medium effect size Cohen's f = 0.25; alpha error probability 0.05; power (1- beta) 0.95; conservative non-sphericity correction 0,5). Accounting for a 25% dropout rate, we will enrol 66 participants.

To estimate the intervention effect on the primary and secondary outcomes, we will use linear mixed models under an intention-to-treat (ITT) framework (or generalised linear mixed models for non-normal outcomes). A two-level approach with repeated measures (t1-t5) nested within participants will be used. Models will include fixed effects for group (intervention vs. control), time and their interaction, and random intercepts for participant level.

All interview data from the process evaluation will be transcribed verbatim and then analysed thematically using a combination of inductive and deductive coding.

3.6. Ethics

This study was approved by the Research Ethics Review Committee, Faculty of Science, Vrije Universiteit Amsterdam (BETHCI) on 7 August 2025 (reference: 2025-028) and is registered in a Dutch trial register NL-011127, 28/11/2026: https://onderzoekmetmensen.nl/nl/trial/58190 In this study we include participants with specific and diverse needs such as children, individuals with minor disabilities, and ethnic minorities (i.e., people with a migration background). Dedicated attention will be given to informed consent, participant well-being, and harm reduction of such groups.

4. Discussion

Results from this study will contribute to knowledge on the effectiveness of NBIs. We anticipate three key challenges during the implementation of this trial: i. ensuring initial and ongoing engagement of vulnerable groups; ii. mitigating power imbalances and establishing trust; and iii. creating co-benefits for humans and nature. Next to these implementation issues, we expect various difficulties during the scaling up of NBI, i.e. the sustainable embedding of the NBI approach into the Dutch health system and beyond.

Acknowledgements

We acknowledge contributions of the NATURELAB consortium. Particularly, FTHUB and APHTS for the development of NBI components and advise on study outcomes and the target population. We are thankful to all stakeholders who participated in consultation and co-creation sessions; their insights helped to refine our study aim and design.

This project is funded by the European Union under Grant Agreement No. 101083857 and co-funded by the UK Research and Innovation Grant Award No. 10067111. 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.

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HOW YOUNG ADULTS OF DIFFERENT GENDERS PERCEIVE NATURE-INDUCED PSYCHOLOGICAL BENEFITS

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ABSTRACT

This paper examines how young adults of diverse gender identities experience the mental health benefits of nature. Based on 12 qualitative interviews with participants aged 18–30 from the Netherlands-Germany border region, the study moves beyond binary gender frameworks by including cisgender, non-binary, and transmasculine perspectives. Using phenomenological and heuristic methods, it integrates the biophilia hypothesis with intersectional ecofeminism to explore both shared and socially shaped experiences. The findings show that nature generally promotes stress reduction, relaxation, emotional regulation, and mental clarity across all genders. However, these benefits are not equally accessible. Cis-female and female-presenting participants often reported safety concerns that restricted their ability to relax, while cis-male participants felt safer and viewed nature as a space for emotional expression beyond traditional masculine norms. Non-cis participants described nature as especially liberating and inclusive, though still influenced by issues of visibility and safety. Overall, the study concludes that although nature provides universal psychological benefits, gendered social structures affect who can fully access them, and it also emphasises the importance of gender-sensitive public health approaches and inclusive urban planning to make natural spaces safe and welcoming for everyone.

Keywords: Nature Exposure; Mental Health; Biophilia; Intersectional Ecofeminism; Gender Differences.

1. Objective

This thesis investigates how young adults of different genders experience the psychological health benefits of exposure to nature. Although a substantial body of research has demonstrated that natural environments contribute to stress reduction (Gaekwad *et al.*, 2023), emotional well-being, and improved mental health outcomes (Jimenez *et al.*, 2021; Sundermann *et al.*, 2023), existing studies often treat gender as a binary category (Núnez *et al.*, 2022) and neglect the role of social norms and intersecting identities (Colley *et al.*, 2022; Nunes *et al.*, 2023). This results in a limited understanding of how diverse groups actually access and benefit from natural environments. The aim of this study was therefore twofold: first, to identify the psychological benefits that young adults associate with nature, and second, to explore how these benefits are shaped by gender identity, societal expectations, and cultural framings. By integrating the **biophilia hypothesis** - which provides a biological explanation for universal positive responses to nature (Wilson, 1984) - with **intersectional ecofeminism** - which highlights the influence of social structures and power relations (Öztürk, 2020; Shiva, 1989) - the research seeks

to offer a more comprehensive perspective on the gendered dimensions of human-nature interactions.

2. Methods

The study applied a qualitative design to capture the lived experiences of young adults. Twelve semi-structured interviews were conducted with participants aged 18–30 in the border region between the Netherlands and Germany. The sample included individuals identifying as cis-male, cis-female, non-binary, and transmasculine, thereby ensuring that perspectives beyond the gender binary were represented. Interviews were conducted in either German or English, recorded, transcribed, and analysed using the software ATLAS.ti. The analysis followed a phenomenological approach in order to foreground the meaning participants ascribed to their experiences, complemented by heuristic inquiry that incorporated the researcher's reflexive engagement with the topic. Inductive coding was combined with theory-driven interpretation. The biophilia hypothesis was used to examine universal affective responses to nature, while intersectional ecofeminism was employed to uncover the ways in which gender norms, safety concerns, and social identities mediated these experiences. Ethical approval was obtained from Maastricht University, and informed consent was secured from all participants.

3. Results

Across all gender identities, participants reported a variety of positive mental health effects from spending time in nature. These included feelings of relaxation, reduced stress, greater mental clarity, and improved capacity for emotional regulation. Nature was consistently described as less stimulating and overwhelming than urban environments, allowing participants to "reset" mentally. These findings lend support to the biophilia hypothesis by illustrating the universal benefits of human-nature contact. To illustrate these patterns, several participants described nature as a place where they could "breathe again" or "clear their mind," while others emphasised that its calmness enabled them to process emotions they usually suppressed. Some participants noted that natural settings allowed them to "slow down," experiencing a sense of grounding that contrasted with the pressures of everyday life.

However, the study also revealed pronounced differences shaped by gendered social norms. Cis-female and female-presenting participants frequently reported safety concerns, particularly fears of assault when visiting natural areas alone or at night. For example, participants described avoiding unlit or remote paths because the fear interrupts the relaxing effect nature would otherwise provide. Others emphasised needing to stay alert or change routes which reduced their ability to feel fully at ease. These concerns influenced the times of day and locations in which they felt able to enjoy nature, and in some cases limited the restorative potential of their experiences. By contrast, cis-male participants did not generally express such fears; instead, they highlighted how nature provided them with a rare opportunity for emotional openness and reflection outside of traditional masculine expectations. For example, one male participant described being able to cry in nature and thus regulate his emotions effectively. Non-cis participants described nature as a gender-neutral or even liberating space, where authenticity and belonging could be fostered in contrast to more regulated

social environments. To them, nature was a "mirror" of the self – a reflection where nature was neither masculine or feminine and where they could be entirely themselves. Several participants also reflected on how gender stereotypes shaped access to outdoor activities, with women being steered toward "gentle" engagement and men toward more competitive or consumptive activities.

4. Discussion

The findings of this study confirm earlier research showing that exposure to natural environments has consistent psychological benefits such as stress reduction, improved mood, and emotional regulation. Yet, the results also highlight that these benefits are not distributed equally across genders. This suggests that universalist frameworks such as the biophilia hypothesis are insufficient when applied in isolation. While biophilia explains the innate attraction to and psychological restoration derived from nature, it assumes a homogeneity of human experiences that do not exist in practice. The data presented here illustrate how lived experiences are shaped by intersecting social factors, most notably gender, which either enable or constrain access to nature's benefits.

An important contribution of this study lies in showing how safety concerns - especially among cis-female and female-presenting participants - limit the restorative potential of natural environments. Fear of assault or harassment not only reduces the willingness to visit natural areas alone but also alters the conditions under which nature can be experienced. This demonstrates that the health benefits of nature are contingent not merely on the availability of green spaces, but also on the perception of these spaces as safe and accessible. By contrast, male participants largely described feelings of security, in some cases linked to their physical appearance or socialisation, which provided them with a more unrestricted experience of nature. These findings align with existing feminist scholarship, which argues that public spaces, including natural ones, are never socially neutral but are inscribed with power relations that affect bodies differently.

The narratives of non-cis participants further enrich this discussion. For them, nature was frequently experienced as a more inclusive and less regulated space, offering opportunities for authenticity and relief from normative gender expectations. This suggests that natural environments can function as counter-spaces to societal marginalisation. At the same time, their accounts reveal that gender identity continues to influence how one moves through and relates to these environments, particularly when visibility or "passing" affects perceptions of safety. This underscores the importance of adopting an intersectional perspective: gender interacts with other identities-such as sexuality, ethnicity, or socioeconomic background-in ways that shape both access to and interpretation of nature's benefits.

Another dimension that emerged is the cultural framing of nature. Many participants described nature in idealised terms, portraying it as inherently safe, healing, and restorative. Such framings reflect Western cultural imaginaries of "mother nature" as a nurturing and benevolent force. However, these narratives risk overlooking the ways in which power relations, exclusions, and environmental injustices are also present in natural spaces. Intersectional ecofeminism challenges such idealisations by drawing attention to the exploitation of both women and the environment under patriarchal

structures. The findings of this study, therefore, suggest that critical reflection on cultural framings is necessary if we are to fully understand how people experience and benefit from nature.

Finally, the results have broader implications for both research and practice. For public health, they highlight that interventions designed to promote mental well-being through nature exposure must take social inequalities into account. Simply increasing the amount of green space in urban areas may not be sufficient if women, queer, or marginalised individuals do not feel safe using them. Similarly, for urban planning, the design of green spaces should prioritise safety, inclusivity, and accessibility-features, such as good lighting, clear sightlines, and community involvement can significantly influence perceptions of safety. On a theoretical level, the study demonstrates the value of integrating biological and sociocultural frameworks, thereby moving beyond the dichotomy between "universal" human tendencies and "contextual" social experiences.

5. Conclusion

This study contributes to closing the research gap on how gender influences the psychological benefits of nature exposure. It demonstrates that while nature can foster mental well-being across genders, access to these benefits is unequally distributed and mediated by gender norms, safety, and cultural expectations. The integration of biophilia and intersectional ecofeminism provides a more holistic understanding of these dynamics and suggests practical implications for public health and urban planning. Interventions aimed at promoting nature-based health benefits should explicitly address gendered barriers by ensuring that green spaces are safe, inclusive, and accessible to all individuals, regardless of their gender identity. Beyond individual well-being, strengthening human-nature connections is also critical for planetary health, as it fosters pro-environmental attitudes and behaviours necessary to address ongoing ecological crises. By recognising both the universal and the socially mediated aspects of human–nature interactions, this research underscores the need for gender-sensitive approaches in health promotion, environmental policy, and urban design.

Acknowledgements

The author declares no acknowledgements.

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NATURELAB APPROACH: DEFINING COMPONENTS AND METHODOLOGIES FOR NATURE-BASED THERAPIES

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ABSTRACT

The NATURELAB project, funded by the European Union's Horizon Europe Research and Innovation programme (Grant Agreement 101083857) and the UK Research and Innovation (UKRI), develops a comprehensive methodology for Nature-Based Therapies (NBT) by defining their essential components and structured implementation. Deliverable D2.2 of Work Package 2 establishes the NATURELAB Approach (NA), building upon recent scientific advances and partners' expertise in practices such as Forest Therapy (FT), Forest Bathing (FB), and Horticultural Therapy (HT), among other practices. This extended abstract outlines the objectives, methodological framework, and implications of the NA for advancing standardised, science-based interventions that enhance health and well-being and are flexible enough to be adjusted across diverse populations and settings.

Keywords: Nature-Based Therapies; Structured Interventions; Forest Therapy; Horticultural Therapy; Public Health; Well-Being.

1. Objective

The objective of Deliverable D2.2 is to define the components required to structure effective NBT programmes. The NA provides a unified framework for designing, implementing, and validating interventions across multiple contexts, ensuring scientific robustness, ethical integrity, and cross-cultural applicability. It aims to bridge the gap between fragmented practices and the need for standardised, evidence-based Nature-Based Interventions (NBI) applicable within public health systems (Gesse et al., 2024). The NA is grounded in concrete partners' prior experiences from multiple fields and research methodologies within nature-based therapies and related disciplines, drawing on applied practice, pilot interventions and empirical observation across diverse contexts. These experiences have contributed to strengthening the methodological foundations of NATURELAB, while remaining methodologically independent and not tied to a single project framework. As a result, the NA constitutes a robust and highly transferable approach, capable of being adapted and applied across different settings, populations and systems.

2. Methods

The NA was developed through a comprehensive literature review of existing NBT methodologies and evidence-based practices (Chun et al., 2023; Cipriani et al., 2017), a comparative analysis of therapeutic frameworks to identify gaps in standardization (Harper & Dobud, 2021), and the integration of partners' expertise in structured NBI programmes validated through practice (Gesse et al., 2023; Gesse & Ayats, 2024). Its novelty lies in the explicit identification and operationalisation of five transferable core components applicable across different NBIs, moving beyond single-modality approaches toward a structured and reproducible framework:

1. Nature Connection Activities (NCA): structured practices that deepen emotional and meaningful connection with nature, strongly associated with well-being.
2. Structured Sequences of Activities: purposeful sequencing and exposure to optimise "nature dose" and health outcomes.
3. Spaces / Noticing: sensory awareness and reflective practices that strengthen attention, connection and social cohesion.
4. Expressive Arts in Nature (EAN): creative activities that support emotional processing and meaning-making.
5. Nature-based Activities (NBA): transferable practices integrated into daily life to sustain long-term benefits.

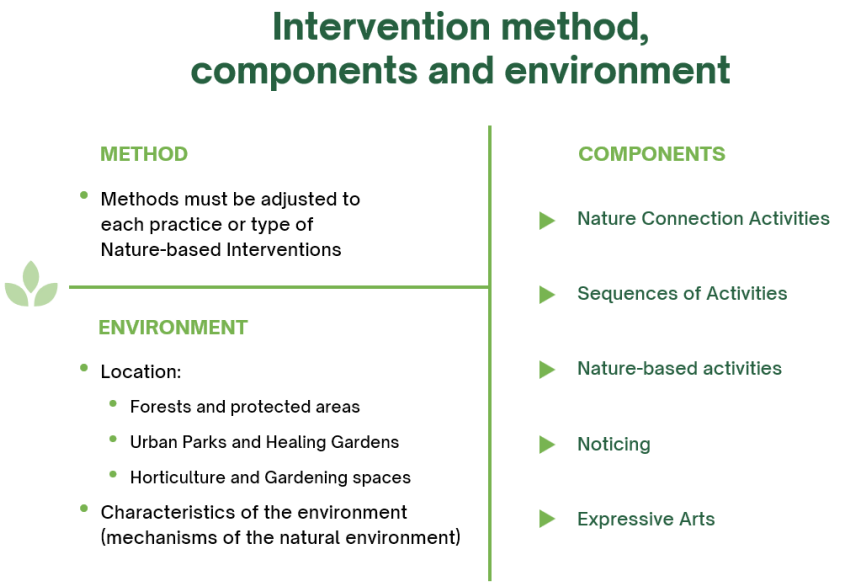

Figure 1. Components of Nature-Based Interventions. Adapted from "Handbook for the Certified Forest Bathing Guide and for the Certified Forest Therapy Practitioner" (Gesse et al., 2023).

3. Results

The NATURELAB Approach provides a structured framework adaptable to different therapeutic contexts and types of nature spaces, including:

- Forests and Protected Areas (FPA)
- Urban Parks and Healing Gardens (UP/HG)
- Horticulture and Gardening Spaces (HGS)

This categorisation is intended to enable tailored NBIs, ensuring the suitability of each environment for specific interventions. The forthcoming pilot programmes will serve to test the NA's versatility and capacity to generate replicable, culturally adaptable interventions. Meanwhile, existing evidence from recent studies shows that FT and FB can produce measurable improvements in stress reduction and mental health outcomes (Bratman *et al.*, 2015; Chun *et al.*, 2023; Siah *et al.*, 2023), HT interventions have demonstrated benefits for individuals with mental health conditions (Cipriani *et al.*, 2017).

4. Discussion

NBT practices have been widely applied but often lack standardised definitions and methodologies. The NATURELAB Approach (Deliverable D2.2) responds to this need by offering a replicable, science-based structure that remains adaptable to cultural and environmental contexts.

The importance of such standardisation is strongly supported by large-scale reviews linking nature exposure to measurable health outcomes (Twohig-Bennett & Jones, 2018; White *et al.*, 2019). In addition, NA integrates ethical considerations, ensuring informed consent, inclusivity, safety, and sustainability. Grounding practices in rigorous methods and scientific validation enhances credibility and facilitates the integration of NBT into preventive healthcare and rehabilitation programmes (Harper & Dobud, 2021).

Finally, multi-country piloting contributes to understanding the universality of NBT components while allowing for adaptation to social, cultural, and ecological variables (Gesse *et al.*, 2023).

5. Conclusion

Deliverable D2.2 establishes the NATURELAB Approach (NA) as a structured methodology for implementing NBT programmes in public health and community well-being contexts. Defining five key components, mapping their suitability across different types of natural spaces, and embedding ethical principles, the NA provides a foundation for:

- Advancing scientific research on causal links between nature exposure and health outcomes.
- Designing replicable and adaptable therapeutic programmes across specific populations and natural environments.

- Integrating NBT within healthcare systems as complementary interventions.

The NA represents a step forward in bridging theory, practice, and policy, positioning NBT as a legitimate, standardised, and impactful field in global health promotion.

Acknowledgments

This work was developed within the NATURELAB project, funded by the European Union's Horizon Europe Research and Innovation programme under Grant Agreement number 101083857 and supported by the UK Research and Innovation Grant Award No.10067111.

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IWI TOPIC
Cultural Ecosystem Services assessment in NBS/NBT research

HEALING GARDENS WITHIN NATURELAB CASE STUDY: PUERICULTORIO PÉREZ ARANÍBAR (LIMA, PERU)

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ABSTRACT

Within NATURELAB, an EU-funded research project on nature-based therapies (NBTs), we designed and implemented a child-centred healing garden at Puericultorio Pérez Araníbar (Lima, Peru), a foster-care institution. Using a structured six-phase process (site-selection, child-centred landscape design guided by universal design, budget definition, on-site layout, implementation, and maintenance planning), we delivered five functional zones: activity space, meditation areas, podotactile path, willow teepees, and a physical-activity area with tree stumps, supported by drip irrigation and a clear upkeep protocol. Planting emphasised sensory engagement, climate resilience, and the provision of ecosystem services. Following activation, the garden became part of routine programming (play, regulation, and small-group NBT sessions), demonstrating operational feasibility and low risk within existing staffing and maintenance routines. This case study offers transferable design principles for similar institutional contexts, while avoiding overgeneralization. Next steps include structured evaluation of feasibility, acceptability, and early participant outcomes, alongside documentation of operating costs to inform policy and long-term financing for NBTs within health and social care systems.

Keywords: Healing Gardens; Nature-Based Therapies; Universal Design; Ecosystem Services; Child Well-Being; Lima, Peru.

1. Introduction

NATURELAB examines how green and/or blue spaces support health and well-being through tailored NBTs (e.g., horticultural therapy, forest bathing) across multiple European sites and three sites in Peru. This case study reports the practical design and implementation of a healing garden in Lima, Peru, emphasising concise, practice-oriented lessons for practitioners and decision-making. The Puericultorio Pérez Araníbar (PPA) is a century-old institution serving around 250 children referred by judicial or administrative authorities. Programming also reaches local community children. Given the prevalence of emotional dysregulation and undiagnosed neurodiversity among residents, the garden was conceived to support regulation, sensory engagement, and social interaction within accessible, low-maintenance infrastructure and interventions.

2. Objective

Describe the end-to-end process of delivering a healing garden at Puericultorio Pérez Araníbar– from brief partnerships to activation. In doing so, we aim to recognise specific design and implementation principles that can be applied in comparable institutional settings.

3. Methods & Result

The intervention unfolded in six phases. For each phase, we summarise what was done (methods) and what was delivered (results) (see Table 1).

Table 1. Intervention phases

Phase	Methods	Results
1. Site selection	Assessed candidate spaces with the institution and school operator; reviewed user flows, safeguarding, shade, water access, and supervision needs.	Selected a suitable plot for circulation and sensory micro-spaces; secured institutional agreement.
2.Child-centred design (Universal Design)	Co-designed with a landscape architect; mapped user needs to the spatial characteristics; applied universal design principles; planned the inclusion of shade, seating, and wayfinding.	Concept plan featuring five zones, accessible paths and seating, clear sightlines, and a preliminary palette that emphasises native, low-maintenance, and sensory plants.
3. Budget definition	Itemised civil works, substrates, plant materials, drip irrigation, and furnishings; aligned scope with available resources and maintenance capacity.	Approved bill of quantities and phased procurement list.
4. On-site layout	Staked paths and zones; verified gradients and circulation; adjusted locations to preserve existing vegetation and shade.	Finalised layout; prepared beds and substrates for installation.
5. Implementation	Installed drip irrigation; planted trees, shrubs, herbs, and groundcovers; installed seating, willow teepees, podotactile path, and stumps.	Five functional zones are operational; irrigation has been tested; a safety check has been completed.
6. Maintenance & Activation	Defied roles/frequencies for irrigation, pruning, repairs, and cleaning; trained staff; embedded small-group NBTs sessions in routine schedules.	Garden integrated into programming (play, regulation, NBTs); early indications of feasibility and acceptability.

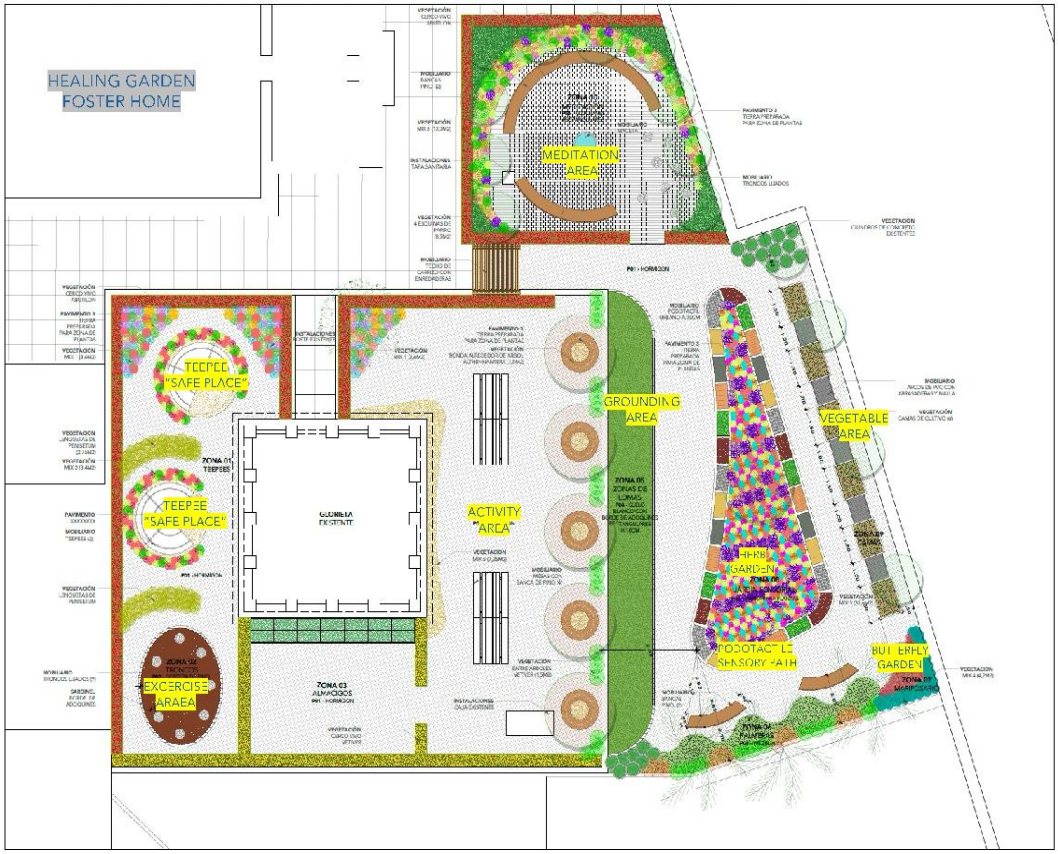

Figure 1. Landscape design of the healing garden in Puericultorio Pérez Araníbar by APHTS

4. Discussion

Feasibility and risk management of the healing garden were assessed, and it was discovered that the viability of the intervention was enabled by the following principles: (i) universal design for intuitive, equitable access; (ii) sensory-rich, native-forward, low-maintenance plantings aligned with climate resilience and biodiversity; (iii) early governance and garden maintenance planning; and (iv) the inclusion of safeguarding principles (clear sightlines, supervision, durable surfaces).

The transferability of the implementation lies in these process principles, which can be adapted to local actors, budgets, and environments.

5. Limitations & Next Steps

As a single-site pilot in a specific institutional context, results are not generalizable. Planned work includes:

A. Structured evaluation of feasibility and acceptability;

B. Early participant outcomes;

C. Documentation of operating costs to support policy integration and long-term financing.

Acknowledgements

The NATURELAB project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

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CHANGING OUR PERSPECTIVE ON URBAN GARDENS: A CASE STUDY FROM THE WEST OF IRELAND

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ABSTRACT

This project aimed to transform an underused outdoor area into a therapeutic sensory garden for children and adolescents with Autism Spectrum Disorder (ASD) at the Galway Autism Partnership (GAP) in Galway City, Ireland. The primary objective was to create a safe, all-weather environment that supports sensory regulation, calm curiosity, and social engagement through intentional landscape design. The garden was designed and implemented collaboratively with GAP professionals and volunteers. The site was divided into distinct sensory zones connected by a multi-textured, resin-bound pathway. Design decisions prioritised safety, durability, and multisensory engagement through carefully selected planting, tactile materials, water features, and sheltered structures appropriate to Galway's climate. Since opening in early 2024, the garden has been used daily. Observations indicate that children comfortably transition between active and quiet areas, while staff and parents report reduced stress and increased informal social interaction. Notably, parents have adopted the space as a restorative retreat. Despite its modest scale, the project demonstrates how thoughtfully designed sensory environments can transform neglected spaces into inclusive therapeutic settings. While tailored to ASD needs, the garden's benefits extend to the wider community, challenging assumptions about space, scale, and outdoor well-being design.

Keywords: Sensory Gardens; Autism Spectrum Disorder, Children; Adolescents.

1. Introduction

Why do we place so much trust in our senses? It is a question worth revisiting, given how frequently our sensory systems mislead us by simplifying an overwhelmingly complex world. Our evolved perceptual shortcuts can create genuine challenges, particularly for individuals whose sensory experiences differ markedly from the norm. Rather than focusing solely on the limitations of our senses, it is equally important to consider what they enable when environments are designed to support them. For many people, a quiet room and a single sunlit plant are enough to evoke calm. A nature enthusiast may find similar comfort in an irregular patch of moss masquerading as grass. Yet some individuals, often without consciously intending to, cannot tolerate such minimal or poorly considered attempts at creating restorative spaces. Individuals with Autism Spectrum Disorder (ASD) exemplify this sensitivity (WHO, 2025).

This raises a compelling question: could the sensory needs of ASD individuals catalyse more intentional and creative environmental design? Sensory gardens offer one promising answer. These spaces are designed to engage multiple senses, touch, smell, sound, and movement, not merely vision. For children and adolescents with ASD, whose

sensory experiences are often unusually intense or overwhelming, such environments can foster calm, curiosity, and social engagement. Although the origins of their sensory differences are not yet fully understood, we are increasingly learning what kinds of environments support their well-being. In doing so, we may also discover principles that enhance outdoor spaces for all individuals, not only those with ASD.

2. Objectives

This project set out to transform an unused and poorly positioned area of space into a therapeutic garden for children with ASD within the Galway Autism Partnership (GAP) organisation in Galway City, Ireland. The aim was to create an all-weather, usable space that promotes a sense of calm curiosity through sensory exploration and outdoor experience. This project was designed and implemented by Landscape Services Ireland, based in Bearna, Co. Galway.

3. Methods

Working alongside GAP care professionals and volunteers, the site was redesigned into distinct sensory zones. The user encounters a multisensory experience as they walk through the garden's multi-textured pathway. Safety guided every design choice: a pond was replaced with a shallow millstone water feature, resin-bound paths provide stable, non-slip surfaces, and natural wood structures offer tactile interest under a shaded canopy. The planting scheme was selected for its multisensory qualities and suitability for Galway's cool-temperate oceanic climate (see Table 1). Material choices further ensured long-term maintenance and weather durability.

Table 1. Planting scheme organised by sensory qualities

Sensory category	Key species (common & Latin names)
Structure & visual	Rowan tree (Sorbus aucuparia, native); Black-eyed Susan (Rudbeckia fulgida); Montbretia (Crocosmia x crocosmiiflora, introduced hybrid); Male fern (Dryopteris filix-mas, native); Lady fern (Athyrium filix-femina, native); Verbena (Verbena bonariensis).
Smell & visual	Catmint (Nepeta cataria, naturalised); Traveller's joy (Clematis vitalba, native); Common honeysuckle (Lonicera periclymenum, native); Lavender (Lavandula angustifolia).
Texture & feel	Lamb's ear (Stachys byzantina); Sedum (Hylotelephium spectabile); Hart's-tongue fern (Asplenium scolopendrium, native).
Smell & taste	Chives (Allium schoenoprasum, native in areas); Rosemary (Salvia rosmarinus); Fennel (Foeniculum vulgare, naturalised in coastal areas); Water mint (Mentha aquatica, native); Basil (Ocimum basilicum); Wild thyme (Thymus polytrichus, native).
Movement & sound	Mexican feather grass (Stipa tenuissima); Tufted hair-grass (Deschampsia cespitosa, native).

3.1. Implementation of the Sensory Garden

A central element in fostering confidence within this project was the sensory experience offered by the garden environment. Vibrant colours from Rudbeckia and Verbena, the distinctive scent of Nepeta cataria, and the movement and sound of ornamental Stipa grasses created an enriched yet balanced sensory setting. These stimuli heighten perception without overwhelming it, drawing on the inherently calming and restorative qualities of natural elements. Designing the garden, however, was far from straightforward. The chosen site, a dimly lit, narrow plot with irregular boundaries (see Figures 1 and 2), had been deemed a "dead space." Constraints quickly became evident: the unconventional shape and size of the area, limited access points, and the challenge of sourcing appropriate materials that would maximise sensory engagement while maintaining safety.

Figure 1. Area of site chosen.

Figure 2. Maximum use of space.

To address these limitations, key natural components were incorporated with careful intention. Wooden arches were selected for their tactile patterns, organic scent, and structural capacity to support fragrant, colourful climbers such as Clematis and Honeysuckle. A water feature was planned as the focal point, drawing visitors along the pathway toward a dynamic centre of colour, sound, and movement. Although the initial open pond design was abandoned due to drowning risks, it was replaced with a robust medieval-era milling stone. This feature provided multisensory interest: the sound of trickling water, the shifting temperatures of wet and dry stone, and richly textured surfaces (see Figure 4). Raised wooden beds accommodated herbs and insect habitats, adding layers of scent, taste, and texture while supporting local biodiversity. Upon entering through the wooden boundary gate, visitors follow a curved, multi-textured pathway that winds through the garden, circles the water feature, and concludes beneath a colourful plexiglass-and-wood canopy offering shelter from rain.

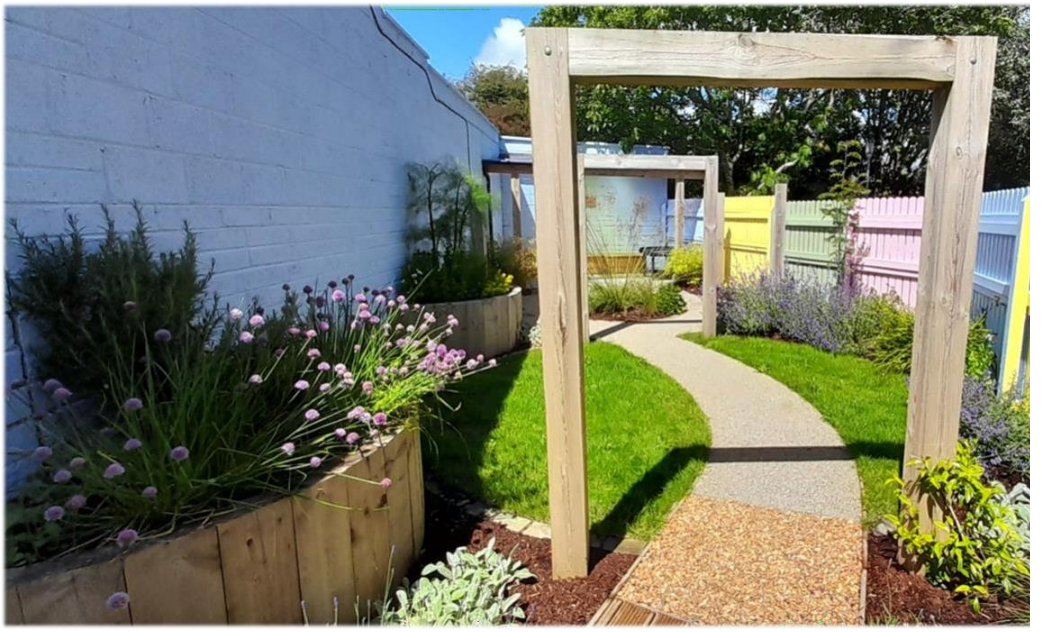

Figure 3. Finished garden.

Originally, the pathway was designed with embedded stones of varying sizes, but safety concerns regarding loose materials led to the use of resin-bound, naturally multicoloured gravel instead. This adaptation allowed for a stable yet diverse walking surface featuring cobblestones, anti-slip wooden beams, artificial grass, and scented groundcover plants. The path transitions into smooth resin stone before opening onto a natural lawn and circling the remainder of the space (see Figure 3). Throughout this short route, visitors encounter plantings selected for their tactile qualities, colours, fragrances, and auditory effects in windy weather. The design further encourages insects, birds, and small urban wildlife, enhancing both biodiversity and the natural soundscape.

Figure 4. Millstone water feature & resin pathway.

4. Results

Since its completion and public opening in early 2024, the garden has received daily use. Staff and parents report that children move easily between active and quiet areas, while sheltered seating encourages informal interactions. Parents, unexpectedly, have become some of the most frequent users, finding the space restorative in its own right.

5. Conclusion

In reflection, although this sensory garden project may appear modest in scale, its transformation of an overlooked "dead space" demonstrates the potential for intentional design to inspire larger and more accessible initiatives. The limited size of the site meant that not every desired feature could be incorporated. Yet the diversity of natural materials and sensory stimuli was maximised to the delight of the children and adolescents using the space, as well as the care professionals and volunteers supporting them. Crucially, outdoor spaces are only meaningful when designed with the needs of their intended users in mind. The assumption that substantial land is required to create wellbeing-enhancing environments is, at best, an unhelpful misconception. Such assumptions contribute to a growing cultural shift toward a "great indoors" across Ireland, Europe, and beyond. While this project focused on the sensory needs of individuals with Autism Spectrum Disorder, the broader lesson is that neglected outdoor spaces can be reimagined to benefit people of all ages and backgrounds.

This was underscored by an unexpected outcome observed months after the garden opened: parents increasingly used the space as a brief retreat, engaging in restorative conversations over cups of tea while enjoying the calming sensory environment. This unintended but welcome use highlights the multipurpose potential of thoughtfully designed outdoor spaces, spaces that respond not only to explicitly stated needs, but also to needs that may remain unspoken or unrecognised. Ultimately, this project illustrates that there is no true "dead space"; there are only spaces in need of better design. What began as a small intervention for children with ASD became a catalyst for wider therapeutic benefit within the community. Rooted in a remote neighbourhood yet broadly relevant, this case study demonstrates how sensory engagement with nature can yield far-reaching well-being outcomes. It serves as a timely reminder for a society increasingly oriented toward indoor life: the outdoors continues to offer restorative potential, precisely when it is needed most.

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IWI TOPIC
NBS/NBT integration on health care system and society

PROMOTING CIVIL SOCIETY AWARENESS OF NATURE'S POTENTIAL FOR HEALTH AND WELL-BEING. PRELIMINARY RESULTS FROM A CASE STUDY IN PORTUGAL

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ABSTRACT

NATURELAB aims to promote paradigm shifts by integrating Nature-Based Solutions (NBS) and Nature-Based Therapies (NBT) into healthcare practices, including potential prescription by practitioners in the Portuguese National Health Service. As part of its outreach, NATURELAB participated in the Festival de Bem Estar, the largest Portuguese event on complementary therapies, which attracts a receptive and diverse audience. The project hosted a stand, staffed by trained members, where visitors could engage with scientific evidence on NBS and NBT through brochures, leaflets, and interactive discussions. A key element was the implementation of an on-site survey exploring participants' connection with nature, knowledge of NBT, and openness to evidence-based approaches. The survey gathered 252 responses, complemented by qualitative insights. Preliminary observations highlight strong interest, particularly from women and younger participants, as well as curiosity about professional guidance in NBT. The initiative fostered dialogue with civil society, providing an understanding of public perceptions regarding nature's role in health and well-being. The analysis of results will provide information able to support replicating and expanding similar initiatives.

Keywords: Awareness Raising; Dissemination; Survey; Civil Society.

1. The importance of public awareness of nature's role in health and well-being

Among the NATURELAB's objectives, there is the shifting of paradigms and encouraging open, integrated, and inclusive approaches, particularly regarding the relationship between human and nature, as well as to the potential integration of NBTs into prescriptions issued by practitioners within the National Health Service (NHS), in Portugal and in other consortium countries. To this end, communication and dissemination activities across multiple fronts are essential, whether at the institutional or personal level, through press releases, podcasts, articles, videos, and other media formats. In this context, NATURELAB's participation in events aimed at civil society is considered pivotal for the broad dissemination of the project to an audience that is, from the outset, more receptive to the themes we address.

The Welfare Festival (Festival de Bem Estar) is the first and largest national event dedicated to Complementary Therapies that occurs in Portugal. Formerly known as the 'Feira Alternativa', since 2004, this festival has represented a gathering and a moment of union for those seeking to live with greater awareness and balance. As a research project, the core mission of NATURELAB is fully aligned with the Festival's purpose of contributing to 'a better life in awareness and balance'. Therefore, it seemed promising to make the decision to register and apply for a stand at this event, in a collaborative effort joining three of the Portuguese partners of NATURELAB.

2. The participation of NATURELAB at a well-being festival with national impact in PORTUGAL

2.1 The chosen approach

Centred on the promotion of nature-based interventions for the enhancement of health and well-being, the project's presence at the event aimed to raise participants' awareness and curiosity regarding scientifically validated solutions for improving health and well-being, while simultaneously fostering greater environmental balance and the sustainability of urban spaces. NATURELAB works towards this end by promoting Nature-based Solutions (NBS) and Nature-based Therapies (NBT), which harmonise the relationship between nature and the human being, activating a symbiotic connection.

The main objective of NATURELAB's presence at the Wellbeing Festival was to disseminate the project among civil society and highlight the relevance of NBS and NBTs for promoting population health and well-being. NATURELAB decided that two representatives would be present at all times at the stand. All the persons hosting the stand were project team members, including those from the communication and dissemination leadership or partner members with relevant experience in engagement activities with civil society, who were briefed on the project. A range of materials was made available at the event to provide information about the project. This included three versions of leaflets, created on purpose for the event, which summarise the project and present scientific evidence of the role of nature in improving health and well-being. In addition, project flyers and brochures were provided for those seeking more detailed information about the project. A roll-up banner was also displayed to increase the visibility of the project at the venue.

2.2 Implementation of the survey

It was decided to use this opportunity to implement a questionnaire survey, to be preferably completed on-site or during the visit. The purpose of this instrument was twofold: on the one hand, to inquire about participants' knowledge of nature-based therapies, nature and its associated benefits, as well as their degree of connection and interaction with natural environments; and on the other, to foster reflection and raise awareness regarding these topics. The questionnaire was accessible via a link, as well as a QR code, made available at the venue. The survey structure and key topics are presented in Table 1.

3. Results

During the three days - from the 5th to the 7th September 2025 - the Festival was open to the public from 3pm-11pm (Friday); 10am-11pm (Saturday) and 10am-9pm (Sunday). The NATURELAB stand was always hosted by two people.

Figure 1 illustrates some materials and interaction with the participants. The people who approached the NATURELAB stand demonstrated mostly an open-minded attitude, as many of them had already attended the former Feira Alternativa and therefore tended to adopt a more holistic perspective of health and well-being, rendering them particularly receptive to the themes addressed. On Saturday, attendees were observed to come from various regions of the country, with a strong presence from the North of Portugal, including, for example, Aveiro and Gaia, although not all places of origin could be recorded. The location of the stand, near the entrance (and exit), facilitated the engagement, as it allowed for interactions both at the entrance and upon exit from the Festival.

All participants who successfully completed the survey were allowed to take out a raffle and receive a gift, ranging from organic tea bags and plant seeds to a bracelet with the project logo with the sentence "I am NATURELAB," as well as a gift for children.

Table 1. Structure of the Connection with Nature and Well-Being Survey

1. Demo-graphics	2. Connection with nature	3. Interactions with nature	4. Nature-Based Therapies
Age groups	Time spent in nature	Activities in nature	Knowledge of nature-based therapies
Gender	Relaxation induced after spending time in nature	Purpose-seeking when in nature	Knowledge about nature-based therapies validated by science
Education	3 words that come to mind when you think of nature	-------	Interest in trying nature-based therapies to improve health and well-being
Place of residence	Nature Connection Index scale (Richardson *et al.*, 2019)	-------	Support to GPs being able to prescribe nature-based therapies

Figure 1. The informative materials at the stand, interactions with the public and participants completing the survey

It was possible to collect 252 answers to the questionnaire, which is considered highly satisfactory. Since not everyone who was informed about NATURELAB decided to complete the survey, it is estimated that around 300 people received information about the project. The data was not yet analysed, except for the reply to the question "*Tell us three words that come to mind when you think of nature*". Figure 2 represents the word cloud with the answers received, being "Health", "Peace", "Connection" and "Calm" among the most chosen words to represent nature.

Some empirical information and acknowledgements from conversations with participants revealed that the relationship and interaction with nature proved to be a topic of genuine interest. Several participants even emphasised the need for more nature spaces to enable people to benefit more fully from contact with nature. A considerable number of participants expressed both curiosity and appreciation when informed of the existence of scientific validation underpinning NBT. This seems to indicate a willingness to engage with evidence-based approaches. Most attendees posed questions, further demonstrating active interest and engagement with the project.

4. First conclusions and next steps

Although the public was diverse, responses to the survey were mainly provided by women, indicating a gendered aspect in receptiveness to the project. Furthermore, younger participants were especially responsive, with most engaging positively and enthusiastically about the project. Fourteen respondents were non-Portuguese speakers.

In terms of thematic content, many participants reported familiarity with the concept of nature-based therapies (NBT). Nonetheless, a recurring question concerned the necessity of a guide or therapist, with some participants questioning whether such practices could be undertaken independently. This suggests an area where further clarification and communication regarding the role of professional guidance in NBTs may be warranted. A

key issue is that the respondents to the survey are likely to be more open to NBT, therefore not representative of the Portuguese population.

The forthcoming phase will concentrate on a systematic analysis of the survey data collected during the Festival. This analysis will include both quantitative and qualitative dimensions. Quantitatively, descriptive statistics will be used to characterise respondents' demographics, patterns of interaction with nature, familiarity with nature-based therapies, and attitudes toward their potential integration in healthcare. Qualitative data, including the free-association exercise of "three words that come to mind when thinking of nature," will be further explored to identify prevailing perceptions, symbolic associations, social representations about nature and underlying values allocated to the natural environment. Particular attention will be paid to differences across age groups and educational backgrounds. Building on these findings, NATURELAB will refine its outreach strategies to better engage diverse audiences and support the scientific and policy dialogue on integrating NBT into healthcare systems. Ultimately, this step is crucial for scaling up nature-based interventions and fostering sustainable connections between civil society, nature, and public health.

Figure 2. Word cloud from the question "Tell us three words that come to mind when you think of nature".

Acknowledgements

This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement number 101083857 and co-funded by the UK Research and Innovation Grant Award No. 10067111.

The authors designed the communication approach, including the survey, and hosted the stand receiving the participants on time schedules shared by two people. We are deeply grateful for the amazing support from colleagues from LNEC and Sintra Municipality (CMS), who enthusiastically received the participants throughout the 3 days of the Festival. They are Daniela Ferreira (LNEC), João Fernandes (LNEC), Apolo Melo Silva (CMS), Carla Anselmo (CMS), Patrícia Jorge (CMS) and Susana Vitorino (CMS). They are co-responsible for the success of NATURELAB's participation in this event, and their feedback on the dynamics is highly relevant to analyse more in-depth the outcomes from the participation.

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PERSPECTIVES ON THE INTEGRATION OF NATURE-BASED THERAPIES IN THE PERUVIAN HEALTH SYSTEM

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ABSTRACT

This paper examines how Nature-Based Therapies (NBT) can be integrated into the Peruvian health and social care system as an innovative public health approach. NBTs are structured therapeutic practices that use nature to support mental and physical health, and growing evidence highlights their effectiveness. Using the system innovation framework, the study explores how NBTs can move from small-scale experimentation into mainstream health systems, while identifying barriers and facilitators to this process. The study uses an exploratory qualitative case study design in Peru. Data was collected through 20 semi-structured key informant interviews and three focus group discussions with stakeholders from eight sectors, including healthcare, policy, environmental organisations, civil society, and NBT practitioners. Data was analysed using the framework method. Findings reveal multiple barriers to embedding NBTs, notably shortages of trained personnel, limited awareness, biomedical dominance, restricted access to green spaces, and insufficient funding. Inequality emerged as a cross-cutting issue, particularly regarding access to urban nature. Indigenous knowledge was identified as a key opportunity for culturally grounded NBT development.

Keywords: Nature-Based Therapies; System Innovation; Health; Peru.

1. Objective

This paper aims to explore how to integrate Nature-Based Therapies (NBT) into the Peruvian health and social care system. NBTs can be described as an innovative approach in public health. They are defined as structured, therapeutic practices that intentionally use nature as a medium for psychological or physical healing. They are often delivered by trained professionals (e.g. therapists, healthcare workers). Recent research has proven its benefits both for mental and physical health (Andersen *et al.*, 2021; Coventry *et al.*, 2021; Harper *et al.* 2021). Despite growing evidence on the health and social benefits of NBT, its integration into the health or social care system is novel.

How can innovations be integrated into a system? The system innovation framework (Geels, 2002; Loorbach, Frantzeskaki & Avelino, 2017; Woodward *et al.*, 2021) views innovations as dynamic, multi-level processes that unfold across three levels: the niche

(experimental settings were innovations are tested); the dominant constellations, involving the prevailing set of structure (ways of organising), culture (ways of thinking), and practices (ways of doing) of the existing system; and the landscape (broader social trends and context). Scaling up involves the embedding of an innovation in an existing system (i.e. scaling up), and this process is often challenging. Using the system innovation framework, we explored the barriers and facilitators for integrating NBTs as an innovative approach to promote health and sustainability.

2. Methods

As part of the NATURELAB project, this study adopted an exploratory qualitative case study design, using a transdisciplinary approach which included the perspective of various stakeholders across the health field. This abstract reports on preliminary findings from the Peru case study. A more extended version is in preparation for submission to a peer-reviewed journal. In total 20 semi-structured key informant interviews (KIIs) and 3 focus group discussions (FGDs) with 13 participants were conducted in Peru. All participants were assigned a descriptor from eight a priori selected stakeholder groups: i) Medical and healthcare community; ii) Scientific community and innovation structures; iii) Environmental organisations; iv) Policymakers and governance; v) Small and medium-sized enterprises (SMEs); vi) Civil society; vii) Media; and viii) People in the field of NBT. FGDs had a mixture of new participants and those who previously participated in KIIs.

Regarding on topic discussion, KIIs explored relevant perspectives and issues towards nature-based therapeutic programmes and its sustainable integration into the health system in Peru with a focus on potential systemic drivers (e.g. regulations, financing, health workforce, etc.). While for FGDs, the perceived influencing factors and responses from the KIIs were used to guide this second round of discussions.

With respect to data analysis, KII and FGD data were managed and analysed using the framework method (Spencer L, Ritchie J, Ormston R, *et al.*, 2014), which can be considered a systematic and easy way to thematically analyse data because of its matrix output. It is well-suited to multi-disciplinary research (Gale *et al.*, 2013), making it an appropriate choice for our study. Further details on the analysis approach can be found elsewhere (Woodward *et al.*, 2024; Woodward *et al.*, 2025).

3. Results

KII and FGDs participants identified various barriers, facilitators and strategies for sustainably embedding NBT into existing systems. These are summarised in Table 1 (landscape level and system level).

Table 1. Perceived landscape-level factors (contextual) influencing scaling up of NBTs and perceived niche-dominant constellation-level factors (system) influencing scaling up of NBTs

Barriers	Facilitators or opportunities	Strategies
Weakening human–nature connection (related to advance of technology, urbanism and lack of public spaces); urbanisation and environmental degradation, and political instability or anti-environmental laws recently passed.	Strong historical human-nature connection in indigenous communities, the growth of climate change consciousness, and recent political developments on interculturality.	Work collaboratively with environmental actors, local governments, and NGOs to navigate the political instability at the national level.
Culture: how people think?		
Barriers	Facilitators or opportunities	Strategies
The dominance of biomedicine, which prioritises pharmaceutical treatment over disease prevention, was identified as the main barrier.	Alternative approaches like NBTs were less well-known but were accepted by participants, partly because they were interpreted in connection with the indigenous cultural heritage of natural medicine and relationship with nature	Overcoming these barriers by disseminating evidence on NBTs, conducting local research studies on their benefits, developing tailored communication strategies for diverse audiences, integrating intercultural knowledge, and promoting participatory, citizen-driven approaches to nature and healing.
Structure: how people organise the things they do, either physically, institutionally, or financially?		
Barriers	Facilitators or opportunities	Strategies
Limited natural spaces and accessibility, a shortage of trained NBT professionals, and a lack of policies or regulations for these practices.	Emerging institutional acknowledgement of the intercultural approach, fragmented initiatives in alternative medical practices, and ambiguous legislation regarding environmental protection.	Make cost-benefit analysis for embedding novel approaches like NBTs, build alliances beyond the health sector (educational, environmental or civil society sector) and collaborate with universities for training and knowledge production (key strategies for upscaling).

4. Discussion

Despite the therapeutic promise of NBT (Andersen *et al.*, 2021; Coventry *et al.*, 2021; Harper *et al.*2021), we found various barriers that challenge its embedding in the Peruvian health system. Among all barriers, participants across the three FGDs agreed that the most addressable challenge is the lack of human resources, followed by limited awareness or knowledge of NBTs (linked to biomedical dominance). More difficult barriers included limited access to nature, biomedical dominance, and insufficient financing. Addressing these requires collaboration with diverse stakeholders, from academic institutions for evidence generation and dissemination to civil society groups for environmental protection. Results also indicate a landscape trend – **inequality** – not directly mentioned by participants but described as a transversal factor affecting all other influences. For example, when discussing accessibility to natural spaces, which is critical for NBT, participants highlighted the scarcity and unequal distribution of urban green areas. Lima, for instance, has only about 2.6 m^2 of green space per person, far below the WHO recommendation of 9 m^2, with wealthier districts such as San Isidro enjoying much greater access (Benites, 2017). In this sense, it is important to consider how the upscaling of NBTs can not only overcome these barriers but also help reduce inequalities.

Finally, a key aspect to consider in Peru is indigenous knowledge, which participants highlighted is increasingly being revalued. National norms have supported the recognition of indigenous knowledge on health practices, such as those related to traditional birth giving (Pesantes *et al.* 2025). The close relationship that indigenous populations maintain with nature aligns closely with the principles of NBTs. As several participants emphasised, this creates the opportunity for collaboration with indigenous peoples in the development of NBTs.

5. Conclusion: Recommendations for mainstreaming NBT in Peru

Mainstreaming NBT in Peru will be constrained by systemic and contextual factors such as the dominance of biomedical paradigms, insufficient knowledge on NBT, lack of trained therapists, and financial limitations. Overcoming these obstacles requires **multi-level collaboration** between health, education, environmental, and civil society actors. Following KII and FGDs participants, the following recommendations are formulated:

- **Generate scientific evidence:** Local experiments, such as those conducted under the NATURELAB project, should be expanded to provide robust evidence, cost–benefit analyses, and implementation guidelines for NBT. This evidence base is critical to legitimising NBTs within the biomedical system and for scaling them into larger profitable projects that can inform national policies.
- **Develop a multistakeholder NBT awareness network:** Engage stakeholders from key fields to strengthen awareness and communication on NBTs. This should highlight key enabling factors such as scientific evidence of NBT benefits, testimonials and intercultural links between NBT, indigenous knowledge and nature conservation.
- **Engage NBT in the educational curriculum:** Include NBT in the education system curriculum (schools, technical institutes and universities) that enables

student-teacher introductory courses, specialisations, or projects related to exploring NBT benefits with local community impact.

- **Bottom-up approach and use of existing green areas:** promote the application of NBTs in institutionalised green spaces within hospitals and private clinics from a bottom-up perspective, so that these paradigmatic cases can accelerate the scaling-up of NBTs.
- **Connecting with urgent ecological issues:** The NBT agenda and awareness can serve as a bridge to transmit ecological problems (climate change and biodiversity loss that currently affects Peru), since maintaining green areas for NBT depends on the preservation of other wider natural ecosystems.

These recommendations aim to help the integration of NBT into the public health system, which in turn can help support the transition into more plural, patient-centred, and sustainable healthcare models.

Acknowledgements

This project is funded by the European Union under Grant Agreement No. 101083857 and co-funded by the UK Research and Innovation Grant Award No. 10067111. 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.

We would also like to thank Manuela de Szyszlo and Daniela Silva-Rodriguez from the Peruvian Association of Horticultural Therapy (APHTS) for their support in the data collection and validation. Also, to Camila Sattler Rey de Castro for her support in the analysis.

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INTEGRATING ECOPSYCHOLOGY INTO HEALTHCARE: AWARENESS-RAISING TECHNIQUES FOR NATURE-BASED THERAPIES (NBT)

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ABSTRACT

This paper addresses the limited awareness of Nature-Based Therapies (NBT) among healthcare professionals despite growing evidence of their benefits for stress reduction, rehabilitation, and well-being. Drawing on ecopsychology, it synthesises Sterckx's (2023) quality framework for integrated NBT and develops a nine-criterion conceptual framework and practical checklist to support healthcare organisations, authorities, and funders in adopting evidence-based NBT.A scoping review examined applied ecopsychology methods, including forest bathing, horticultural therapy, ecotherapy, and structured nature interventions, with attention to awareness-raising techniques, implementation barriers and facilitators, and measurable outcomes. Findings indicate that these methods enhance professionals' awareness, understanding, stress management, and motivation to adopt NBT. Experiential practices foster embodied connection to nature, improve comprehension of therapeutic mechanisms, and strengthen engagement, collaboration, and organisational buy-in. Key barriers include limited institutional support, training opportunities, and familiarity with ecopsychology, while facilitators involve structured frameworks, stakeholder engagement, and hands-on learning. The paper concludes that integrating applied ecopsychology into professional training can promote sustainable, evidence-based adoption of NBT, benefiting both healthcare practice and ecosystem health.

Keywords: Ecopsychology; Nature-Based Therapies; Healthcare professionals; Healthcare training; Policy pathways.

1. Objectives

Healthcare professionals often have limited awareness of Nature-Based Therapies (NBT), despite growing evidence of their benefits for stress reduction, rehabilitation, and overall well-being. Ecopsychology offers a theoretical and applied framework for understanding the human–nature relationship and for designing experiential, awareness-raising techniques. This paper synthesizes findings from the literature on applied ecopsychology and NBT, drawing on Sterckx's (2023) quality assessment framework, to propose a nine-criteria conceptual framework and a practical checklist. Additionally, it identifies concrete educational and policy-relevant pathways for integrating applied ecopsychology methods into healthcare training systems, including university curricula, continuing professional development, and training provided by healthcare institutions and professional associations.

2. Methods

A scoping review of the literature on NBT and applied ecopsychology methods was conducted, with particular emphasis on Sterckx's (2023) work assessing the quality of integrated NBT interventions in healthcare facilities. Evidence on the effects of forest bathing (Shinrin-yoku) on stress, mood, and professional well-being was examined in studies by Park *et al.* (2010). Horticultural therapy was reviewed in rehabilitation and mental health contexts, drawing on Gonzalez and Kirkevold (2014) and Soga *et al.* (2017). Ecotherapy and structured nature interventions for healthcare staff were analyzed following Jordan and Hinds (2009) and Tong *et al.* (2025), with attention to organizational engagement and professional learning outcomes.

2.1 Data Extraction

Data extraction focused on awareness-raising techniques, applied ecopsychology methods, facilitators and barriers to implementation, and reported outcomes relevant to healthcare professionals, training contexts, and organizational settings.

3. Results

Applied ecopsychology methods proved effective in improving healthcare professionals' awareness, understanding, and motivation to engage with Nature-Based Therapies (NBT). Forest bathing supported stress management and fostered an embodied connection with natural environments, while horticultural therapy enhanced understanding of patient engagement, rehabilitation processes, and therapeutic outcomes. Ecotherapy and structured nature interventions promoted experiential learning, emotional engagement, and reflective practice, deepening appreciation of the mechanisms underlying NBT. Participatory workshops further strengthened emotional connection, interdisciplinary collaboration, and organizational engagement. Across the reviewed literature, recurring barriers to implementation included limited institutional support, a lack of formalized training opportunities, and low familiarity with ecopsychology principles among healthcare professionals. Facilitators included structured quality frameworks, stakeholder engagement, and hands-on, experiential learning formats. The synthesis of findings also indicates that these methods are most feasibly integrated through existing healthcare education and training structures. Specifically, the literature supports their inclusion within university healthcare curricula as experiential modules, within continuing professional development (CPD) programs for practicing professionals, and within training initiatives delivered by healthcare institutions and professional associations, particularly in the context of staff well-being, prevention, and organizational health.

4. Discussion and Conclusion

Integrating applied ecopsychology methods into healthcare professional training supports experiential learning that enhances awareness, motivation, and adoption of Nature-Based Therapies (NBT). Forest bathing, horticultural therapy, ecotherapy, and structured nature interventions combine embodied experience with reflective practices, while participatory workshops promote interdisciplinary collaboration and organizational engagement. Sterckx's (2023) quality framework provides an evidence-informed structure to support coherent, context-sensitive implementation. The findings further suggest that these methods are most feasibly embedded within existing healthcare education and training structures, including university healthcare curricula, continuing professional development pathways, and training initiatives delivered by healthcare institutions and professional associations. While not prescriptive, these insights may inform policy-relevant discussions on capacity building and professional education. Given the limitations of the reviewed literature, future research should investigate long-term effects on professional practice, patient outcomes, and organizational integration. Overall, applied ecopsychology offers a structured, experiential pathway for strengthening the role of NBT in integrative healthcare.

Acknowledgments

This work acknowledges the contributions of prior research in applied ecopsychology and NBT.

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MULTI-SITE ECONOMIC EVALUATION FRAMEWORK FOR NATURE- BASED INTERVENTIONS: THE NATURELAB PROTOCOL

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ABSTRACT

Nature-Based Interventions (NBIs) are expected to be cost-effective, multi-benefit interventions addressing societal challenges. However, systematic economic evidence for NBIs remains critically limited. This paper presents an economic evaluation framework designed to assess NBI cost-effectiveness across healthcare systems. The framework will be implemented across 14 experimental sites in five countries (Portugal, Greece, the Netherlands, Germany, and Peru) with 600-650 participants expected. The analytical approach employs four complementary methods: Cost-Benefit Analysis, Cost-Effectiveness Analysis, Cost-Utility Analysis, and Budget Impact Analysis. This multi-site comparative design captures real-world implementation variability across geographic contexts, healthcare systems, delivery models, and diverse health conditions.

Keywords: Cost-Benefit Analysis; Nature-Based Interventions; Health Economics; Healthcare Integration; Implementation Costs; Economic Evaluation.

1. Introduction

The European Union defines Nature-Based Solutions (NBS) as solutions that are "inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience" (EU, 2021). Critically, NBS should be cost-effective, multi-benefit, and adaptive. However, systematic economic evidence demonstrating the cost- effectiveness dimension remains limited, particularly for nature-based health interventions.

The NATURELAB project addresses this gap through 14 experimental sites across Portugal, Greece, the Netherlands, Germany, and Peru, representing diverse nature and climate contexts. Recognised by the European Commission (2024) as a cross-cutting NBS project focused on "health and well-being," NATURELAB investigates nature-based interventions (NBIs) for promoting health, well-being, and environmental sustainability. This framework specifically addresses the cost-effectiveness dimension through comprehensive economic evaluation.

Nature-based interventions have demonstrated significant mental, physical, and social health benefits across diverse populations and health conditions (Bragg & Atkins, 2016; Coventry *et al.*, 2021; Mygind *et al.*, 2019). Despite robust clinical evidence, systematic economic evaluations of nature-based interventions remain sparse. A recent scoping review identified only three studies, all single-site evaluations with significant

methodological limitations, including retrospective economic analysis after intervention completion (Busk & Sidenius, 2022). No multi-site implementation cost analysis exists capturing real-world variability across diverse healthcare contexts and health conditions.

This paper presents an economic evaluation framework designed to assess NBI cost-effectiveness across NATURELAB's 15 experimental sites. By integrating economic evaluation from study inception and employing multi-site comparative design across diverse health conditions, the framework addresses identified methodological gaps and tests the cost-effectiveness dimension central to NBI implementation.

2. Objective

This study presents a comprehensive economic evaluation framework for assessing nature-based intervention cost-effectiveness across healthcare systems. The framework addresses four key questions: (1) What are real-world implementation costs across delivery models and health conditions? (2) Is NBI cost-effective relative to standard care? (3) What are optimal delivery models from an economic efficiency perspective? (4) What are system-level implications for healthcare integration? Implementation spans 14 experimental sites across five countries (Portugal, Greece, the Netherlands, Germany, and Peru).

3. Methods

3.1 Study Design

Multi-site comparative design spanning 14 experimental sites across Portugal, Greece, the Netherlands, Germany, and Peru (N=600-650 participants expected). Sites launch March 2026, with data collection starting simultaneously and full economic analysis taking place October 2026- November 2027. Site-specific analyses will be conducted as experimental sites finalise their NBI protocols, with initial observations obtained on a rolling basis. This protocol integrates with clinical health outcomes assessment and stakeholder engagement components of the broader project.

3.2 *Cost Data Collection Framework*

The analytical approach follows established health economics methodology for complex interventions (Drummond *et al.*, 2015), adapted to capture unique characteristics of nature-based health interventions (Busk & Sidenius, 2022). Following EU guidelines, cost data collection employs a three-phase structure:

- Phase 1 - Pre-Program: Setup costs including site preparation, staff training, materials procurement, and administrative setup.
- Phase 2 - Operational: Ongoing intervention delivery costs captured through weekly tracking across four standardised categories: *Staff costs* (intervention delivery, session preparation, documentation, training, supervision, administration valued at actual wages or minimum wage equivalents for volunteers); *Operations* (facility access, utilities, maintenance, insurance, transportation, administrative overhead); *Materials* (session supplies, assessment instruments, equipment, technology, documentation); *In-kind contributions*

(volunteer time, donated materials, free venue access following standardised valuation approaches).

- Phase 3 - Post-Program: Program closeout, final documentation, and data synthesis costs.

Google Sheets-based templates enable standardised weekly cost tracking by site coordinators, with automated calculations and monthly aggregation. This pragmatic approach balances data quality with coordinator burden, consistent with recommendations for implementation cost studies in community settings.

3.3 Health Outcomes Integration

Clinical outcomes collected through the health assessment component include diverse indicators across mental, physical, and quality of life domains: *Mental health* (depression, anxiety, stress using validated psychometric instruments); *Physical health* (blood pressure, body mass index, cardiovascular and metabolic markers); *Quality of life* (standardised measures enabling QALY calculations for cost-utility analysis). Data collection aligns temporally with intervention sessions to enable cost-outcome linkage, following established methods for integrated clinical-economic evaluations (Drummond *et al.*, 2015). The breadth of outcomes reflects diverse health conditions addressed across experimental sites, including mental health disorders, cardiovascular conditions, metabolic disorders, and chronic disease prevention.

3.4 Analytical Framework

The framework enables four complementary economic evaluation approaches:

- Cost-Benefit Analysis (CBA): Monetisation of health benefits, net benefit calculation, and benefit- cost ratios.
- Cost-Effectiveness Analysis (CEA): Cost per unit of health outcome, incremental cost-effectiveness ratios (ICER) compared to standard care benchmarks.
- Cost-Utility Analysis (CUA): Cost per QALY gained, ICER compared to country-specific thresholds (€20,000-€80,000 per QALY in European contexts).
- Budget Impact Analysis (BIA): System-level cost implications and scale-up projections following ISPOR guidelines.

As data becomes available on a rolling basis, analyses will proceed from descriptive cost profiling to comparative cost-effectiveness assessments. The phased analytical approach accommodates site-specific implementation timelines while maintaining methodological rigour (Drummond *et al.*, 2015).

3.5 Comparative Design

The multi-site design enables systematic comparison across: geographic context (urban/rural), healthcare systems (five national contexts), delivery models (forests, parks, gardens, horticulture), session formats (individual, group, mixed), and target populations (age groups, health conditions, socioeconomic status). Statistical analyses will include descriptive statistics, subgroup analyses by delivery context and health condition, with

multivariate and sensitivity analyses conducted where sample sizes and data quality permit.

4. Concluding Remarks

The framework addresses critical gaps in NBI economic evaluation identified by recent scoping review (Busk & Sidenius, 2022) through two key methodological innovations: (i) integrating economic evaluation from study inception rather than retrospective analysis, and (ii) employing multi-site comparative design across diverse health conditions and healthcare contexts. This approach enables rigorous assessment of implementation variability essential for real-world healthcare decision-making, overcoming limitations of previous single-site evaluations.

Standardised protocols enable cross-context comparison across five national healthcare systems, multiple delivery models (forests, parks, gardens, horticulture), and diverse health conditions (mental health, cardiovascular, metabolic disorders). Integration with clinical health assessment ensures matched cost-outcome data collection, strengthening economic analyses. The pragmatic approach balances methodological rigour with practical feasibility across diverse international sites. The framework will generate multiple evidence types required for healthcare adoption decisions: cost profiles by delivery model and health condition, cost-effectiveness evidence compared to standard care, implementation efficiency benchmarks, and financial sustainability indicators. Results will provide economic evidence for policymakers and healthcare planners considering NBI integration, directly testing the cost-effectiveness dimension central to NBI implementation at a wider scale.

Several limitations warrant acknowledgement. Ethics restrictions preventing healthcare utilisation data collection limit ability to capture offset costs from reduced conventional care use, addressed through literature-based comparisons and scenario analyses. Volunteer time valuation employs conservative minimum wage approaches providing lower-bound cost estimates. Cross-country economic contexts are managed through country-stratified analyses and purchasing power parity adjustments. Timeline constraints are accommodated through phased analytical approaches, with site-specific analyses conducted on a rolling basis as data becomes available.

This standardised methodology provides a replicable model adaptable to other NBI modalities and settings, supporting evidence generation across the broader field. By systematically collecting implementation cost data across 15 diverse sites and integrating with rigorous clinical outcome assessment, the framework generates economic evidence to inform healthcare decision-making and policy development. Results will contribute to translating NBI clinical evidence into sustainable healthcare practice and advancing NBI health economics as an emerging methodological sub- discipline.

Acknowledgements

The NATURELAB project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No.101083857 and was co-funded by the UK Research and Innovation Grant Award No. 10067111.

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STEPPING INTO THE SYSTEM: AN EMBODIED 4D MAPPING WORKSHOP WITH THE GARDENS OF BRASA CASE

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ABSTRACT

The workshop introduces 4D Mapping, an embodied practice from Social Presencing Theater, as a method to support complex, transdisciplinary collaboration. While such collaborations aim to integrate diverse forms of knowledge, engaging the body remains challenging. Using the NATURELAB project in Amsterdam's Gardens of Brasa as a case, participants will explore how 4D Mapping can reveal hidden dynamics within systems and offer new insights into collective transformation.

Keywords: Social Presencing Theatre; embodied learning; awareness-based systems change; transdisciplinary collaborations; NATURELAB

1. Introduction

Transdisciplinary collaborations have become increasingly widespread in response to the complex, interconnected challenges that our global society is currently facing, which require integrated knowledge and inclusive, context-sensitive solutions (Klein, 2001). These collaborations are generally grounded in the belief that addressing today's societal challenges demands the integration of diverse methodologies, knowledge systems, and perspectives and therefore include not only contributions from multiple academic disciplines in the research process, but also the lived experiences and insights of practitioners and citizens (Regeer *et al.*, 2024). Whilst transdisciplinary collaborations aspire to move beyond purely analytical approaches by embracing diverse forms of knowledge, including embodied, sensory, and experiential ways of knowing, it remains challenging to explicitly engage bodily knowledge in practice. Social Presencing Theater (SPT) offers a way to do so. This method can be used for groups seeking deeper insights into systems awareness by working with complex societal cases.

2. Theoretical background

Social Presencing Theatre (SPT) is an arts-based change method developed by Otto Scharmer and Arawana Hayashi. Scharmer, author of Theory U, developed a framework and methodology for social transformation. He states that there is a disconnect between "head and hand," which stems from a lack of awareness of the internal source from which our attention and intention arise. Theory U offers a framework for deep innovation and systemic transformation by guiding participants through a shift from habitual, past-driven reactions towards heightened awareness of the present, and finally to actions informed by the emerging future. The process unfolds across five core phases: (1) Co-Initiating, which involves cultivating shared intention and deep listening; (2) Co-Sensing, where participants observe the system from multiple vantage points; (3) Presencing, a pivotal stage of connecting with deeper sources of knowing at the "bottom" of the U; (4) Co-Creating, where emerging insights are prototyped; and (5) Co-Evolving, in which new practices and ideas are integrated into the broader system (Scharmer, 2016) (see Figure 1). The U process enables individuals and groups to become aware of their inner attention and intention, reconnect with their authentic selves, and tap into deeper levels of insight and creativity. Traditional systems change often fails by merely rearranging parts of a flawed system without altering its underlying paradigm. In contrast, Scharmer's awareness-based systems approach aims to shift the very foundation of human collaboration by transforming consciousness at both individual and collective levels.

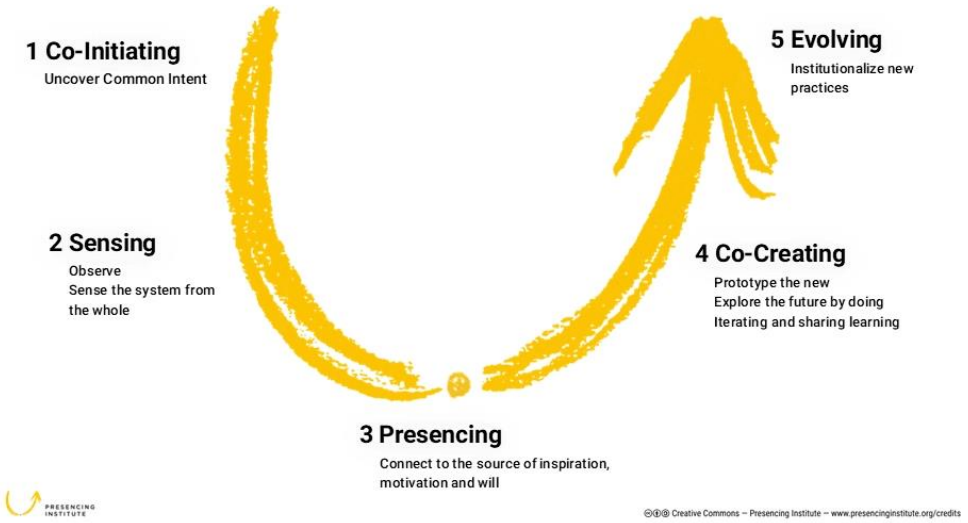

Figure 1: The five main phases of Theory U (https://www.presencing.org/theoryu)

PT is an embodied awareness-based approach which aims to bridge the disconnect between head and hand by making social dynamics and relationships visible through embodiment and movement (Hayashi, 2021). The name reflects the practice's essence: 'Social' highlights group-based, embodied experiences; 'Presencing' (coined by Scharmer) blends 'presence' and 'sensing' to describe connecting with one's highest future potential (Scharmer, 2016). 'Theatre', from the Greek *theatron* ("a place for viewing"), signifies making inner experiences visible and shared (Scharmer, as cited in Hayashi, 2021, pp. XV–XVI). SPT is "a way to perceive and experience our potential to co-create healthy teams, organisations, and communities", since it creates a space where deeper awareness of individual and collective dynamics can unfold (Hayashi, 2025, pp. 14–15). Therefore, SPT is a particularly powerful method when working in a complex, transdisciplinary collaboration since it makes the current reality in this collaboration visible. As such, it enriches the already present quadruple helix of knowledge available in most transdisciplinary collaborations with embodied knowledge. Through embodied group practices, participants literally embody the system, thereby making hidden dynamics visible and felt. This deepens understanding beyond intellect. SPT is primarily non-verbal and practised through stillness. Also, it is without goal orientation (Hayashi, 2021). Letting go of any preconceived, merely cognitive ideas allows for what wants to emerge.

3. The workshop: 4D Mapping with The Gardens of Brasa in Amsterdam

SPT consists of a set of nine embodied practices[5], one of which is 4D Mapping. This is a social embodiment practice that allows a group to make visible the current reality of a system – not just through mental models or data, but through lived, felt experience. Participants step into roles (ranging from stakeholders to abstract elements like fear or climate change) not to act them out, but to sense, through bodily awareness, what it's like to be that part of the system. This deepens understanding by linking personal embodiment with system-wide perspectives, a key feature of SPT. Unlike traditional system analysis, 4D Mapping introduces a human, intuitive dimension, helping participants sense pathways for transformation. As Jung and Hayashi (2025) note, it "enables transformative shifts in understanding and action by integrating analytical, rational, and intuitive ways of knowing" (p. 39). This method is especially useful when there is a desire to see the system differently, or when there is a wish to engage stakeholders at a deeper, more intuitive level (particularly if typical dialogue has hit a wall). 4D Mapping aims to reveal systemic shifts between so-called Sculpture 1 (current reality) and Sculpture 2 (emerging future) (Jung & Hayashi, 2025). Below, we outline the 4D Mapping process (see Figure 2).

3.1 Introduction to Theory U and SPT (15 min.)

The workshop starts with a brief introduction to Theory U, SPT, and 4D Mapping. The focus of this workshop is on embodiment instead of cognitive-driven discussion and the potential effect on systems change following the theory of Theory U, Systems Awareness, and Presencing (doing less of the same). The different roles will be outlined, so those of

[5] The other practices are: 20-Minute Dance, Dance of Fives, Village, Duets, Field Dance, Stuck, Seed and Case Clinic (for more information, see Hayashi, 2021).

the facilitators, the case givers, the participants who want to embody a role, and those who will witness the 4D Mapping. The introduction will conclude with a brief somatic warm-up to help participants become more present in their bodies.

3.2 Co-Initiating (5 min.)

The case givers (NATURELAB The Gardens of Brasa) will introduce their case, the stakeholders, their key challenges, and the main question they would like to explore with this 4D Mapping.

3.3 Co-Sensing (40 min.)

After the introduction of the case, the facilitators will call out the different stakeholders, and participants can volunteer to embody one of the stakeholder roles if they feel invited to do so. Rather than just stepping into the field or space through cognitive reflection, participants are invited to explore their role through embodied experience by sensing their place, level, and direction within the system, in silence. Once in the shape, the player says one sentence from the experience of that shape, in the first-person "I" voice. Once all roles are divided and all players have found their place, the resulting configuration constitutes Sculpture 1, representing the current reality of the system (Jung & Hayashi, 2025). Sculpture 1 makes visible both restrictive forces (blind spots, marginalisation patterns) and enabling forces (e.g. leverage points).

3.4 Presencing & Crystallising (30 min.)

After a pause, players are invited to transition into movement and slowly start to move from Sculpture 1 to Sculpture 2. The transition process between these sculptures aims to help identify enabling conditions and crucial shifts or movements necessary for the system to evolve. The resulting configuration, Sculpture 2 is also referred to as the emerging future of the system, as it explores possible next steps in the system's evolution. From Sculpture 2, each player says the name of their role and one sentence about their experience. The facilitator can invite people from the circle to also offer one sentence.

3.5 Generative Dialogue (30 min.)

The players are asked to step out of their role. Then, in smaller groups, all participants are asked to reflect on what they experienced with the provided reflection questions. After some time in the subgroups, everyone shares in plenary about their experiences and observations, thereby adding to the collective sense-making process.

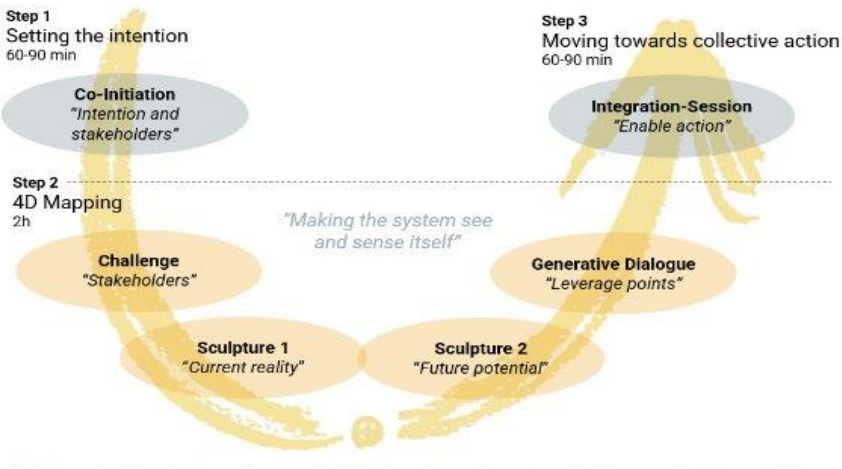

Figure 2: 4D Mapping Process, adapted from Jung & Hayashi (2025)

4. NATURELAB case study: The Gardens of Brasa in Amsterdam

The case giver of the workshop is NATURELAB: The Gardens of Brasa in Amsterdam. They offer nature-based therapeutic programmes with the aim to create more accessible, socially acceptable, and culturally sensitive form of mental health support in the "Gardens of Brasa", a community garden in Amsterdam South-East. The surrounding neighbourhood is multi-ethnic and socioeconomically disadvantaged, with psychological issues, such as stress, anxiety, depression, and loneliness, up to 50% higher than the national average (https://buurtatlas.vzinfo.nl/#ervaren_gezondheid). Despite this need, people with low socioeconomic status, migration backgrounds, or low health literacy often underutilise mental health interventions. Barriers include daily stressors, time constraints, language and cultural mismatches, and issues of affordability and accessibility.

While NATURELAB aims to improve health through accessible, culturally sensitive programmes, there is concern that these barriers may still prevent participation. To get more understanding and deeper insights into the different dynamics at play in this transdisciplinary project, the NATURELAB Gardens of Brasa will do a 4D Mapping with the following question:

> *How can we ensure that local residents of the Gardens of Brasa engage with NATURELAB's nature-based therapeutic programmes, both during the trial and in future scale-up, without encountering the same systemic and practical barriers?*

During this 2-hour workshop, we aim to: (1) explore the NATURELAB case in ways that uncover new insights into this local system, and (2) offer participants a deeper understanding of the transformative potential of 4D Mapping. We expect that by 'stepping into the system', all participants (those who are stepping into roles, but also those who witness the 4D Mapping) will experience something new. By (trying to) letting

go of our analytical mind and reconnecting with our bodies, this workshop will invite participants to pause and make space for stillness and embodied knowledge. Apart from yielding new insights into the Gardens of Brasa case, this workshop will offer new, fresh, and unexpected insights to all participants.

Acknowledgements

This project has been funded by the CTL SoTL fund 2024/2025 of the Vrije Universiteit Amsterdam, granted for the project 'The BODY Matters: Embodied learning as transformative pedagogy'.

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