Impact of Nature-Based Solutions: A Summary

Genoa

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About UNaLab

The UNaLab project is contributing to the development of smarter, more inclusive, more resilient and more sustainable urban communities through the implementation of nature-based solutions (NBS) co-created with and for local stakeholders and citizens. Each of the UNaLab project's three Front-Runner Cities – Eindhoven (NL), Genova (IT) and Tampere (FI) – has a strong commitment to smart, citizen-driven solutions for sustainable urban development. The establishment of Urban Living Lab (ULL) innovation spaces in Eindhoven, Genova and Tampere supports on-going co-creation, demonstration, experimentation and evaluation of a range of different NBS targeting climate change mitigation and adaptation along with the sustainable management of water resources. The Front-Runner Cities actively promote knowledge- and capacity-building in the use of NBS to enhance urban climate and water resilience within a network of committed partner cities, including seven Follower Cities – Stavanger, Prague, Castellón, Cannes, Başakşehir, Hong Kong and Buenos Aires – and the Observers, Guangzhou and the Brazilian Network of Smart Cities. Collaborative knowledge production among this wide network of cities enables UNaLab project results to reflect diverse urban socio-economic realities, along with differences in the size and density of urban populations, local ecosystem characteristics and climate conditions. Evidence of NBS effectiveness to combat the negative impacts of climate change and urbanisation will be captured through a comprehensive monitoring and impact assessment framework. Further replication and up-scaling of NBS is supported by development of an ULL model and associated tools tailored to the co-creation of NBS to address climate- and water-related challenges, a range of applicable business and financing models, as well as governance-related structures and processes to support NBS uptake. The results of the project will be a robust evidence base and go-to-market environment for innovative, replicable, and locally-attuned NBS.

Partners

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1. NATURE-BASED SOLUTIONS FOR URBAN CHALLENGES

Nature-based solutions (NBS) have emerged as an umbrella concept that encompass and build upon previous concepts that aimed at actions for enhancing climate change adaptation (CCA) and disaster risk reduction (DRR). These concepts include but are not limited to Ecosystem-based Adaptation (EbA), low-impact development (LID) and sustainable urban drainage systems (SUDS), ecological engineering, green infrastructure and ecosystem services. The distinguishing feature of NBS is simultaneously providing economic, social and environmental benefits and co-benefits. Many definitions of the NBS concept have been developed over the years, including those by IUCN and European Commission and the latest definition by the UN.

> *"... actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits." - Fifth Session of the United Nations Environment Assembly (UNEA-5)*

The lifecycle of an NBS project comprises six equally important steps or phases (Figure 1). The lifecycle begins with a framework identification phase, which will be adopted first in the project, and which will drive the implementation of the next actions. The following phases of identifying the relevant NBS given the identified urban pressures and challenges and the key performance indicators (KPIs), and developing a monitoring scheme to capture the change from the baseline conditions – are crucial for evaluating the NBS performance and impact. Once the monitoring scheme is defined and monitoring equipment is tendered, a prolonged period of NBS monitoring begins. The monitoring outputs are continuously reviewed to assess NBS performance and impact, and to ensure the soundness of the equipment and the methods of data acquisition. Ideally, NBS monitoring should span several years for critical evaluation of NBS performance and impact to support future development proposals. Several phases of the NBS project lifecycle directly contribute to the NBS Knowledge Base, which can be perceived as a collection of good practices regarding NBS implementation across the EU Member States.

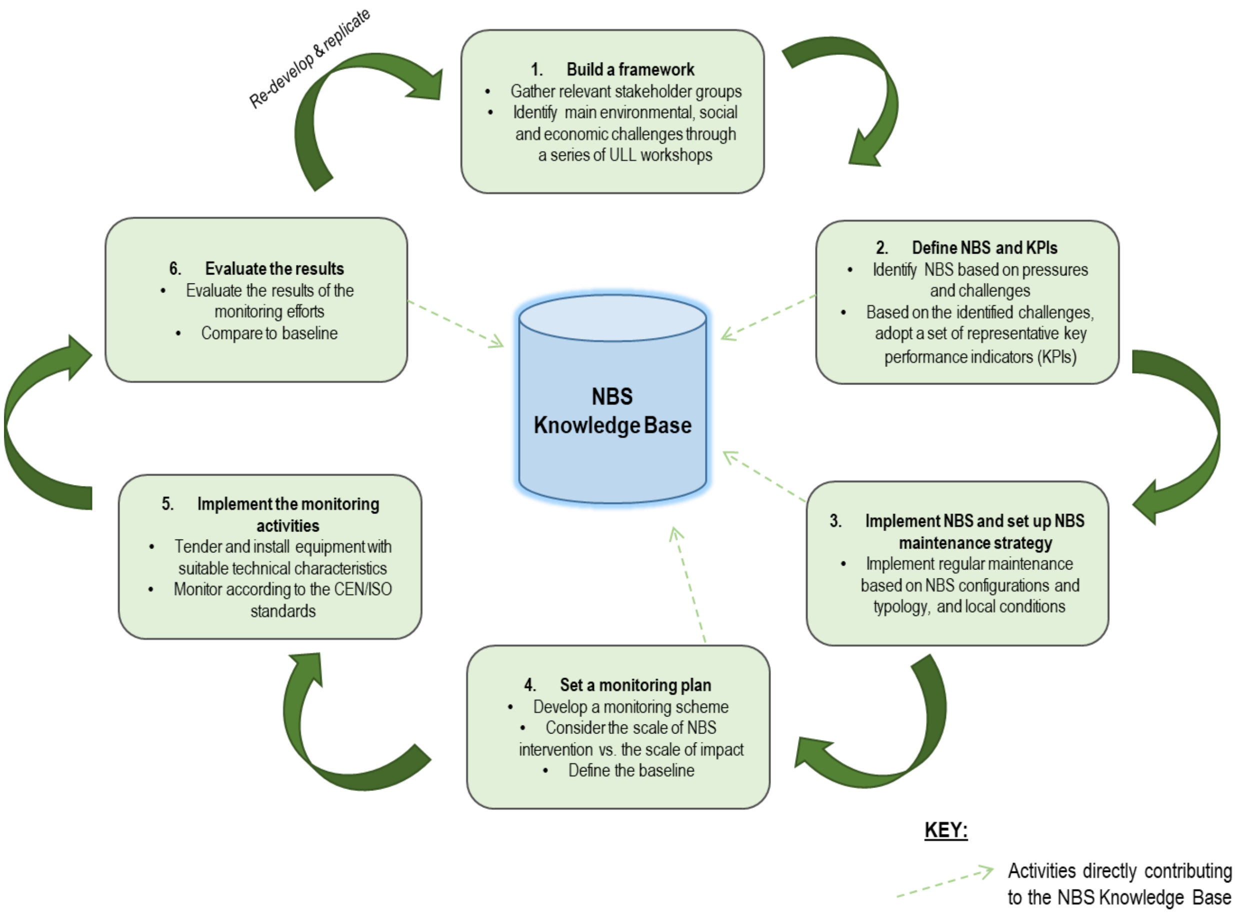


Figure 1. Lifecycle of an NBS project.

This publication presents a high-level summary of the highly detailed *Impacts of NBS Demonstrations*. The report aims to provide the key messages and outcomes of the NBS monitoring process and impact assessment produced within the UNaLab project for each of the UNaLab front-runner city. This report provides only the key messages – for an extensive evaluation the reader is referred to the complete *Impacts of NBS Demonstrations* publication (Roebeling et al., 2023).

The knowledge, data and its evaluation and resources developed throughout the UNaLab project aim to serve as a reference for the NBS practitioners and other involved parties in developing, executing and evaluating the NBS projects in different socio-economic and climatic contexts. The list at the end of this report provides references for further reading.

2. NATURE-BASED SOLUTIONS CO-MONITORING AND IMPACT ASSESSMENT

In times of rapid urbanization and anthropogenic climate change, urban areas face an increasing number of extreme weather events and other environmental burdens such as water and air pollution. NBS are associated with distinct impacts on ecosystem services and improvement of a range of environmental aspects hindered by urban growth. However, a selection of NBS to address the identified challenges and pressures should demonstrate its impact and indicate whether the anticipated outcomes are achieved, including monetary and environmental targets, to consolidate the future investments into wider NBS implementation. Monitoring is one of the central factors determining the success of the NBS impact assessment as it provides quantitative and qualitative evidence of the impact generated by the NBS interventions.

The UNaLab tools that complement the co-developed holistic framework for nature-based solution (NBS) initiation in front-runner cities (FRC) follow the Plan-Do-Check-Act (PDCA) adaptive management cycle (see Dubovik et al., 2020). Monitoring and impact assessment of NBS forms part of the PDCA-cycle (Check), and aims to provide quantitative and qualitative evidence of the impact generated by NBS.

Monitoring and impact assessment of NBS comprises several steps that are equally important for the development of a holistic monitoring and impact assessment strategy (Figure 2). Once the NBS have been (co-) defined (Plan; Do), these steps include the identification the representative key performance indicators and establishment of the baseline – thereby accounting for the scale of impact which will dictate the scale of monitoring. In turn, the data acquisition mode needs to be defined such that it allows to capture the impact in terms of its temporal and spatial resolution, and granularity. Finally, the evaluation framework determines the thresholds and the overall evaluation scheme of the NBS performance and impact.

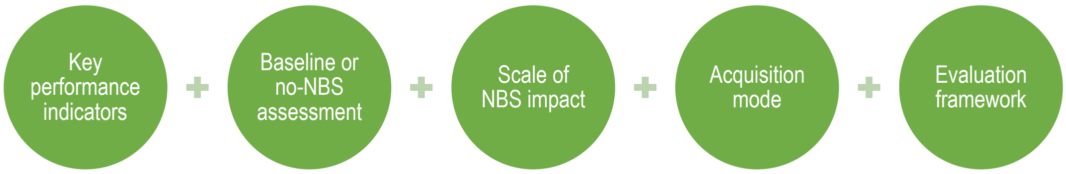


Figure 2. *UNaLab monitoring and impact assessment strategy (source: Dubovik et al., 2020).*

Co-definition of **NBS performance and impact indicators** can be viewed as an intermediate step between setting the goals and targets and formulating a sound plan for NBS monitoring (Figure 3). The first and foremost requirement for the NBS performance and impact indicators is to reflect the targets and objectives set in the beginning of NBS co-creation process. In co-identifying indicators with stakeholders, it may be beneficial to limit the number of indicators by assembling a local expert group (familiar with the local challenges) who will recommend a narrowed list to further the discussion.

There are numerous NBS performance and impact indicators, and selecting them can be challenging for an inexperienced person. The Task Force 2 handbook *Evaluating the Impact of Nature-based Solutions: A Handbook for Practitioners* (Dumitru & Wendling, 2021a) and its *Appendix of Methods* (Dumitru & Wendling, 2021b) alone collects more than 400 recommended and additional indicators over 12 key societal challenge areas:

1. Climate Resilience
2. Water Management
3. Natural and Climate Hazards

4. Green Space Management
5. Biodiversity Enhancement
6. Air Quality
7. Place Regeneration
8. Knowledge and Social Capacity Building for Sustainable Urban Transformation
9. Participatory Planning and Governance
10. Social Justice and Social Cohesion
11. Health and Wellbeing
12. New Economic Opportunities and Green Jobs

Indicators of NBS performance and impact should be selected to reflect both primary benefits as well as any associated co-benefits.

It is equally important to **establish baseline** – a pre- or no-NBS situation for understanding the reference conditions and quantifying the actual impact or change in indicators with-NBS. Baseline measurements either occur prior to NBS implementation (pre-NBS) and/or occur in a similar reference area without NBS (no-NBS). In addition, baseline data can be derived from spatial and non-spatial historical and statistical data. Modelling can also be used to derive reference (baseline) conditions.

On data outputs

Granularity is different from *accuracy*, the degree of correctness of the outputs with respect to the true value, and from *precision*, the accuracy when the observations are repeated.

Instead, *resolution* is a specification of *granularity*, and it indicates the size of the minimum unit/area in a data output (e.g., spatial data).

Once the monitoring scheme is defined and set, establishing the **appropriate data acquisition** means will ensure careful data collection at relevant scales. A number of data acquisition options exist that could be employed for NBS performance and impact monitoring. Means of measurement refers to whether data is obtained through in-situ observations, statistical and legacy data, remote sensing and earth observations, citizen science initiatives and/or modelling. Finally, data collection equipment needs to be selected based on precision, accuracy, resolution, detection limits, sampling frequency, sensitivity, units of measurement, data transmission or retrieval, device unit cost, device calibration, device maintenance schedule, device lifetime and operational environment.

On monitoring scales

The choice of scale and resolution/granularity is subjective and is typically informed by prior experience, but they should not be selected arbitrarily or haphazardly. Careful considerations for the suitability of scales and their interactions will produce the most reliable outcomes.

Considerations of the **scale of NBS monitoring** and the **frequency** of recorded data are of outmost importance requiring an understanding of the spatial and temporal impact of NBS at which the impact can be measured. Given the multiple ecosystem functions, services and values provided by NBS, multiple spatial and temporal scales need to be defined in accordance with the selected indicators. Multiple monitoring data can be combined to yield information on a broader scale and, alternatively, modelling data can provide approximations and projections for a larger scale or various NBS.

NBS are essential elements in some of the **major European and global policies and strategies** that shape and direct the actions at building the structural, environmental and social resilience. European policies and the current development agenda generally support the implementation and uptake of NBS, and some directly mention NBS as means for achieving certain goals. International policies may not directly mention NBS but they all focus on CCA and DRR which is inherent to all NBS activities.

NBS **impact assessment framework** is the essential step when targets and objectives are evaluated against the measured performance during the NBS monitoring stages (Figure 3). Impact assessment identifies causalities and aids in determining the supporting or additional interventions necessary for achieving the goals. This makes the NBS implementation process cyclical enabling the adaptive management cycle of every NBS project.

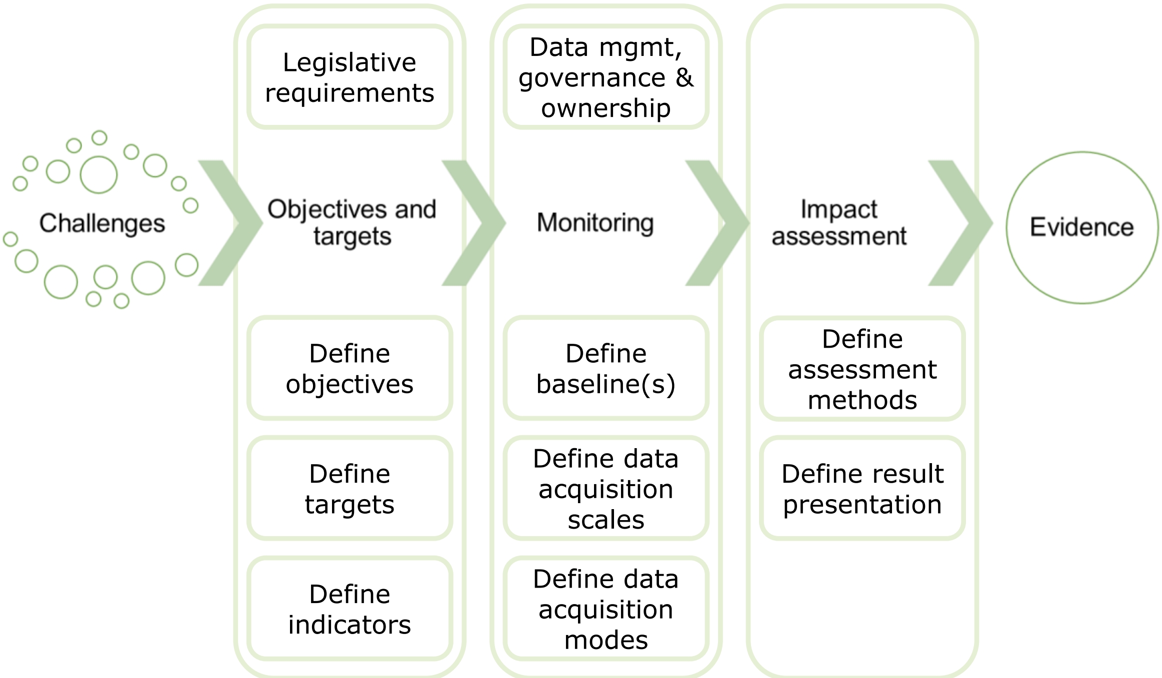


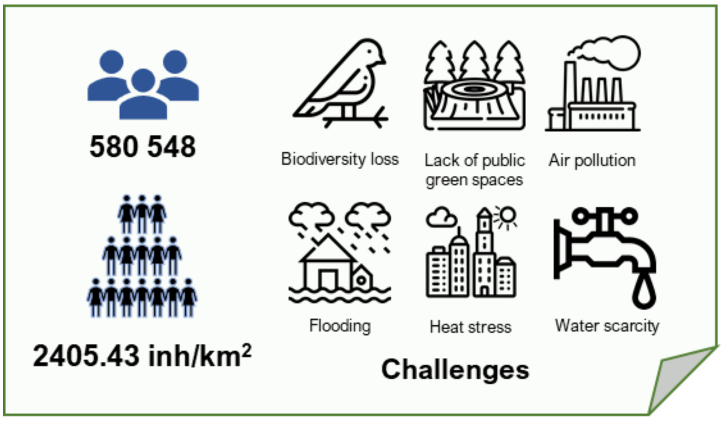
Figure 3. Framework for co-definition of NBS performance and impact indicators and assessment protocols (based on Dubovik et al., 2020).

The UNaLab project used a highly participatory approach to produce evidence of NBS impact, including co-creation, co-development, and co-monitoring activities. In the NBS impact assessment process in the UNaLab front-runner cities first involved co-definition of NBS performance and impact indicators in an interactive way with a wide range of local stakeholders. After co-definition of indicators, the UNaLab front-runner cities iteratively co-developed the monitoring and evaluation strategies together with project partners and other technical experts to assess NBS performance and associated impacts in a cost-effective way.

The UNaLab approach to co-development of the monitoring strategy relied on a diverse group of participants, in terms of cultural and educational background and needs. Deep stakeholder engagement was important for identifying the local challenges and monitoring and evaluation needs and capabilities. The selection of suitable performance and impact indicators and identification of the monitoring needs were facilitated through engagement of a wide range of experts during NBS monitoring and impact assessment planning.

NBS impact assessment in UNaLab was facilitated by the development of an ICT platform and other NBS monitoring and evaluation tools developed by UNaLab project partners. Automated collection of NBS monitoring data from IoT sensors complemented by manual entries supports long-term NBS monitoring and impact evaluation.

3. IMPACT OF NATURE-BASED SOLUTIONS IN GENOA



The City of Genova (44°24′40″N 8°55′58″E) is located in the northern Italy. Genova has historically been one of the most important ports in the Mediterranean region and its port is currently the busiest in the Mediterranean Sea. The city experiences acute densification and lack of public green spaces, making urban heat stress a pronounced challenge. Air pollution and biodiversity loss are among the other challenges Genova targeted to address through NBS implementation.

The NBS in Genova primarily target urban heat island effect, flooding and droughts, air pollution and biodiversity. The distinguishing feature of NBS in Genova is their combination in a multifunctional public green space. Here, NBS are combined with other supporting measures to deliver benefits and co-benefits, such as enhanced biodiversity and drought resilience via reclamation of rainwater for irrigation purposes (Figure 4).

Gavoglio park

1. Gavloglio park as a single entity
2. Draining pavements
3. Sand playground
4. Rain garden
5. Infiltration basin
6. Bioswale
7. Tree groups and green areas
8. Drought-resilient orchard and meadows
9. Slope afforestation
10. Green wall
11. Natural engineering for slope securing
12. Gabions
13. Underground water retention basin

Figure 4. NBS demonstrations in Genoa.

Air quality

Air quality data have been continuously collected during the period between June 2021 and September 2022 (Gavoglio area) and July 2021 to September 2022 (Via Napoli area). The measurements included nitrogen dioxide (NO_2), ozone (O_3), particulate matter ($PM_{2.5}$ and PM_{10}), temperature, relative humidity and precipitation.

The relevant difference between the time series of the two sites, the ratio between "inside" (Via Napoli) and "outside" (Gavoglio) monthly averages of each pollutant and meteorological parameter has been calculated (Figure 5). The concentration level of the two gaseous pollutants (NO_2 and O_3) in Via Napoli seems to be significantly (1.5 to 3 times) greater than the one recorded in Gavoglio during the whole data acquisition period, with a peak in November-December 2021. Particulate matter and gaseous components were the main difference between the sites due to specific local sources that could be active in the very proximity of the sensor units (e.g., road works in progress).

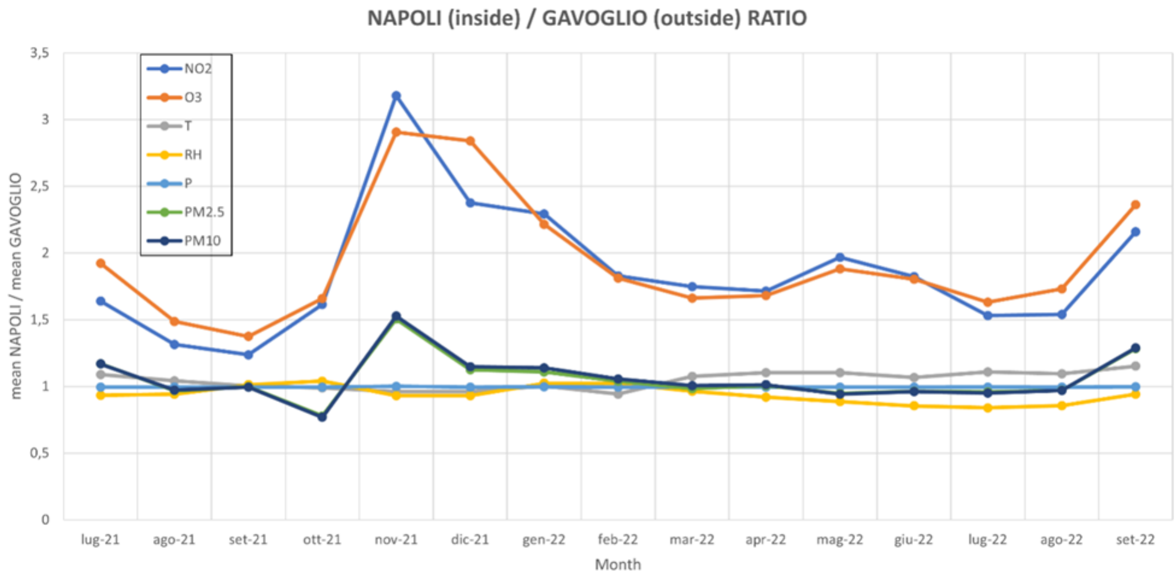


Figure 5. Monthly average ratios of air pollutants. The plot represents the monthly trend of the ratios between outside (Via Napoli) and intside (Gavoglio) average values for each measured parameter.

The overall picture shows concentration values well below the limits fixed by the European Directive for Air Quality (Directive 2008/50/EC) for O_3, NO_2 and PM_{10} while $PM_{2.5}$ concentration values approach the prescribed limit. Further investigations performed by reference instrumentation should/could clarify this particular issue.

Biodiversity

The biodiversity assessment and the evaluation of the diversity of species (Figure 6) in Genoa has been undertaken as a preliminary investigation that will serve as a baseline for future biodiversity monitoring in Gavoglio area.

Figure 6. Diversity of species per Shannon Diversity Index. NBS assessed are: 1. Rain garden, 2. Bioswale, 3. Tree groups and green areas, 4. Drought-resilient orchard and meadows, 5. Slope afforestation, 6. Green wall and 7. Natural engineering for slope securing

Green space accessibility and distribution

The effects of NBS on green space accessibility were neutral to positive indicating no change in proportion of residents with 0 m and 300-400 m distance from the public green space and +0.3% change for residents living within 100-200 m. Results from Genova show no to slight improvements, respectively, on account of the already extensive existence of green spaces prior to NBS implementation. Public green space distribution after the NBS implementation shows small increases (<1%), however it should be noted that these numbers depend on the initial existing green space, as well as the type and magnitude of NBS implemented.

Land and property value

The study in Genoa aimed to assess the effects in the market value of buildings that interact with an urban park that interacted with the Urban Park pilot project at the site of the former Gavoglio Barracks, in terms of use/distance and direct view on green spaces and the NBS. The acquisition of data was based on a questionnaire addressed primarily to Genoa real estate agencies in the Oregina-Lagaccio area and neighbouring districts (San Teodoro, Centro Storico and Sampierdarena) to identify the parameters of evaluation of a property and the expected increase in real estate values. In total, 65 questionnaires were filled (of which 33 were lacking some answers).

Figure 7 illustrates that both proximity of green areas and view to green areas can potentially increase the value of properties, as the percentages of estimated value increases were mostly 1-25%.

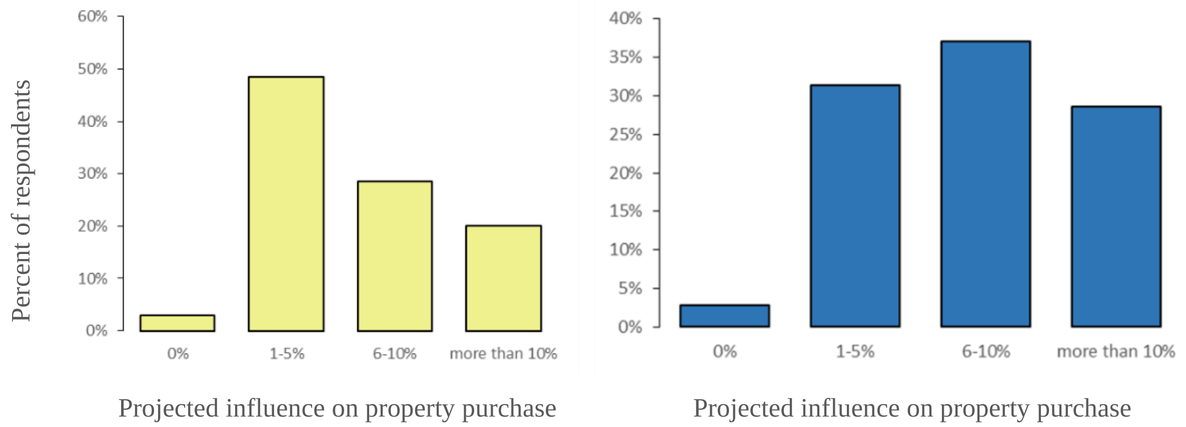


Figure 7. Influences of a proximity of a green area (left, 35 responses) and a view to a green area (right, 35 responses) on the purchase/rental demands of a property.

A view on green space entails an increase in the value of a property of between 1% and 5% for 35% of agents and of between 6% and 10% for 32%; also significant is the percentage of those indicating an increase of more than 10% (24% of respondents) (Figure 8). Therefore, compared with proximity alone, direct view on a green area, whether public or private, accessible or not, entails for most of the respondents an increase of up to 10%. The balanced distribution of the responses in the two main brackets (1-5% and 6-10%) is probably explained by the different qualitative features that the green area possesses, reflected in the different contributions to a property's value.

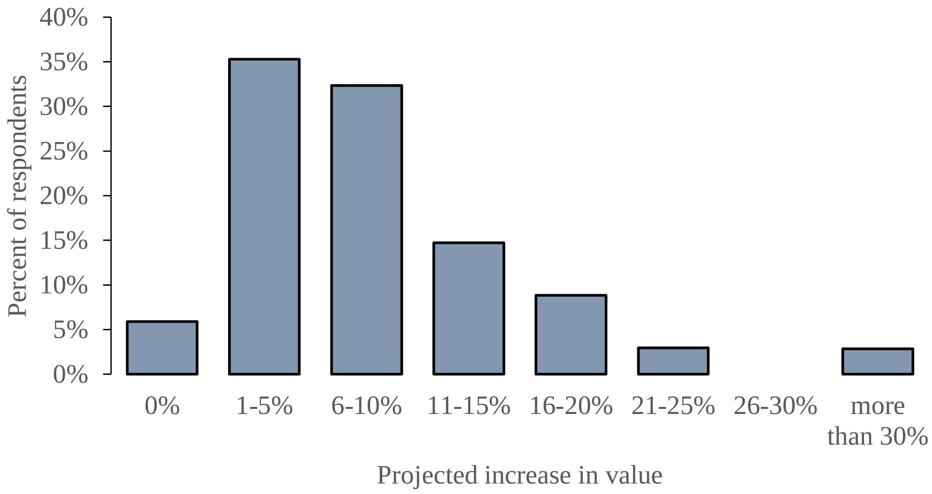


Figure 8. Increase in value due to property's view on a green area (35 respondents out of 65 questionnaire recipients).

The agents indicate that the new Gavoglio Urban Park could entail an increase in values for residential properties: the largest number of respondents (55%) quantifies this increase as between 6% and 10%, 24% of respondents between 11% and 20 % and the remaining 21% between 1% and 5%. None of the respondents indicate that there will be no increase (Figure 9). Based on the question's results, it is expected that the new Gavoglio Park will increase the quality of the urban context and, consequently, the demand for properties both for purchase and for rental: 58% of respondents quantify this increase as between 1% and 5%, 21% between 6% and 10% and the remaining 21% between 11% and 20%

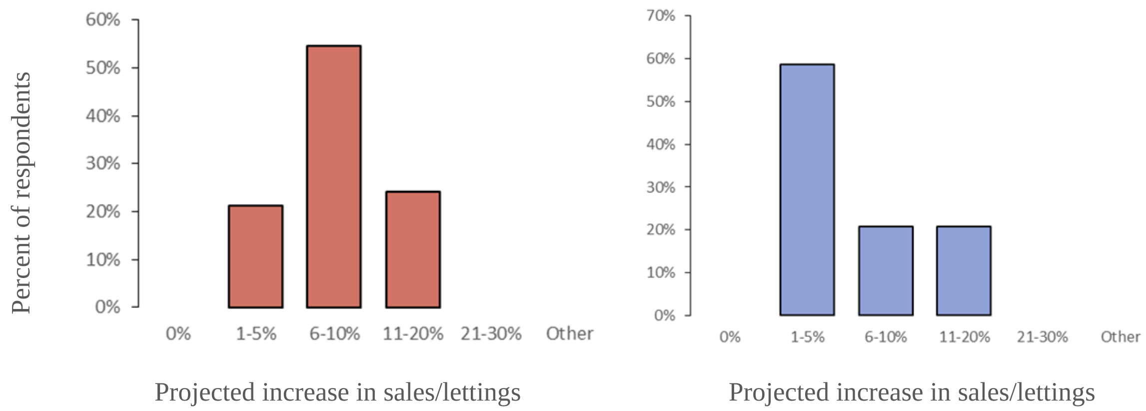


Figure 9. As a consequence of the renovation of the Gavoglio Park, expected increase in values of residential properties (left, 33 responses) and expected increase in the number of sales/lettings of residential properties (right, 29 responses).

4. CONCLUSIONS

Synthesis of the measured and potential performance and impacts of NBS in UNaLab front-runner cities shows that NBS have the capacity to simultaneously address several societal challenges, depending on their geographical location as well as type, size and location of implementation. In particular, they have a noteworthy positive impact on green space management; a small positive impact on climate resilience, natural and climate hazards (flooding), biodiversity enhancement, air quality, and new economic opportunities and green jobs; and an indecisive impact on water quality management and place regeneration.

In Genoa, NBS monitoring and impact assessment has been undertaken to establish a baseline for future NBS impact assessment activities in the Gavoglio area, including air quality, biodiversity and land and property values.

Based on the experiences and outcomes of NBS implementation and monitoring in the UNaLab FRCs, it was possible to draw some joint conclusions summarised in Laikari et al. (2021). The three UNaLab FRCs supported the fact that frequent monitoring is an essential element of NBS implementation, future planning and replication, and concluded that it also aids in identifying and detecting issues related to NBS functioning and supports in solving them. In addition, monitoring is a cross-cutting topic and the division of responsibilities for NBS monitoring should be clearly emphasised already during the planning stages. Finally, the planning stage should include the definition of the data management strategy, data governance, and ownership of data between municipal units generated throughout NBS monitoring.

5. FURTHER READING AND RESOURCES

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