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Project impact and take home message (best-practices): an executive summary for stakeholders

Deliverable 4.10

Work package: 4

Dissemination level: PU

Lead partner: CNR

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Due date: 30/11/2023

Submission date: 29/11/2023

Deliverable	**Project impact and take-home message (best-practices): an executive summary for stakeholders**
Deliverable No.	4.10
Work Package	4
Dissemination Level	PU
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Date	28/11/2023
File Name	D4.10_Project impact and take-home message_CNR_2023-11-28
Status	
Revision	
Reviewed by (if applicable)	Axel Timpe, RTWH; Vasileios Latinos, ICLEI.
Information to be used for citations of this report	Baldacchini, C., Calfapietra, C. (2023): Project impact and take-home message (best-practices): an executive summary for stakeholders, Deliverable No.4.10, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 19 pp.

This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement no. 776528.

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This work was financially supported by the National Key Research and Development Programme of China (2017YFE0119000).

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1	Rheinisch-Westfaelische Technische Hochschule Aachen	RWTH	Germany
2	Stadt Dortmund	DORTMUND	Germany
3	Comune di Torino	COTO	Italy
4	Grad Zagreb	ZAGREB	Croatia
20	Fundacion Privada Instituto de Salud Global Barcelona	ISGLOBAL	Spain
21	Università degli Studi di Torino	UNITO	Italy
22	Consiglio Nazionale delle Ricerche	CNR	Italy
24	Università degli Studi di Bari Aldo Moro	UNIBA	Italy
25	Fachhochschule Suedwestfalen	SWUAS	Germany
33	The Forestry Bureau of Ningbo City (FBNC), City	FBNC	China (People's Republic of)
34	Institute of Urban Environment, Chinese Academy of Sciences	IUE-CAS	China (People's Republic of)

Abbreviations

Dx.x:	deliverable
EC:	European Commission
EU:	European Union
FRC:	Front-Runner City
GIS:	geographic information system
GQ:	general questionnaire
KPI:	key performance indicator
LL:	Living Lab
NBS:	nature-based solutions
NDVI:	Normalized Difference Vegetation Index
PPP:	public-private-partnership
proGIreg:	productive Green Infrastructure for post-industrial urban regeneration
UNEA:	United Nation Environmental Assembly
WP:	work package

Executive Summary

The project entitled “productive Green Infrastructure for post-industrial urban regeneration (proGIreg)” implemented eight different types of nature-based solutions (NBS) in post-industrial sites of four different cities (called front runner cities - FRC). The implemented NBS are rather local, on spatial scale, but, in every FRC, they are networked within a Living Lab (LL) vision that engages a single district. One of the main goals of the project was to assess the benefits produced by the implemented NBS.

To obtain an overview as comprehensive as possible of the benefits produced, both at the LL district and at the NBS (local) scale, by the implemented and monitored NBS, four domains have been explored, to assess: 1) socio-cultural inclusiveness; 2) health and wellbeing; 3) ecological and environmental restoration; and 4) economy and labour market benefits.

Impact assessment is performed in compliance with the guidelines described in the Handbook for practitioners elaborated by the **NBS Impact Evaluation Taskforce** of the European Commission in 2021. The acquired data and the related Key Performance Indicators (KPIs) are available on the project data platform (**www.progiregdata.eu**).

A negligible impact has been assessed at the district level in term of environmental benefits and improved walkability, likely due to the very spotted size of the NBS interventions and to the substantially unchanged land use in the LL. However, even if a direct cause-effectiveness relation with the proGIreg implementations cannot be demonstrated, a general positive impact on socio-economic aspects is assessed at the district scale, likely due to the LL approach, and to the regeneration policies put into action in the selected post-industrial district by the municipalities, in general.

The impact of the single NBS interventions is often significant only with respect to a single (or a few) societal challenges. Interestingly, different impacts were assessed when the same NBS type was realized in different cities, likely depending on the implementation strategy and cultural background and, consequently, stakeholder engagement. When several interventions originally planned as separated exist within the same site, they can be grouped into single success stories of virtuous NBS, and multiple benefits can be assessed, especially if different types of stakeholders are engaged in both the design and the implementation phases.

Provision of multiple benefits, under different domains is crucially in the NBS definition, thus, much attention has to be paid in this connection. However, trade-off balance of the provided benefits is still an open issue in NBS interventions. Approaches based on the analysis of the whole life cycle are required to fully describe their potential impact. Another open issue is impact evidence. Sometimes, impact is expected but not assessed. This may depend on several reasons, which are discussed in this deliverable.

This document represents a key deliverable for Work Package 4 (WP4 - “NBS benefit assessment and monitoring”).

1. Introduction

1.1. Introduction to the project

Productive Green Infrastructure for post-industrial urban regeneration (proGIreg) has developed and tested nature-based solutions (NBS) co-creatively with public authorities, civil society, researchers and businesses. Eight nature-based solutions (NBS), which will support the regeneration of urban areas affected by deindustrialisation, were deployed in Dortmund (Germany), Turin (Italy), Zagreb (Croatia) and Ningbo (China). The cities of Cascais (Portugal), Cluj-Napoca (Romania), Piraeus (Greece) and Zenica (Bosnia and Herzegovina) received support in developing their strategies for embedding nature-based solutions at local level through co-design processes.

1.2. Introduction to the deliverable

Following the most recent, commonly accepted definition of NBS, released by the United Nation Environmental Assembly (UNEA) in 2022, they are "…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, resilience and biodiversity benefits"[1].

The NBS capacity of providing multiple benefits and co-benefits, ranging across different domains, makes them one of the main bricks to pave the way towards just and transformative change. Indeed, NBS have been highlighted in the new **EU Strategy on Adaptation to Climate Change**[2], unveiled on 24 February 2021 by the European Commission (EC), and which aims to enhance adaptive capacity, strengthen resilience, and reduce vulnerability to climate change. According to the long-term vision established therein, Europe will be fully prepared to face the unavoidable impacts of climate change, which will materialise even if carbon neutrality is reached by 2050. The new strategy recognises that adaptation needs to be systemic and recognise the interdependency between a stable climate and the maintenance of ecosystem services such as biodiversity, food, clean air, drinking water and flood protection. To ensure these are preserved and enhanced, the Strategy emphasises that decisive actions should be taken to promote NBS in cities and regions across the European Union (EU). Following this, NBS have been adopted as core concept in many policy documents, ranging from the Kunming-Montreal Global Biodiversity Framework released by the Convention on Biological Diversity at the end of 2022[3] (which is one of the basic principles on which

[1] UNEP/EA.5/Res.5, Resolution adopted by the United Nations Environment Assembly on 2 March 2022.
[2] COM(2021) 82 final, Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change, {SEC(2021) 89 final} - {SWD(2021) 25 final} - {SWD(2021) 26 final}, European Commission, 24.2.2021.
[3] CBD/COP/DEC/15/4, Decision adopted by the Conference of the Parties to the Convention on Biological Diversity (2022).

the EU Nature Restoration Law is based[4]), to the recent attention paid to NBS by the International Labour Organization in connection with the opportunity for "decent" work[5].

According to the UNEA definition, impact assessment is key in NBS monitoring since it drives their evidence-based adaptive management, which is also one of the criteria of the Global Standard for NBS released in 2020 by the International Union for the Conservation of Nature (IUCN) [6].

To strengthen and foster the uptake of knowledge from and on NBS efficiency, clearly emerged in the last years the need of a common evaluation framework[7]. The building of this framework has been the object of an intense work, rooting in real-world NBS implementations, particularly those supported by the EU. Indeed, with the introduction of NBS in the EU Research & Innovation (R&I) agenda, embracing approaches such as green infrastructure (GI), and ecosystem services (ESs), the EU positioned itself as a pioneer and leader in this field since 2013, with the aim to greening the economy and achieving sustainable development, while fostering biodiversity and human well-being[8]. To do this, a huge effort has been made by the EC, which funded R&I programs to generate knowledge and theories (research) and implement innovative approaches and best practices (innovation) as well as disseminate, promote and deploy the NBS concept, with the final aim of translating these best practices into policies and governance models[9]. The core of this plan being the collection of data able to demonstrate the efficiency of the NBS approach, to promote future evidence-based decisions. The EU NBS Project Database is presently comprised of 300 projects, including 100 projects from H2020 and FP7, 35 NBS projects from BiodivERsA, 86 NBS projects from Interreg and 79 NBS projects from LIFE[10].

The European NBS impact evaluation framework has been reported in the Handbook entitled "Evaluating the impact of Nature-Based Solutions", released in 2021 by the NBS Impact Evaluation Taskforce of the EC[11]. This framework, together with the Global Standard of IUCN previously mentioned[6], constitutes the basis on which has been developed the European Roadmap to 2030 for Research and Innovation on Nature-based Solutions[10], which, among

[4] P9_TA(2023)0277, COM(2022)0304 – C9-0208/2022 – 2022/0195(COD), Regulation of the European Parlament and Council on nature restoration, 12 July 2023.
[5] ILO, UNEP and IUCN. 2022. Decent Work in Nature-based Solutions 2022. Geneva. Licence: CC BY-NC-SA 3.0 IGO.
[6] IUCN (2020). Guidance for using the IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of Nature-based Solutions. First edition. Gland, Switzerland: IUCN.
[7] Raymond, C. M. et al. (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology & Hydrology, Wallingford, United Kingdom.
[8] EEA, 2015, Exploring nature-based solutions: The role of green infrastructure in mitigating the impacts of weather- and climate change-related natural hazards, EEA Technical Report No 12/2015, European Environment Agency.
[9] Faivre, N. et al. (2017) Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges, Environmental Research 159, 509–518.
[10] El Harrak M. & Lemaitre F. (2023), European Roadmap to 2030 for Research and Innovation on Nature-based Solutions. NetworkNature.
[11] Evaluating the impact of nature-based solutions: A handbook for practitioners, A. Dumitru and L. Wendling Eds, European Union (2021).

the rest, includes the NBS definitional framework that is the prerequisite to translate best-practices into policies and governance models.

The project proGIreg belongs to the number of projects funded by the EU within this vision: the implemented NBS should, among other aspects, provide insights on their potential in producing benefits in connection with different societal challenges. Work Package (WP) 4 is the WP dedicated to monitoring and impact assessment, and it is a collaborative action involving local authorities, the civic sector, small-medium enterprises (SMEs), and research institutes, with the aim of providing a significant and comprehensive evaluation of the impact of the implemented NBS.

During proGIreg, eight different types of NBS have been implemented[12] (Figure 1):

- NBS1: Leisure activities and clean energy on former landfills;
- NBS2: New regenerated soil;
- NBS3: Community-based urban farms and gardens;
- NBS4: Aquaponics;
- NBS5: Green walls and roofs;
- NBS6: Accessible green corridors;
- NBS7: Local environmental compensation processes;
- NBS8: Pollinator biodiversity.

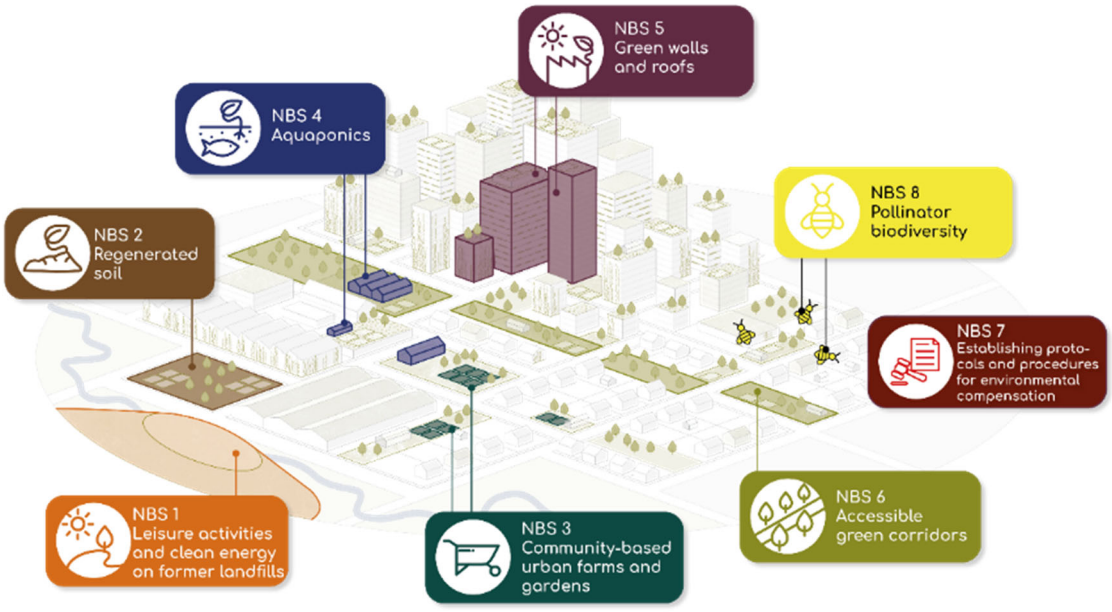

Figure 1. Eight NBS being implemented in the proGIreg FRC (image © RWTH Institute of Landscape Architecture).

[12] Saraco, R. (2020): FRC Implementation Plans, Deliverable No. 3.2, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission.

Performance monitoring and impact evaluation of these NBS have been performed in compliance with the guidelines of the European NBS impact evaluation framework[11]. The NBS impact evaluation framework is composed by 12 key societal challenge areas (Figure 2):

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 Well-being
12. New Economic Opportunities and Green Jobs

For each of the identified societal challenge areas, a list of useful Key Performance Indicators (KPIs, i.e., measurable parameters that demonstrate how effectively an NBS is producing benefits) is reported, with detailed methodology[10]. To provide a holistic description of produced benefits and ensure comparability, per each area, a few indicators are listed in the Handbook as "Recommended": these are the indicators that, when feasible and reasonable, should be assess. A further long list of "Additional" indicators is provided, to match specific implementation needs.

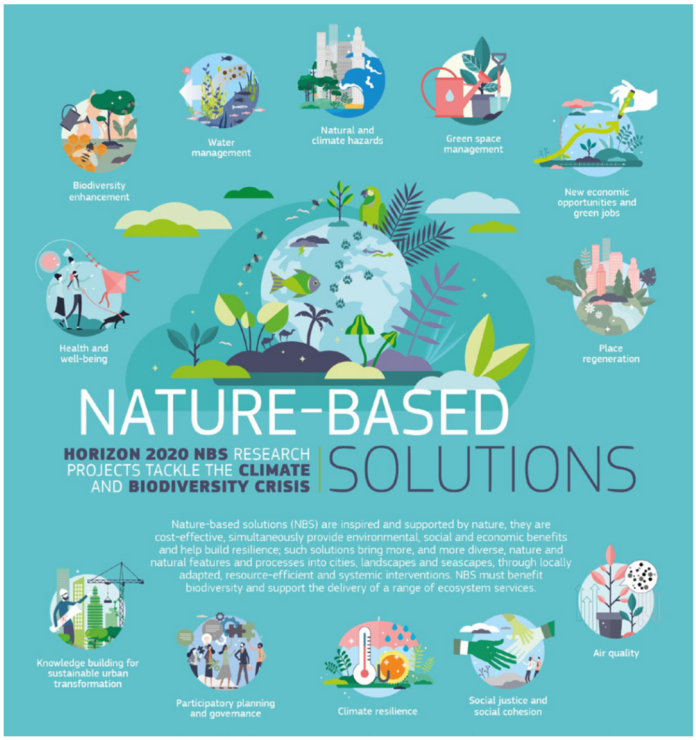

Figure 2. Key societal challenge areas identified in the Handbook realized by the EC NBS Impact Evaluation Taskforce (reprinted from Ref. 7 - image © European Union, 2021).

Based on the expected impact of the implemented NBS, the overall assessment process was divided on proGIreg into four main assessment domains[13], to address 9 over 12 of the above-mentioned societal challenges of the European framework[10]:

- "Socio-cultural inclusiveness" mainly relates to areas 8,10 and 11;
- "Human health and well-being" matches area 4 and 11;
- "Ecological and environmental restoration" includes areas 1, 2, 4, 5, and 6;
- "Economic and labour market benefits" matches area 12.

Due to the reduced spatial size of the implemented NBS[14], their impact has been mainly assessed at the local (i.e., NBS) scale[15] (Figure 4). However, the NBS interventions being networked within a Living Lab (LL) that engages an entire district, the impact at the LL district scale has been also evaluated[16] (Figure 4). The assessed impact at these two scales is discussed in Chapter 2. It is worth mentioning that impact has been assessed in terms of KPIs mainly belonging (or related) to the European evaluation framework[10]. However, some KPIs not belonging to the framework have been also assessed, since they have been considered as relevant for the analysis. Also, even if many "Recommended" KPIs have been evaluated, the majority are "Additional" ones, since the monitoring plan of proGIreg was established three years before the release of the European framework, and then adapted, as much as possible[17]. All the assessed KPIs, as well as the datasets from which they have been obtained, are reported in the project data platform (**www.progiregdata.eu**). For those indicators that have been calculated based on data monitored over a long period, the averaged values measured at the beginning and at the end of the monitoring activities (averaged over a similar period, in terms of time period and seasonality) are reported as KPI. For those indicators that have been obtained by questionnaires, personal data protection has been put into action, and only aggregated, anonymized data are available in the platform[13].

Figure 3. Spatial scales of interest in the proGIreg monitoring activity: city, LL district and NBS (image © RWTH Institute of Landscape Architecture).

[13] Baldacchini, C. (2019): Monitoring and Assessment Plan, Deliverable No. 4.1, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 124 pp.
[14] Saraco (2022): Four Implemented LLs in Front Runner Cities, Deliverable No. 3.5. proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, page number pp.113
[15] Baldacchini, C. (2023): Living Labs impact at the NBS level, Deliverable No.4.9, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 86 pp.
[16] Baldacchini, C. (2023): Living Labs impact at the district level, Deliverable No.4.8, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 92 pp.
[17] Baldacchini, C. (2021): Report on benefits produced by implemented NBS, Deliverable No.4.5, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 146 pp.

Finally, it is worth noting that the impact evaluation finally obtained is not completely matching what was planned at the beginning of the project also in terms of protocols of measurements[18] (i.e., the list of monitored NBS, the timing of the data collection and the type of collected data changed through the project). Indeed, many barriers have been encountered both in the NBS implementation and in the monitoring phase[19]. However, most of them have been overcome, thanks to the resilience and the flexibility of the developed monitoring plan. The encountered barriers, and the mitigation / adaptation measures undertaken, are described in Chapter 3, together with the corresponding lessons-learned and key massages for stakeholders.

2. Project impact

2.1. Project impact at district scale

KPIs in agreement with the European evaluation framework have been assessed at the LL district scale for the four FRCs in proGIreg[16]. Geographic information system (GIS)-derived data have been used to calculate spatial indexes related to the societal challenge area 4 – Green Space Management. Namely, the Walkability index and the Normalized Difference Vegetation Index (NDVI), which are included in the European framework as "Additional" (being numbered 8.37 and 8.2, respectively) have been assessed. Additionally, social, health and economic benefits at the LL district scale (in connection with the societal challenge areas 4, 8, 10, 11 and 12) have been assessed by experimental data collected, in a pre/post-implementation and treatment/non-treatment design (through the use of a control district as reference), with 36-months delay, with a general population survey, called the *"General Questionnaire"* (GQ). The GQ is part of a novel interdisciplinary measurement tool, called the *proGIreg AssessmeNt Tool (GIANT)*, that combines previously validated methods to monitor and assess health, wellbeing, social and economic benefits derived from NBS implementation, as well as their observed use, across different spatial scales[13]. A total of 26 KPIs have been evaluated, among which, 4 are listed as (or connected to) "Recommended", 15 as "Additional", and 7 are newly introduced.

The overall impact of our LLs at the district scale was mainly negligible: the temporal trend of spatial KPIs at the LL level reproduces the same trends observed at the city scale, and most of the KPIs evaluated by the GQ have the same temporal trend in both the LL and in a control district. However, NDVI and self-reported KPIs about social, health and well-being, and financial and economic situation showed sometimes a different trend, with respect to the LL scale, when evaluated at the NBS level. On one side, this demonstrates that setting the appropriate scale is crucial for capturing the NBS produced impact, and on the other that the

[18] Baldacchini, C. (2019): Protocols of Measurements, Deliverable No.4.3, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 39 pp.
[19] Pölling, B. (2021): Collective scheme/report of technological and non-technological barriers, Deliverable No. 5.5, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 73 pp.

proGIreg NBS interventions are mostly not large or networked enough to produce an impact at the district scale, but they potentially could be, upon intervention upscaling[20].

Nevertheless, some significant differences emerged between the citizens of the LL district and those of the control districts, in the three European FRCs.

In Dortmund's LL district there was a significantly increase in connectedness to nature, while in Turin's LL district, a significant increase in the perceived social support and in the perceived restorativeness was found.

The analyses of the health and well-being indicators at district level, suggest beneficial effects of the implemented NBS for emotional well-being, somatization, self-reported stress, and anxiety symptoms of the LL district residents, especially in Zagreb, where the sample size was larger.

Regarding the economic dimension, the overall trend is more positive in the LL than in the control districts. This concerns employment (green jobs and household income), the overall citizens' financial situation (based on a self-assessment and affordability of basic needs), and property value.

Since these differences have been observed among citizens of two different districts, within the same city, at the same time, this allowed us to reasonably decouple these results from events occurred in the project period at the national or international level, such as COVID-19 pandemic and Zagreb's earthquake in 2020. However, we cannot exclude that the attention paid by the local authorities to the LL districts, beyond proGIreg, could have played a role. Indeed, for instance, the significant effects measured in Zagreb concerning health and well-being impact was bit surprising, since the LL was still partially incomplete when the post-implementation survey was conducted.

2.2. NBS impact at local scale

To evaluate the impact at NBS level of the proGIreg implementations, research partners have developed 10 NBS-level monitoring tools[13], which allow to obtain one or more KPIs[15], each. Such tools have been used to collect data from NBS implementations selected based on their spatial and temporal scales (which should be significant[18]). The impact evaluation of at least one intervention per NBS type per FRC has been performed, in connection with more societal challenges as possible.

In total, 18 NBS interventions have been monitored for impact evaluation at the local scale, by using 33 KPIs, related to 9 of the 12 societal challenge areas identified as relevant for NBS by the European impact assessment framework[10]. The choice of the evaluated KPIs per implementation was depending on the expected impact, availability of pre-implementation baseline data or capability of collecting them according to the implementation timing, and ex-

[20] Ristorini, M., Baldacchini, C. (2022): Guidelines for upscaling, Deliverable No.4.6, proGIreg. Horizon 2020 Grant Agreement No 776528, European Commission, 68 pp.

pertise of the local partners involved in data collection. Among the 33 KPIs selected for impact assessment, 30 belong (or are related to) the European assessment framework for NBS[4], while 3 were newly introduced. Among the KPIs from the European framework, 10 are "Recommended" ones, while the other 20 are "Additional".

Despite the planned multi-domain assessment, the impact evaluated for the single NBS interventions was often significant only with respect to a single (or a few) societal challenges. This is likely due to several reasons, among which: i) the NBS intervention has been shaped by focusing on a single (or a small) number of target challenges and aspects related to other possible benefits are underdeveloped; ii) the background (surrounding) area provides similar benefits, hindering those due to the intervention; iii) the delays occurring during the implementation process did not leave enough time to perform impact monitoring within the project timeframe; iv) low quality of the collected data.

Nevertheless, thanks to the LL approach, success stories of virtuous NBS can be identified within proGIreg, by grouping into a single narrative the NBS interventions realized in the same site. Specifically, three success stories have been identified, which have had a positive, significant impact in connection with several societal challenges, covering all four assessment domains, thus providing significant benefits to both humans and nature[15]:

- **The regeneration of a former landfill in Dortmund**, integrating a previously recultivated area (about 150,000 trees have been planted for this purpose) with the realization of a barrier-free path to make it accessible (NBS6: Connection Huckarde with renatured Emscher river and Deusenberg sites), and a photovoltaic plant realized on top of the site (NBS1.1: Integrating solar energy production on Deusenberg landfill);

- **The generation of new soil from urban waste and its use for the creation of new green urban areas in Turin,** where regenerated soil based on excavated material with the addition of compost from organic fraction of municipal solid waste, zeolites and innovative biostimulants, defined with the main scope of minimizing maintenance needs, has been used to realize an "urban forest" of 1200 sqm. along the banks of the Sangone river (NBS2: New soil in Sangone Park);

- **The regeneration of an urban lake in Ningbo,** which has been made possible thanks to a joint action of local authorities and research institution (represented by the model of governance put into action by NBS7: Procedures for environmental compensation) and an NBS intervention consisting in the planting of aquatic plants along the shore of the lake (NBS3: Planting aquatic plants along the shore of the lake).

The other NBS implementations for which a significant impact has been evaluated, belong to more "traditional" NBS types and they have been implemented by the three European FRCs: Dortmund, Turin and Zagreb. They are interventions mostly focusing on single impact domains, and we successfully obtained the expected outcome from impact evaluation. Namely:

- Urban gardens provided an increased social cohesion perception, frequency of use and new jobs;

- Green roofs and walls mitigated the local temperature;
- Accessible green corridors increased the users' physical activity.

Interestingly, replicating similar NBS interventions in the different FRCs allowed us also to compare the obtained impact as a function of design and implementation parameters[15].

However, also some of these NBS interventions, thanks to the synergy among different stakeholders, have been planned and realized as multifunctional NBS.

For instance, the "Orti Generali" urban gardens and the closely connected green corridor in Turin also showed a significant impact on pollinator biodiversity. Indeed, specific actions were introduced with biodiversity enhancement aim in their planning, thanks to the involvement of local researchers in biodiversity conservation and monitoring. This result is particularly interesting because they have been realized in already green areas, which hindered, on the other side, any other environmental impact to be detected.

By following the same strategy (i.e., different stakeholder engagement in design and monitoring, also including research staff), apart from the impact on local temperature and heat-stress levels, also the impact of green walls on air quality has been obtained, which is more often an underestimated aspect. Indeed, due to the relatively small size of these interventions, standard methods such as air quality sensors can hardly measure significant differences. However, by studying at the microscopic level the leaves of the plants used to build the green walls, the amount of PM removed has been estimated. This also deserves interest for the selection of the plant species in future, similar, NBS implementations.

3. Lessons learned and best practices

3.1. How to design a success story

Taking advantages from the experience in proGIreg, we can draft a summary of what can make an NBS implementation successful. These aspects, which are common to the proGIreg success stories, make them particularly interesting as example of how NBS should be implemented in the future, to pave the way towards just societal transformation.

- **Design for multiple benefits.** An NBS intervention should be designed by integrating actions focusing on benefits for humans and on benefits for nature, with a special care to biodiversity.
- **Quadruple helix approach.** This aspect guarantees the involvement of a diverse group of stakeholders, with different goals to reach, and thus supporting a holistic impact. For instance, the involvement of the private sector allows to obtain significant financial revenues and number of new jobs created, which are essential prerequisites (or at least are expected to favour) for long-standing maintenance of the implementation itself, which is currently an open issue in NBS implementation. On the other side, the involvement of re-

searchers in the co-design allows a reliable and robust monitoring to be carried out, facilitating the impact evaluation. At the same time, the involvement of local authorities and civil society sectors makes easier the identification and the addressing of local population needs, in terms of social and well-being aspects.

- **Design at scale.** This is particularly relevant for ecosystem-based approaches. Changes produced (or expected/foreseen) on the surrounding environment can be measured only if the NBS intervention is designed at scale, especially if included into already green area. The same is true for impact on humans: having a significant number of people getting into contact with the NBS implementation allows both the application of reliable statistical approaches (which require a minimum number of participants in the sample) and a significant economic and labour market impact. Thus, only NBS designed at scale (or networked at a sizable scale) could allow the required monitoring/evaluation/adaptation loop that is included into the NBS definition.
- **Innovation.** Innovative partnerships among stakeholders from different fields should be put into action, to introduce new business models (by integrating sustainable solar energy or soil production with ecosystem regeneration actions, such as in Dortmund and Turin) or governance (based on public-private partnership, such as in Ningbo), to improve knowledge on NBS and make easier their translation into policy and practice.
- **Suitable for upscaling / replication.** Upscaling and replication are key[20], if NBS are conceived as building blocks for future transformative changes, and several implementation, including the success stories listed above, represent great examples of NBS to be upscaled / replicated in the future in the same context or in other contexts, upon being adapted to the local situations.

3.2. Design a reliable, resilient and feasible impact monitoring and assessment plan

The design of the impact monitoring and assessment plan is one of the pillars in NBS implementations and several theoretical frameworks have previously described how to set up a proper impact monitoring and assessment plan[10,20]. Some of their aspects deserve to be discussed here, in connection with the proGIreg experience on the ground, to clarify why they are important.

- **Reliability.** The reliable evaluation of NBS impact requires that baseline data are measured before the NBS implementation, and the comparison with a reference site or sample as a function of time. Indeed, the time span between the baseline assessment and the post-implementation evaluation could last years (and, often, the benefits increase with time, depending on the intervention). This increases the possibility that local, or district level data could be strongly affected by events occurring at higher spatial level (i.e., regional, national, or even globally), disregarding the presence of the implemented NBS. The comparison with a reference site or sample, across the same time period, ensures the proper evaluation of larger spatial scale events. This is, for instance, the experimental design of the GQ used in proGIreg to evaluate the impact at the LL district scale on social, health and well-being, and economic aspects: a pre-implementation/post-implementation and treatment/non-treatment design, which allowed to exclude the two main events occurred in 2020 in the

proGIreg FRCs (the COVID-19 pandemic, globally, and the earthquake in Zagreb) from the possible reasons of the observed impact.

- **Resilience.** The requirement of a resilient development monitoring plan pertains especially to NBS interventions realized upon a specific project funding, since project time constrains may avoid a proper impact evaluation, if something happens and changes the planned NBS implementation and / or monitoring timeline. This was the case in proGIreg, where NBS implementation encountered a few barriers that delayed the implementation activity[19], such as technical and non-technical or administrative barriers, natural hazards, and disasters (such as earthquake in Zagreb or the global COVID-19 pandemic), or co-design processes that took longer than expected. Moreover, the monitoring activity itself encountered barriers, such as the unavailability of trained staff for data collection or, again the lock-down measures due to the COVID-19 pandemic. The occurrence of similar events simultaneously must be considered when planning a monitoring plan and set the mitigation measures. For instance, the availability of trained staff should be clarified in advance or suitable hiring should start in time, considering the required administrative procedures. To reduce the risk related to delay in the design and /or in the monitoring activity or unexpected availability of an outcome (i.e., due to a failed sensor), a suitable number of replicate measurements, both in time and in space, should be planned. In any case, robustness and redundancy that are key elements of a resilient system should be considered and included in the planning and implementation of NBS at local and district scale.

- **Feasibility.** To obtain robust, scientifically sound evidence of NBS impact, scientifically tested procedures should be applied. However, if data collection should be performed by non-expert staff, attention must be taken in finding the good compromise among scientific needs and staff capacity. To this aim, researchers should suitably train non-experts in applying scientific methods or at least data collection. This would not only be better for the data obtained, but it would also be beneficial in the acceptance of scientific results in the general population (which is at risk as we can observe with the rise of populism and in the context of the (post-)pandemic). In proGIreg, these difficulties have been partially mitigated by adapting the monitoring tools. For instance, easy-to-use sensors have been used for air temperature and quality monitoring, or a simplified questionnaire has been developed to be administered by teachers when school pupils should be interviewed. This allowed data to be obtained, but the over-simplification of the assessment method, together with the low expertise of the staff involved and /or the insufficient research training, led to data that were less representative than expected. Another main issue to mention in connection with feasibility is the low response rate of the GQ, which was partially due to the involvement of non-expert staff, but also to some barriers perceived by the participants, such as the length of the interview, the presence of the interviewer, the request of information felt as too personal.

3.3. Promote stakeholder engagement

Stakeholder engagement is key for the success of an NBS intervention. This has been already mentioned in the previous two chapters, but it deserves to be clarified as much as possible. **Stakeholder engagement is key to:**

- **Design interventions able to provide benefits in multiple domains**, since different expertise is required to identify the local needs and address them efficiently, as well as to properly plan the NBS maintenance;
- **Design and perform efficient monitoring**, since the success of the monitoring activity increases if it is planned together with, and tailored on, the NBS implementation process, and this can be obtained by engaging the same group of stakeholders in both processes;
- **Disseminate knowledge and increase awareness**, since the wider the community that gets in contact with the NBS intervention, and the higher its level of commitment, the wider will be the knowledge uptake and the crosstalk among different sectors.

3.4. Take care of trade-off balance

Trade-off balance evaluation was one of the pillars of the definitional framework for NBS set-up by IUCN in 2016[21], and one of the criteria of its Global Standard for NBS[6]. However, it is still one of the most underestimated aspects in NBS implementation. This is likely since, up to now, most NBS implementations are designed to address one (or at least few, often connected) societal challenges, as also occurred in proGIreg. Thus, multi-domain impact evaluation has been very rarely obtained in the last years. Now, upon the release of the UNEA-5 definition[1], multi-functionality clearly emerges as key in NBS implementation. This new complexity makes the trade-off balance issue rising as urgent to be addressed. At the same time, multi-domain impact assessment is required to make the trade-off balance addressable. And this will become more and more evident in the future, with increasing the NBS intervention complexity and the stakeholder engagement.

Just to make a historical example[22], if during the implementation of green roofs and walls, only the mitigation of the effects of global warming is taken under consideration, clones from one or very few plant species, regardless of their biogeographical distribution, could be used. As a consequence, such structures would hardly contribute to increase biodiversity, would lead to poor resistance and resilience to future extreme events, increasing management costs, and risk of biological invasions.

In proGIreg, we didn't have evidences of unbalanced trade-off, because attention has been paid to this aspect during the design phase. However, an example can be made, overall, to

[21] Cohen-Shacham, E., Walters, G., Janzen, C. and Maginnis, S. (eds.) (2016). Nature-based Solutions to address global societal challenges. Gland, Switzerland: IUCN. xiii + 97pp.
[22] Eggermont, H. et al. (2015), Nature-based Solutions: New Influence for Environmental Management and Research in Europe, GAIA 24, 243.

clarify the concept: the implemented urban gardens and farms significantly improved the quality of life of the users and also local pollinator biodiversity, but no changes have been observed in local air quality and temperature before and after the intervention. This is likely due to the fact that they have been realized in already green areas, and that a very low number of trees is present, while they are crucial to obtain benefits in terms of mitigation of the climate change and its effect. The reasons behind the decision of planting no or few trees in these NBS interventions can be many, such as reducing the maintenance costs of the site, or improving the available soil or the sunlight for food production. Performing trade-off balance during the design phase could have made clear this criticality. However, thanks to the monitoring and impact assessment, this need is now emerged, suggesting a possible adaptation of these NBS interventions, to make them even more efficient and resilient in the future. This is how the NBS life cycle works.