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.

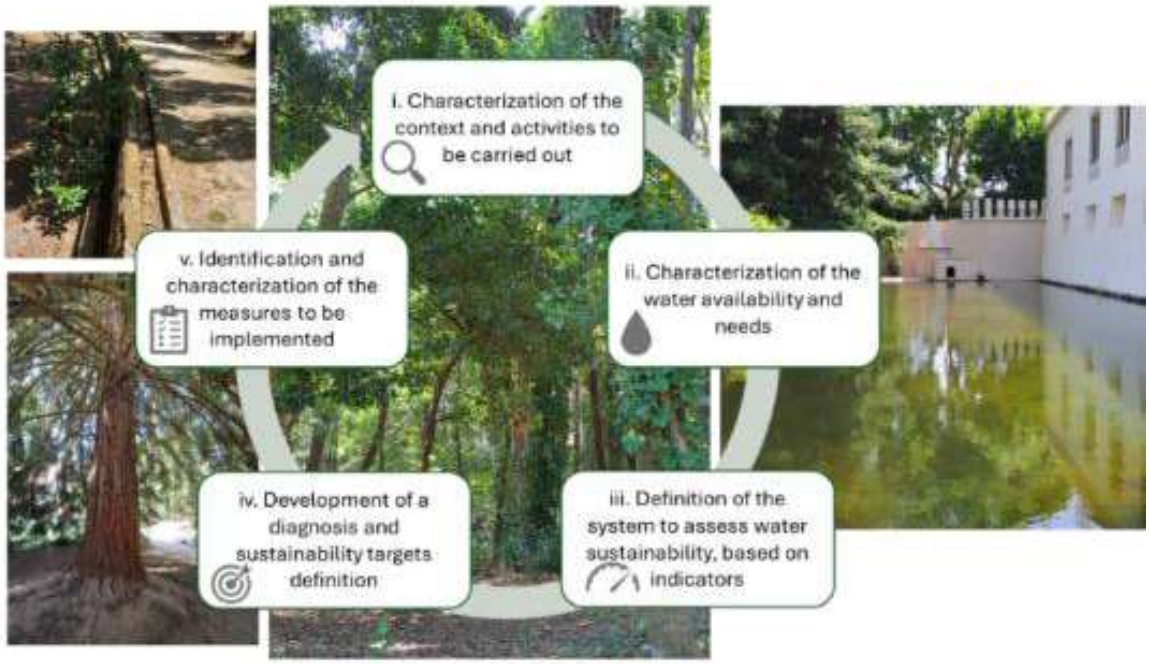


Figure 1. Approach for sustainable water usage and management of the urban natural spaces to be used for NBT.

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.

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