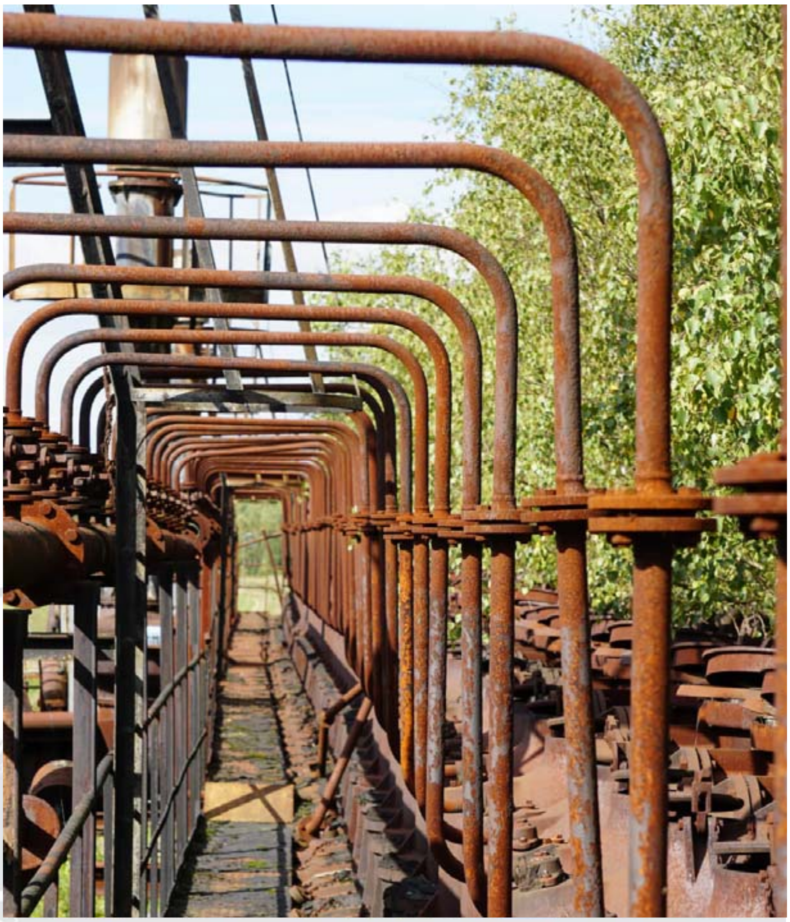

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Deliverable 5.2

Report on technological barriers

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Author: Paola Zitella

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Partner organisations

No.	Name	Short name	Country
1	South-Westphalia University of Applied Sciences	SWUAS	Germany
2	Local Governments for Sustainability	ICLEI	Germany
3	Environment Park	ENVIPARK	Italy

Abbreviations

FC: Follower Cities

FRC: Front-Runner Cities

NBS: nature-based solutions

proGIreg: productive Green Infrastructure for post-industrial urban regeneration

TRL Technology Readiness Level

Executive Summary

The report on technological barriers is part of WP 5 “Market readiness, barriers, and upscaling” of the EU HORIZON 2020 project proGIreg (productive Green Infrastructure for post-industrial urban regeneration). ProGIreg’s overarching objective of demonstrating NBS-integration into (partly) self-sustained business models requires emphasising upon possible bottlenecks for NBS when entering the market. Thus, WP 5 aims to, firstly, identify technological and non-technological barriers that hinder broader implementation and, secondly, to develop a catalogue of business models for NBS with regard to market readiness and upscaling. Besides detecting barriers, it is of importance to find solutions for overcoming barriers at different stages of NBS development. This report focuses on technological barriers encountered when planning, implementing and maintaining NBS.

Technological barriers to upscaling NBS at the city level can originate from different angles; most importantly these refer to technical requirements, guidelines and frameworks needed for implementing NBS and the current Technology Readiness Level (TRL). The detection and addressing of technological barriers aim to create products that are market ready with worthy potential for upscaling. Based on the proGIreg industry partners’ know-how and experience, the collection of technological barriers has been differentiated between NBS.
Close monitoring of the NBS implementation processes in WP 3 allows detecting technological barriers within the project.

The interview programme with the standardised questionnaire developed in Task 5.1 was conducted by personal in-depth interviews with proGIreg project partners and other stakeholders involved in the implementation of nature-based solutions in front-runner and follower cities. The method defined by the international WP5 team (ENVIPARK, ICLEI and SWUAS) benefited from being able to conduct interviews in mother tongues where possible. Thus, gaining a more accurate understanding of interview results in cases where interviewees (e.g. operators, nurserymen) did not have sufficient command of the English language. This process allowed to identify technological barriers to upscaling for each NBS implemented.

This questionnaire was complemented by state-of-the-art analyses which allow a more comprehensive identification of the technological problems to be addressed and applicable solutions to overcome them.

The analysis of the interviews results from the standardised questionnaires revealed the difficulties various front runner cities are facing in planning and implementation phase of nature-based solutions.

This report provides a brief description of the NBSs implemented in the different cities followed by summary tables of the barriers encountered, as reported by the interviewees, during the planning, implementation and subsequent management of the activities.

In general, since most of the nature-based solutions involve the use of plants, they are subject to and regulated by the plant’s life cycle and therefore require constant maintenance. If not automated, this requires the use of human resources who must be involved in the management beyond the useful life of the implementation projects.

Safety issues detected during the interviews can be solved by holding specific training courses for safety, providing the appropriate personal protective equipment and training for workers. Visitor safety is not an issue except for some allergic reactions that can be easily overcome by informing users through information panels and by selecting less dangerous pollinating insects such as butterflies.

Key interview results highlight the blurry borders between technological and non-technological barriers such as the need for suitable spaces for implementation, the lack of widespread experience and technical know-how, and needs of cooperation among public authorities and citizens.

The main recommendations common to all NBS are: the need of an initial strategic plan at urban level when applying NBS; the preliminary creation of a multidisciplinary project team which also includes representatives of the local community who can inform citizens about NBS benefits targeted for them; a good analysis of the territory that allows to immediately identify the most suitable locations for implementation; the creation of a support at the municipal administration level that helps creating the legislative and authorization framework essential for the development of NBS.

1. Introduction

1.1. Introduction to the project

Productive Green Infrastructure for post-industrial urban regeneration (proGIreg) is developing and testing nature-based solutions (NBS) co-creatively with public authorities, civil society, researchers and businesses. Eight NBS, which will support the regeneration of urban areas affected by deindustrialisation, have been implemented or are going to be deployed in four front-runner cities: Dortmund (Germany), Turin (Italy), Zagreb (Croatia) and Ningbo (China). The follower cities of Cascais (Portugal), Cluj-Napoca (Romania), Piraeus (Greece) and Zenica (Bosnia and Herzegovina) in the meantime receive support in developing their strategies for improving nature-based solutions at local level through co-design processes. The NBS to be tested are:

- NBS 1: Renaturing landfill sites for leisure use and energy production
- NBS 2: New regenerated soil thanks to biotic compounds for urban forestry and urban farming
- NBS 3: Community-based urban farms and gardens
- NBS 4: Aquaponics
- NBS 5: Capillary GI on walls and roofs
- NBS 6: Making post-industrial sites and renatured river corridors accessible for local residents
- NBS 7: Establishing protocols and procedures for environmental compensation at local level
- NBS 8: Pollinator biodiversity improvement activities and citizen science project

1.2. Introduction to WP 5 and Tasks 5.1 and 5.2

The standardized questionnaire on technological and non-technological barriers is part of WP 5 “Market readiness, barriers, and upscaling” of the EU HORIZON 2020 project proGIreg (productive Green Infrastructure for post-industrial urban regeneration). WP 5 aims at detecting barriers to implement NBS, to find solutions to overcome them, and to develop a catalogue of business models for nature-based solutions, based on scientific assessments of the multiple benefits they provide for social, ecological and economic regeneration. ProGIreg’s overarching objective of demonstrating NBS-integration into (partly) self-sustained business models requires emphasising upon possible bottlenecks for NBS when entering the market. Thus, WP 5 aims to identify technological and non-technological barriers that hinder broader implementation, to find solutions to overcome them, and to develop a catalogue of business models for NBS with regard to market readiness and upscaling. WP 5 builds especially on the NBS pilot implementation within WP 3 and WP 4 benefit assessment and monitoring during and after the NBS pilot implementation. The key research question with regard to barriers is: Which barriers occur at different stages of NBS development and how can they be overcome to enable NBS upscaling?

The tasks 5.1 “Tackling technological barriers to upscaling” (ENVIPARK) and 5.2 “Tackling non-technological barriers to upscaling” (ICLEI) aim to detect potential hurdles for NBS when entering the market and to find solutions how to overcome them. Both, technological and non-technological barriers are faced in the reports basing on skills and competences of the lead partners of these tasks and by analysing outcomes resulting from the answers provided by the stakeholders interviewed with the standardized questionnaire. The questionnaire represents WP 5’s first Deliverable (5.1, M23) and builds on desktop research and internal proGIreg progress, especially WP 2. The desktop research takes advantage of thematically similar projects and activities, i.e. Eklipse, BiodivERsA, URBAN GreenUP, CLEVER Cities, Connecting Nature, GrowGreen, and Naturvation. References include for example:

- Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, H. Korn, J. Stadler, K., Zaunberger, and A. Bonn. 2016. Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society 21(2):39. http://dx.doi.org/10.5751/ES-08373-210239
- CLEVER Cities
    - “Barriers and success factors for effectively co-creating nature-based solutions for urban regeneration” (Del. 1.1.1)
    - “Green market opportunities and business policies for urban nature-based solutions” (Del. 1.1.2)
- URBAN GreenUP
    - Barriers and Boundaries Identification (Del. 1.5)
    - EKLIPSE/EPBRS/BiodivERsA Joint Foresight Workshop: Social innovation and nature-based solutions (Brussels, December 2016); including “barriers to implementing NBS and/or to social innovation approaches”

The data collected with the help of the standardized questionnaire have been used to analyse technological and non-technological barriers (s. Figure 1). D5.4 will benefit from ICLEI's worldwide network of cities to collect information on barriers when developing NBS beyond proGIreg. The data collection of D5.4 will not use the D5.1 standardized questionnaire, because the questionnaire is specifically designed to personally interview actors strongly involved in the NBS development inside proGIreg. The outcomes of the second round of personal in-depth interviews will be used to synthesis barriers and solutions how to overcome barriers for upscaling (D5.5).

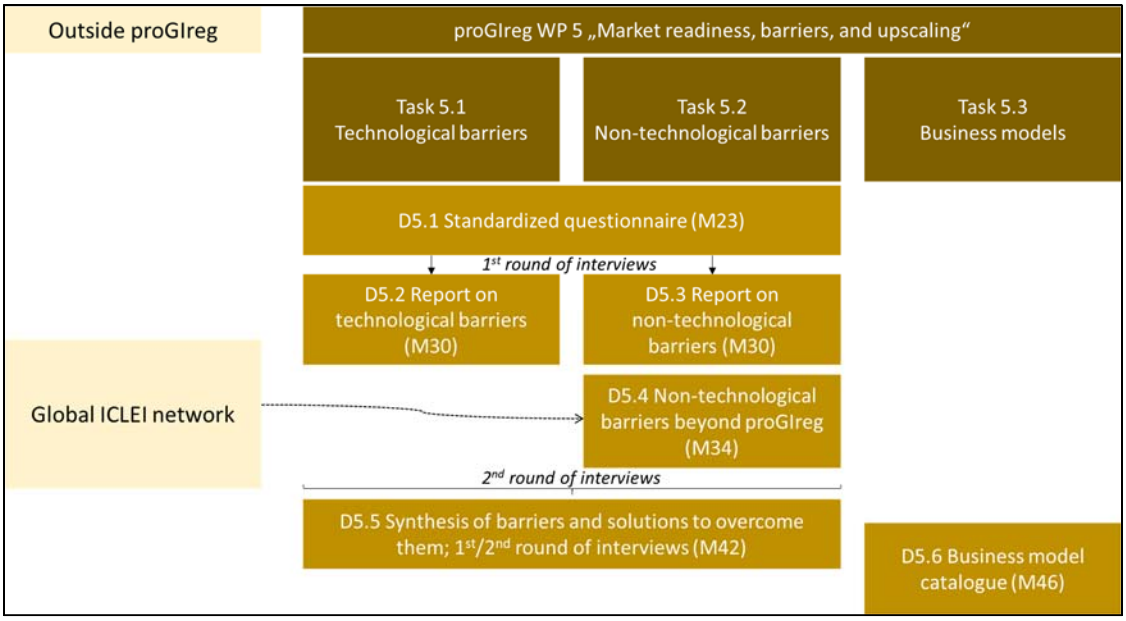

Figure 1. Sequence of WP5 deliverables on barriers and business models

2. Structure of the report on technological barriers

This report aims to detect NBS-specific technological barriers for upscaling emerged in front runner cities and in follower cities. The report focuses also on solutions found to overcome obstacles highlighted or other possible solutions that could be eventually adopted. These solutions sometimes have been found by the work teams involved in the NBSs developments, sometimes are lessons learned from previous experiences, or taken from literature analysis.

This task plays a more important role in technic-intensive NBS, namely NBS 2, 4 and 5, compared to other less technic-intensive NBS such as NBS 3 and 6. The questionnaire collected appropriate data from all stages of market readiness and potentials for upscaling covered in the project and asked for proposals, suggestions and R&D needs to overcome these barriers. Following the collection of primary data, the partners synthesised the existing technological barriers with the aim to find appropriate solutions to tackle them and to provide more suitable conditions for upscaling.

This report includes proposals for solutions and further R&D needs, and explores the opportunities for the optimisation of the supply chain and possibilities to link it with other existing value chains.

The report for each NBS is structured in four sections: introduction, technological barriers and safety issues, possible solutions and conclusions.

The introduction gives a brief description of each NBS, with a focus also on the possible benefits of implementing the specific NBS.

The section on technological barriers and safety issues specifically focuses on how different cities have implemented NBS and the degree of implementation. It then focuses on the technological barriers that have emerged, the phase at which they were encountered and how much they affected the implementation of the NBS. Finally, safety issues highlighted during the interviews are reported

The section on possible solutions focuses on providing technological suggestion to overcome the technological barriers and the safety issues highlighted and also other possible solutions from previous experiences and from state of art (where possible) are reported. At the end of this section future barriers that the cities expect to emerge at a later stage of implementation are discussed.

The section on conclusions presents some considerations about the technological barriers identified and the solutions found; where possible, additional technological barriers that emerged from the state of art but were not highlighted in the interviews are reported.

Finally, a SWOT analysis of each NBS is reported based on interviews. The SWOT analysis is divided in internal factors, which can be classified as strengths or weaknesses, and in external factors, which can be classified as opportunities or threats.

An important note is that the boundary between technical and non-technical barriers for applications such as nature-based solutions, which are intrinsically not particularly technological, is concealed. Sometimes some problems can be considered from both points of view and maybe the solutions can be the result of transversal considerations.

For example, the fact that the lack of maintenance, e.g. irrigation, leading to a different choice in terms of (more resistant) cultivars for green roofs and walls is a technical-management solution. this is a technical solution (selection of the cultivar) to an economic-managerial problem. However, the failure to install an automatic irrigation system (different technical implementation) can be met through a social involvement that leads the public (schools, neighbourhood committees) to take care of maintenance. A management-social solution to a technological problem.

In these instances, the WP5 team agreed to report the proposed solutions in reports D5.2 and 5.3.

3. Methodological introduction

For each NBS and for each city involved in the implementation of the NBS itself, 3-5 people were interviewed.
On the basis of the standardized questionnaire, each person interviewed highlighted technological barriers and provided a personal rank of these issues in order of importance, assigning a rank equal to 1 for the most relevant barrier, a rank equal to 2 for the second most relevant barrier, etc. This is the reason why in some tables on technological barriers or safety problems the same rank number is assigned to different obstacles.

As agreed for Deliverable 5.1 a defined table like the one under reported has been filled in by each interviewed.

Technological barrier(s)	Planning phase	Implementation phase	Operating phase	Rank (1 -4)

Subsequently it was required to provide for each barrier a qualitative opinion that would provide information for subsequent applications of similar urban solution on how much each barrier was limiting for the real implementation of the solution.

This qualitative ranking indicates whether the obstacle could be classified as a minor barrier (that could be overcome with minor effort, such as more time needed or selection of different cultivars), as a major barrier (that could be overcome with significantly more effort), as a barrier that causes the development of alternative NBS or as a barrier that stops the implementation completely.

As agreed in Deliverable 5.1 a defined table has been filled in by each interviewee, asking them to cross one of the columns for each NBS.

Technological barrier(s)	Minor barrier (could be overcome with some more effort)	Major barrier (could be overcome with significantly more effort)	Barrier causes the development of alternative NBS	Barrier stops the implementation completely

In some cases, the interviewees did not establish a rank for technological barriers, for this reason some tables for technological barriers in this report do not include a ranking. Safety issues, were not ranked.

For each barrier highlighted, what was acknowledged by the interlocutors was therefore reported, bearing in mind that not everyone provided all the answers (so sometimes, for example, the ranking is not present) and that for someone similar barriers showed to be more insurmountable than for others (so not even coherent ranking).

A summary of proGIreg's planned and implemented NBS in each city is provided in Table 2.

It must be emphasized that the collection of information from people involved at several levels in different cities is based on personal experiences and opinions, thus the perception of difficulties encountered is therefore subjective, lacking of a common reference.

For each barrier highlighted by the interviewee, not everyone provided all the answers (which is reflected in the absence of a ranking) and that in certain situations barriers proved to be more insurmountable than in others.

In some cases, the interviews carried out did not reveal particular evidence of technological barriers. In these instances, no reference is made to the outcomes of these interviews in this report but instead the interview results are captured in deliverable 5.3 on non-technological barriers.

NBS	Dortmund	Turin	Zagreb	Cascais	Cluj-Napoca	Piraeus	Zenica	Ningbo
1: Leisure activities and clean energy on former landfills	x						x	
2: New regenerated soil		x						x
3: Community-based urban farms and gardens	x	x	x	x	x			x
4: Aquaponics	x	x	x					
5: Green walls and roofs		x	x		x		x	
6: Accessible green corridors	x	x	x	x	x	x	x	
7: Local environmental compensation processes		x	x					x
8: Pollinator biodiversity	x	x		x		x		

Table 1. NBS developments in proGIreg cities

4. NBS 1: Renaturing landfill sites for leisure use and energy production

4.1. Introduction

Landfill sites are post-industrial urban areas that can be renatured. The landfills redevelopment is major problem of the European city, in particular of the big town, in which the environment impact is of primary importance, especially in end of life management. After the closure of municipal waste dumps, the management is protracted for many years, in which leaching, biogas and all the risks associated with the landfill must be managed.

The exploitation of the site after the closure of the dump is the challenge of including landfills into their respective neighborhoods. One of the main solutions is to use the site for restoring green area or to install an energetic production park on it. In fact, these sites offer well-exposed and large areas for solar energy production, but also slopes and inclined planes for special sports and high elevations which provide good overviews when converted in public parks.

Landfill renaturation can provide different benefits; in fact, it can make the city more livable and inclusive and can help improving physical and mental health of citizens.

An important social study about the feedback on redevelopment of brownfields in urban areas was written by Simis in 2016 [1]. This paper is a comparative study based on the respondents' perceptions toward their quality of life before and after the redevelopment of ex-landfills as public parks. The perception of the status of health increased by 75% for the respondents and, in addition, the perception of the status of safety increased by 44%. Moreover, respondents perceived the status of surrounding air quality as "better" (26%) after redevelopment [1].

4.2. Technological barriers and safety issues

Based on interviews collected, two cities have embarked on redevelopment of landfills, front-runner city Dortmund (Germany), and follower city Zenica (Bosnia and Herzegovina).

In Zenica the purpose is to renature a landfill site which is situated at the eastern valley slope near the city (area around 30.000,00 m^2).

In Dortmund the initial purpose was to produce energy and also to create a park on the landfill of the Deusenberg. The integration of energy production on the top of the Deusenberg was completed in 2017, prior to the proGIreg project. The creation of an exercise park in the landfill at the location of Deusenberg was cancelled because it is reserved for IGA 2027 (International Garden Exhibition); so, it was decided to create an exercise park within an existing public park, Gustav-Heinemann-Park, in Huckarde district (area around 5 ha). It is a re-cultivated area; in

[1] Simis, M., Awang, A., & Arifin, K. (2016). "From Ex-landfill to Public Park: Impact on local community's quality of life and living environment", *Procedia - Social and Behavioral Sciences Vol. 222*: 763-771; https://doi.org/10.1016/j.sbspro.2016.05.157

the past there was a brick factory in the western part and in the eastern part, where the project is to be implemented, there are probably remains of the industrial production.

The two cities have developed or are developing NBS1 in different ways (Table 2).

City	Realization of NBS1	Current status of the NBS implementation
Dortmund	Exercise park	Planning phase
Zenica	Horticultural arrangement of the closed landfill	Implementation phase, Operating/Maintenance phase

Table 2. Outline of how NBS1 is or was implemented for each city involved and degree of implementation

Dortmund and Zenica have encountered different technological barriers in developing this NBS (Table 3).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Dortmund	Soil pollution	Planning phase	1	Major barrier (could be overcome with significantly more efforts)
	Material used for fixtures (natural → manufactured)	Planning phase	1	Barrier causes the development of alternative NBS
Zenica	Expensive technology	Planning phase and implementation phase	1	Major barrier (could be overcome with significantly more efforts)
	Landslides	Implementation phase	1	Major barrier (could be overcome with significantly more efforts)

Table 3. Technological barriers and relative ranking encountered by each city in developing NBS1 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table

City	Safety issues	People involved
Zenica	Fires	Workers/Users

Table 4. Safety problems that are critical for the successful implementation of NBS1

4.3. Possible solutions

Table 5 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
Dortmund	Soil pollution	Allocate a part of the budget to prepare the soil (excavation)	Soil remediation after characterization
	Material used for fixtures (natural → manufactured)	-	Use of naturally/ environmentally friendly fixtures
Zenica	Expensive technology	-	
	Fires and explosions	-	Risk analysis of the area for fires
	Landslides	Planting trees [2]	Compacting surface waste to mitigate slopes

Table 5. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 1)

The interviews also revealed additional technological barriers that may occur at a later stage of implementation:

- In Dortmund, the risk that people do not know how to use provided tools has been highlighted; this problem could be easily overcome through the installation of explanatory panels.
- In Zenica, the need to fence the entire surface of the landfill has been highlighted in order to avoid illegal entry; the site is in a remote area, so it could be necessary to ensure a continuous monitoring system.

4.4. Conclusions

Renaturation of landfill sites or post-industrial areas is important to convert brownfields into spaces, which can be enjoyed by the local people through various recreational offerings as well as producing renewable energy, which is the purpose of NBS1.

[2] https://progireg.eu/nature-based-solutions/leisure-activities-and-clean-energy-on-former-landfills/ (last access to the site 09/02/2021)

The cities involved in the implementation of this NBS have highlighted several technological barriers and safety issues. In general, these obstacles require substantial investments to be resolved (for example, soil remediation in case of soil pollution, risk analysis of the landfill in case of risk of fires and explosions).

Other specific issues emerged: in Dortmund one problem is the materials used for fixtures to create the exercise park, in fact, the initial idea of using environmentally friendly materials (fibers, wood etc.) has been shelved in favor of manufactured materials. The reasons why manufactured materials are favored seem to be robustness and durability; since the project in Dortmund is in the planning phase, the idea of using natural materials for fixtures could be taken up again with a view to sustainability. Zenica faces the issue of landslides; the solution found is to plant trees, but there is another possible solution, which is to compact surfaces in order to mitigate eventual landslides.

In conclusion, despite the technological barriers and safety issues highlighted by Dortmund and Zenica, the project can be implemented with a reasonable degree of success by taking appropriate measures.

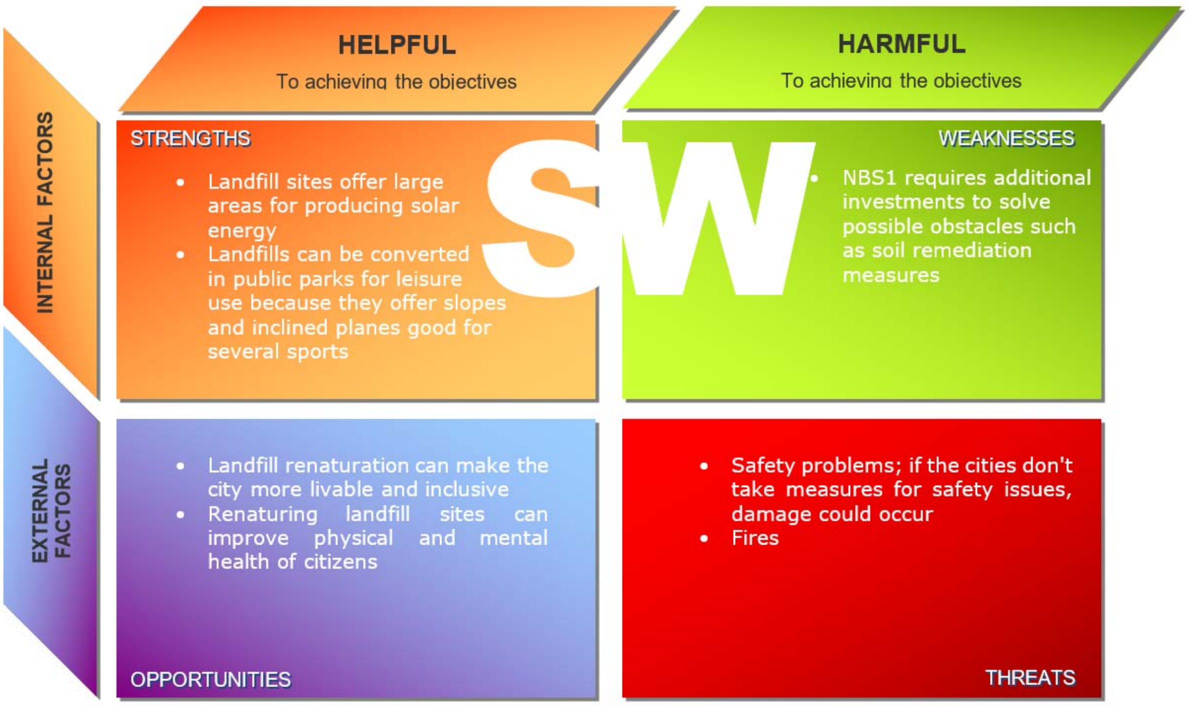

Figure 2. SWOT analysis of NBS 1

5. NBS 2: New regenerated soil thanks to biotic compounds for urban forestry and urban farming

5.1. Introduction

Nature-Based Solutions (NBS) are identified as a useful tool to pursue objectives such as the increase of the sustainability of urban systems and the regeneration of depressed area, with respect to climate change and the improvement of risk management and resilience. Among the main applications of nature based solutions to environmental issues on an urban scale, there is the New Soil, a product obtained from the mix of soil provided from construction work combined with compost. According to the Food and Agriculture Organization of the United Nations, increasing land managed with sustainable practices improves the restoration of degraded soils and promotes sustainable intensification of production through adapted biological resources can represent a key challenge for moving towards sustainable management of urban green areas (FAO 2015).

Post-industrial urban areas suffer from poor soil conditions due to the lack of biologic activity and humification that has characterised them for decades or even centuries. These soil conditions can be an obstacle to their reuse as parks or green spaces. Brownfields with infertile soils which cannot be reused, have negative impact on the surrounding areas: often degraded urban areas are not integrated into the urban fabric and social life of the neighbourhoods, thus deeply affecting their image and lead to lack of care by citizens, creation of social enclaves and increased crime rates.

Through the use of compost deriving from organic waste, soil from excavation works (secondary raw material) and *inocula* with specific microbial consortia, it is possible to restore fertility in arid substrates and create regenerated soil instead of importing agricultural soil from other sites. The new soil will be used for two main purposes: urban forestry and urban gardening on brownfield sites. The role of inoculants containing arbuscular mycorrhizal fungi and bacterial consortia in improving the nutritional value in crops, is investigated in proGIreg project through the monitoring plan that foresee to sample soil and foil in the new soil area and behind in a 'white' area without new soil in order to test with analytical activities the effects on plants of this new soil.

Plant species have been selected according to soil and climatic conditions, so as to allow a renewal of soils and their re-fertilisation. This activity results in different outputs:

1. Fertile new soil as product and as a method to produce it with natural based "ingredients" for growing media.

2. Selection of adequate plants for the climate and natural conditions and abandoned areas re-naturalized.

3. Fertile new soil to be used in urban farming (for green roofs/walls, vegetable garden boxes).

5.2. Technological barriers and safety issues

Based on interviews collected, two cities have embarked on new soil test site implementation, Turin (Italy) and Ningbo (China). In particular, in Turin an area of "urban forest" along the banks of the Sangone river has been created through the use of regenerated soil (New Soil), based on excavated material with the addition of compost from OFMSW, zeolites and innovative biostimulants. The composition of the New Soil has been defined with the main scope of minimizing maintenance needs. The composition is:

- Soil from deep excavation from works in the city as the main ingredient
- Compost from OFMSW for organic matter and nutrients addition (10%)
- Zeolites in the surface layer for the purpose of decreasing the density of the material and with an adsorbent function to retain water
- Mycorrhizae as bio-stimulants to improve nutrient uptake and resilience of plants.

Plants of different species were planted in the New Soil area and in the adjacent area as a control. UNITO begun monitoring of plant growth with laboratory analysis that will last during the next years of proGIreg project in order to evaluate the effect of new soil on vegetation.
Chemical characterizations of the soil from excavation before and after the mixing with the other ingredients have been done in order to verify the compliance with law prescriptions and to proceed with the authorization procedures.

Ningbo NBS new soil is located in the Moonlight Lake scenic area of Ningbo City and consists mainly in clearing the silt at the bottom of the lake and transporting part of the silt at the bottom of the river to the park for afforestation and planting. Some rivers in the local environment are eutrophicated, so the silt from the riverbed is taken out and used to fertilize fields and cultivate plants.
It not only alleviates the eutrophication of lakes to some extent, but also increases the fertility of land soil.
It is beneficial to the cultivation of plants and crops. The sustainability of the newly regenerated soil was studied. At the bottom of Moon Lake in the Living Lab area, there are many sediments such as sludge. They will release harmful substances to the water body, so the lake must be dredged. However, the lake area is huge, and more than 50,000 m^3 of sediment have been removed. Modifying these sediments into soil fertilizers for planting vegetation will greatly protect the environment and save resources.
Before the sediment is converted into soil fertilizer, the sustainability of the new regenerated soil was studied. The physical and chemical properties of the soil have been analyzed first to ensure that the sediment will not cause secondary pollution to the soil.
The current status reported in the deliverable 3.2 submitted in 30/07/2020 declares that, due to high levels of heavy metals in lake sediments, the activity was cancelled.

The two cities have developed or are developing NBS2 in different ways (Table 6).

City	Realization of NBS2	Current status of the NBS implementation
Turin	Creation of an area of "urban forest" along the banks of the Sangone river through the use of regenerated soil (New Soil), based on excavated material with the addition of compost from OFMSW, zeolites and innovative biostimulants	Operating and monitoring phase (after physical implementation)
Ningbo	Transformation of lake sediments into newly regenerated soils	Planning phase (before physical implementation)

Table 6. Outline of how NBS2 is or was implemented for each city involved and degree of implementation

In developing this NBS,nTurin and Ningbo have encountered different technological barriers (Table 7).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Turin	Heterogeneity of the soil	Implementation phase	2	Major barrier (could be overcome with significantly more efforts)
	Identification of materials in compliance with National legal requirements	Planning phase and implementation phase	1/2	Minor barrier (could be overcome with some more efforts)
	Distance among excavation and destination site - transports costs	Implementation phase	n/a	Minor barrier (could be overcome with some more efforts)
Ningbo	Heavy metals are difficult to remove from sediments	Implementation phase	n/a	Major barrier (could be overcome with significantly more efforts)
	Plankton identification is difficult	Implementation phase	n/a	Major barrier (could be overcome with significantly more efforts)
	The technology is immature and imperfect	Operating phase	2	
	Shortage of scientific researchers	Implementation phase	1	
	Difficulty in dehydration: silt contains relatively high moisture.	Implementation phase	n/a	

Table 7. Technological barriers and relative ranking encountered by each city in developing NBS2 (Note rank 1: “most relevant barrier”; rank 2: “2nd most relevant barrier”; rank 3: “3rd most relevant barrier”)

Critical safety issues have also emerged during the implementation of the NBS (Table 8).

City	Safety issues	People involved
Turin	Building site machinery in operation	Workers
Ningbo	Onlookers (dredging curiosity for neighbors – security risks)	Visitors
	Dredging operation (operation of machinery, operating environment, stink of silt)	Workers

Table 8. Safety problems that are critical for the successful implementation of NBS2

5.3. Possible solutions

Table 9 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
Turin	Heterogeneity of the soil and identification of materials in compliance with National legal requirements	Procedure for modification of authoritative urban procedures that allow to use as reference the analytical composition of the destination site	In other Italian regions (e.g., Veneto, Tuscany, Liguria) the presence of substances not due to anthropogenic pollution, allows the legal limit values of the soils to be exceeded, provided that the natural origin of the excess concentrations is ascertained and demonstrated. The 'Natural background value' thus constitutes in effect the new legal reference within the territorial area in which it was defined. The procedure for reaching its determination is indicated in the “Operating Protocol for the determination of the underlying values”. At the regional level it is possible to create "Guidelines for the study of natural background values” with the aim of filling the gap in technical-regulatory plan.

			It will therefore be necessary to provide documentation of the 'geological compatibility' of the values measured for the new soils with respect to the geological conditions present in the territorial context to which they belong.
	Distance among excavation and destination site - transports costs		Incrementation of possible sites in which new soil is produced could reduce the distances in respect to the utilization sites and in turn transportation costs.
	Management of the soil building site	Apply normal construction site safety procedures	Apply normal construction site safety procedures
Ningbo	Heavy metals are difficult to remove from sediments	No solution found, NBS realization was stopped.	Bioremediation approaches, which use biological agents such as microorganisms (bacteria, fungi, algae) or plants for restoring the contaminated sites. Natural attenuation processes involve contaminant attenuation to harmless products through natural processes such as microbial degradation, volatilization, sorption and immobilization. The addition of compost or composting is one of the most cost-effective approaches to remediate contaminated soils because it can increase soil organic matter content and soil fertility. Composting could detoxify or stabilize toxic metals, PAHs and pesticides. Sorption of organic contaminants to soil organic matter can decrease the fraction of contaminant available to microorganisms for degradation. Bioaugmentation is applied by introducing specific microorganisms to decontaminate the soil. Phytoremediation consists of the use of plants to remediate contaminated sites. For remediation of metal contaminated sites, a good alter-

			native could be phytostabilization; it involves stabilization/immobilization of contaminants in the soil vi binding to the roots or complexation through root exudates, which reduces the bioavailability of contaminants, therefore, reduces the risk to food chain.
	Plankton identification is difficult	n.a	Have been developed in-situ automated sensors that help monitor and profile plankton. This equipment helps scientists to better understand the environmental factors and effects on plankton community dynamics.[3]
	The technology is immature and imperfect Shortage of scientific researchers	n.a	As NBS is a relatively new concept, there is a general lack of technical standards and guidelines for implementation and there is a lack of research quantifying the benefits of NBS remediation in different settings. With the greater diffusion of NBS, greater technical and scientific knowledge on the possibilities of application will be developed globally.
	Difficulty in dehydration: silt contains relatively high moisture	Traditional sludge dewatering belt filter press, centrifugal dehydrator and plate and frame filter press	Traditional sludge dewatering belt filter press, centrifugal dehydrator and plate and frame filter press.

Table 9. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 2)

[3] https://blog.fluidimaging.com/blog/technologies-for-plankton-identification-and-monitoring

5.4. Conclusions

Despite the major obstacles in the implementation of the production and use of regenerated soil are not of a technical nature but of an administrative nature (authorizations for the use of land from excavation works), some technical problems may arise.

In particular, the compliance between the analytical quality of the mixture of materials that constitute the new soil and the requirements to be met for use in urban application can be barriers to implementation.
In fact, in some cases some metals may have higher values than acceptable by law even if, in practice, lower than those that can be found by analyzing the urban land of the area in which the new soil is to be used.

One of the problems to consider is the fact that the new soil is composed as a structuring matrix of excavations materials. Such materials are to be considered and analyzed in large quantities.
The guarantee on the homogeneity of the chemical composition of the material is not easy to provide. The analytical step foresees a multiplicity of samplings at different depths in the heap of material on site.
The samples that can be done for chemical analyzes are not always representative of the chemical composition of the entire heap due to the possible non-homogeneity in the composition. In addition, an obstacle in the widespread use of this NBS could be represented by the distance between the site of destination and the place where the components of the new soil are extracted.
This in fact could negatively affect the business plan of this application which in itself could be economically advantageous.

From a technical point of view, the experiments conducted and in progress in Turin is useful to evaluate the TRL (Technology Readiness Level). Results of New Soil experimentation in Mirafiori Sud allow to evaluate the possibility to put on the market natural solutions capable of fully integrating into the demand of soil from public authorities for the construction of urban green areas, also considering the possibility to include new soil as a product in regional price lists and in public procurement specifications.
Turin is leading the way on this issue by attempting to walk along with the authorities in charge of the opening roads in the modification of price lists, tender specifications and authorization procedures. A consultation table is in place in the city of Turin with the aim of inserting the identification of quality of urban land in different areas, as it is, and to use it as a reference for the quality of materials to be used for the replenishment of new soil.
Thanks to the inclusive initiatives, the expectation is focused on obtaining useful indications for the public administration to regulate standards and update the bureaucratic process for the insertion of new soil in the urban environment.
Finally, from an economic perspective, the strategy is to connect the NBS to soil resources already active on the market, in order to structure a list of possible commercial links and collaborations.
For this scope a parallel dialogue is open with all the companies so far involved in new soil production and application for the definition of IPR and market strategy.

Ningbo's application of new soil and the procedure for new soil generation differed strongly from Turin. The main idea to exploit the lake's slime and sediments into new soil could be of interest because sometimes excess of nutrients in water causes eutrophication of water, while, if recovered and used as a nutrient for the soils, it can represent a resource for soil regeneration. However, the lake chosen by the city of Ningbo for the experimentation was a polluted lake due to discharges of both waste water and waste. Consequently, the components present in the bottom silt which were found during the first phase of activity (sampling and detection of pollutants) showed a strong presence of heavy metals.
This made the realization unfeasible; in fact, if this model is to be applied for the production of new soil, it is necessary to choose less polluted water bodies, at least by inorganic compounds, or to foresee an initial remediation or bioremediation phase after the laying of the soil before planting.
Furthermore, the other important technical problem in Ningbo for the new soil has to do with the need to dewatering the high-water content slime meaning it needs to be dehydrated before use. This inevitably generates a strong increase in costs due to the multiple technological process steps needed for reduce the water content.

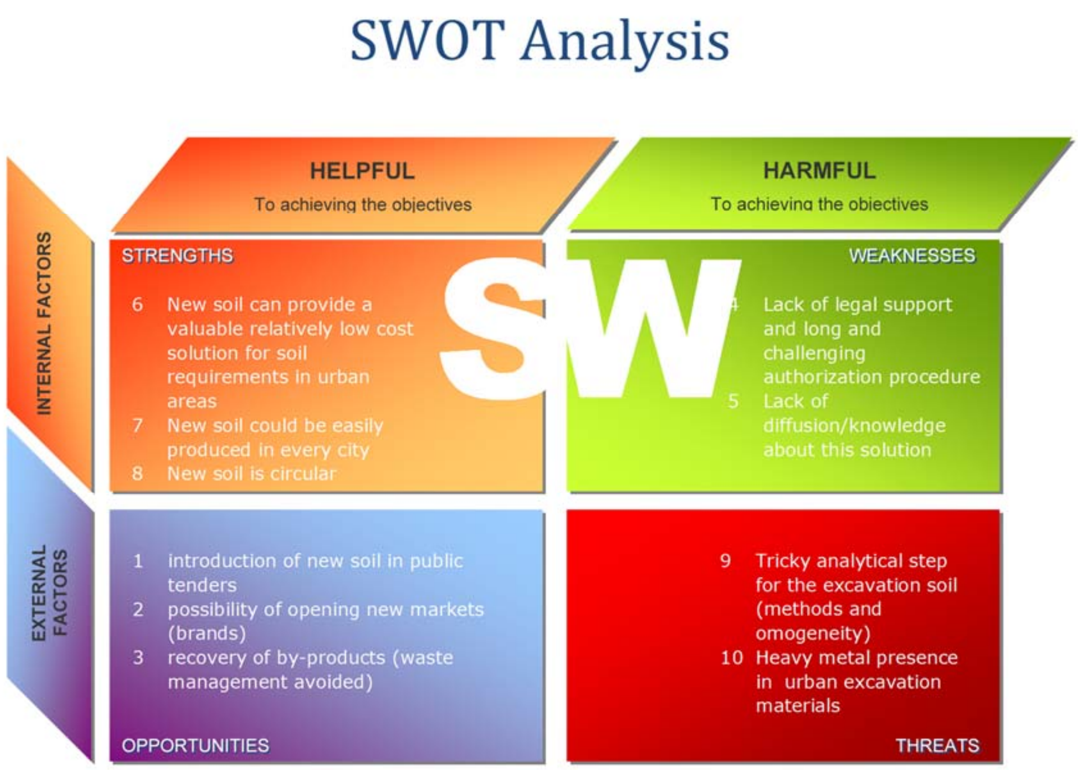

Figure 3. SWOT analysis of NBS 2

6. NBS 3: Community-based urban farming and gardening on post-industrial sites

6.1. Introduction

Post-industrial areas often lack green spaces for public use. Restoration of degraded urban areas and turning into productive community gardens can contributes to key societal challenges of urbanization as biodiversity and ecosystem services, agricultural intensification, resource efficiency, urban renewal and regeneration, land management, public health, social cohesion, and economic growth.

The aim is to build a business model for the transformation and management of post-industrial and metropolitan residual agricultural areas based on environmental sustainability and social equity; in fact, it is claimed that urban shared garden creates social, ecological and economic benefits for the residents and strongly contribute to the development and maintenance of quality life in the city.
The community initiatives involve marginalized groups and children favoring in this way social inclusion, education and new job opportunities.

6.2. Technological barriers and safety issues

Based on interviews collected, five cities have embarked on implementation of community-based urban farming and gardening, Turin (Italy), Zagreb (Croatia), Dortmund (Germany) and Ningbo (China) as front runners Cities, and Cluj-Napoca (Romania) as follower cities.

In Turin several activities have been developed: abandoned and degraded lands parts of the Piemonte Park (2.5 hectares of land) situated along the banks of Sangone river in Mirafiori District, have been redesigned and used for community urban gardens and social farming activities including teaching, job training and integration in the labor market. Gardens in Cascina Piemonte (Orti Generali) aims to foster a socially inclusive and community-driven neighborhood by enabling citizens to grow their own food.
Gardens of different dimensions are assigned to private citizens, families and schools, becoming a shared green space where people can meet and socialize.
Other partners have been involved as Municipality of Turin, who assigned the land, and University of Turin (DBios). Different stakeholders collaborate in educational, social inclusion and cohesion and communication activities as local associations (Mirafiori Community Foundation and Borgata Mirafiori) local health authorities (ASL) and Centro Libenter, association dealing with obesity and eating disorders. Coefficiente Clorifilla manages all activities and promote the collaboration within the parties.
Vegetable gardens have been created in all the primary schools of South Mirafiori district plus two kindergartens and one vocational school and educational activities focusing on the themes

of sustainable agriculture, biodiversity have been provided with the aim of improving the science background in the schools, increase their attractiveness and raise awareness of environmental sustainability.
Furthermore, urban gardens (installation of wooden boxes) close to private and social housing in public areas and a pollinator garden with an apiary for honey production have been developed on a former industrial site, linking NBS 3 with NBS 8.

In Dortmund the purpose of this NBS concerns two activities:

- Implementation of a 3000 m² food forest, a diverse planting of edible plants that attempts to mimic the ecosystems and patterns found in nature and designed for food production in the Huckarde district. It was developed on an unused area of the St. Urbanus community together with the scouts and the members of community. The food forest should also be a place of education for the local population to learn about sustainable cultivation methods for their own garden areas;
- Construction of self-irrigating raised beds on a section of the Gustav-Heinemann park, an area that is directly adjacent to a comprehensive school, interested in implementing an urban garden. In this way a collaboration with students and neighbors from the immediate surrounding is possible.

Ten years ago, a series of plots of land around Zagreb (Croatia) were left unused waiting for redevelopment, but as of spring 2013, these spaces were gradually given to the citizens for use as public spaces or urban gardens, building up on the idea that these community gardens for ecologically producing food that citizens can consume. Today, local people are growing tomatoes, lettuce, peppers, cucumbers and courgettes in 13 city gardens in Zagreb, that include over 2100 garden plots on a surface of 22.5 hectares. One of these gardens is in the Sesvete district, where the proGIreg project focuses its activities in the Croatian capital. The City Council and ZIPS came up with a plan for a new kind of garden equipped for people with psychological and physical disabilities and through proGIreg the city of Zagreb will open its first therapeutic gardens which will be specially designed with the aim of strengthening citizens sensory, cognitive, affective, nutritional, emotional and social potential.

In the city of Ningbo, the activity of NBS3 is planned to be developed along Moon Lake, situated in an urban and touristic area (Yuehu Street, Haishu District) that has often polluted water body. To tackle this issue aquatic plants are used to purify the water quality, improve the environment and re-nature a 5 km corridor surrounding the lake. In this way people are provided with high-quality green space.

Activity of Cluj-Napoca is focused on the enhancement of community gardens with the aim of attracting residents as a means to have productive green spaces, foster community engagement and food production. The area of work is the district of MĂNĂȘTUR.

The cities have developed or are developing NBS3 in different ways (Table 10).

City	Realization of NBS3	Current status of the NBS implementation
Turin	Mirafiori Castle's ruins recovery and new planting	Planned phase
	Gardens in Cascina Piemonte (Orti Generali)	Operating/Maintenance phase (after physical implementation)
	Pollinator friendly gardens (Orto WOW)	Operating/Maintenance phase (after physical implementation)
	"Ortomobile" micro vegetables gardens in boxes	Implementation phase
	Didactic gardens in schools	Operating/Maintenance phase (after physical implementation)
	Community school gardens	Implementation phase
	Gardens around the houses	Operating/Maintenance phase (after physical implementation)
Dortmund	Forest Garden St. Urbanus	Planning phase (before physical implementation) and Implementation phase
	Schulgarten Gustav Heinemann park	Planning phase (before physical implementation) and Implementation phase
Zagreb	Sesvete Therapeutic Garden	Planning phase (before physical implementation) and Implementation phase
	Expansion of Sesvete City Garden	Operating/Maintenance phase (after physical implementation)
Ningbo	Planting aquatic plants along the shore of the lake	Operating/Maintenance phase (after physical implementation)
Cluj Napoca	Community gardens	Planning implementation, operating/maintenance phase (different phase according to the type on intervention)

Table 10. Outline of how NBS3 is or was implemented for each city involved and degree of implementation

The cities in developing this NBS have encountered different technological barriers (Table 11).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
	Plant selection	Planning phase and implementation phase	1	Minor barrier (could be overcome with some more efforts)
	Insufficient technical background of the gardeners, they are hobbyists	Operating phase	1	Minor barrier (could be overcome with some more efforts)
	Maintenance and irrigation of green areas (attribution of responsibilities)	Operating phase	1	Major barrier (could be overcome with significantly more efforts)

Turin	Schools summer closures	Operating phase	1	Major barrier (could be overcome with significantly more efforts)
	Not arable areas: presence of material in the soil that make difficult the land reclamation	Planning phases	1	Minor barrier (could be overcome with some more efforts)
	Difficulty in the retrieval of water resources	Planning phases	2	Major barrier (could be overcome with significantly more efforts)
	Space availability	Planning phases	2	Minor barrier (could be overcome with some more efforts)
Dortmund	Soil contamination	Implementation phase	1	Barrier caused the development of alternative NBS
	Inappropriate tools to work the land	Implementation phase	2	
	Water access	Implementation phase	n.a	Minor barrier (could be overcome with some more efforts)
Zagreb	Water access	Implementation phase	n.a	Important barrier, but solutions are underway
Ningbo	Desilting of lake bottom	Implementation phase	1	Major barrier (could be overcome with significantly more efforts)
	Selection and maintenance of coastal vegetation	Implementation phase	2	Minor barrier (could be overcome with some more efforts)
	Digital tools and services are difficult to implement among seniors	Implementation phase	3	n.a

Table 11. Technological barriers and relative ranking encountered by each city in developing NBS3 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 12).

City	Safety issues	People involved
Turin	Allergy to bees	Workers/Users and Visitors
	Medium risk links to agricultural activities	Workers
Zagreb	Medium risk links to agricultural activities	Workers/Users
Dortmund	Safety concerning use of tools, pesticide treatment	Workers/Users
	Safety of children during the work activities	Workers/Users

Table 12. Safety problems that are critical for the successful implementation of NBS3

For the urban gardens in Cascais there was indeed no information on the technical barriers. The three interviewees mentioned that the technology they have been using in the existing, but also planning for future urban gardens is very rudimentary and they are not expecting any major issues or challenges. Also, all technology has been easy to implement.

6.3. Possible solutions

Table 13 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	**Technological barriers and safety issues**	**Solutions found from previous experiences and state of art**
Turin	Plant selection	Training courses for nurseryman on specific plants for pollinators
	Insufficient technical background of the gardeners, they are hobbyists	Training with the aim of improving competences
	Space availability	Planning of green urban spaces taking into consideration NBS implementation
	Maintenance and irrigation of green areas (attribution of responsibilities)	To allocate responsibilities with relative greater economic commitment To engage people for maintaining activity (for examples watering of plants and gardens). Implementation of and automatic irrigation system
	Not arable areas: presence of material in the soil that make land reclamation difficult	Soil remediation after characterization
	Difficulty in the retrieval of water resources	A canalization system can be provided
	Allergy to bees	Only the butterflies were kept and not the bees to avoid allergy problems
Zagreb	Water access	Build additional water channels to include both the city garden and the therapeutic garden
	Soil contamination	Soil remediation after characterization. Toxicological testing and soil conditioning methods
	Water access	Building of raised bed to store the water; Build of a well (in St. Urbanus) Drilling of wells, laying of water lines and installation of water taps
	Safety concerning use of tools, pesticide treatment	To comply with safety regulations

	Safety of children during the work activities	Personnel dedicated to keep vigilant the children
Ningbo	Selection and maintenance of coastal vegetation	Installation of phytodepurative plants on the lakeshore; these plants can help in purifying contaminated water. Regarding vegetation maintenance, a solution might be to train gardeners on specific plants species
	Desilting of lake bottom	For bottom removal interventions, a characterization of the bottom itself is necessary to keep form the increasing of the concentration of dissolved contaminants. For the use of silt, a characterization of the bottom is necessary to establish whether it is suitable for use as is or needs further interventions
	Selection of plant and animals	Involvement of experts
	Digital tools and services are difficult to implement among seniors	Training course for senior citizens or support of young volunteers
	Unavailability of equipment for transportation of goods and tools and bad logistic system	Planning of operation before implementation.

Table 13. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS3)

The interviews also revealed additional technological barriers that may occur at a later stage of development of this NBS and beyond the project:

In Turin there is the necessity to ensure the monitoring of pollinators over time, the interviewee proposes training courses for citizens even if it results in large efforts in terms of people and economic resources. Involving the stakeholders in general actions may link them to the infrastructure to contribute to maintaining the gardens.
In Dortmund vandalism is a barrier that could be overcome by building a fence, while it could be interesting to have a sensor network in order to provide, for example, mechanical/artificial irrigation.

The interviewee form Ningbo underlined the problem concerning the potential biological invasion from not native species.

6.4. Conclusions

The cities involved in the implementation of this NBS have highlighted several technological barriers and safety issues.

Some of them can be overcome by means of involving experts or organization of training courses, but these solutions would require additional budget.

Water access and irrigations issues emerged also in other NBS, so that the selection of plants. The reliable supply of water and electricity is important to meet basic needs of garden projects and the lack of them is a particular barrier. Gardeners and external experts emphasized that reliable water and electricity supplies including technical measures such as drilling wells, laying water lines, and installing water taps were essential.

Despite the problems encountered in Turin, many activities linked to community-based urban farming and gardening have been carried out. The same situation is expected in Zagreb, as the barriers that have been identified are considered only minor. The Sesvete 'City Garden' will initially have around 100 units (and can be extended to new areas at a later stage), therefore, once this experiment is deemed successful, the city will engage in scaling up of the garden to a bigger asset. It is also expected that food production will be organic and the water pumps will be run on solar power.

In Dortmund the plan to create a city farm and a large food forest on the Hansa cooking plant failed due to soil contamination , in fact this issue is considered as a major barrier in both literature and case studies. Managing the risks of contaminated soils has become an important topic in garden planning and management and relies on toxicological testing and soil conditioning methods. Uncertainties and difficulties of growing plants in contaminated soil were mentioned frequently in the literature and regarded as a significant risk in urban gardening.

Several technological barriers encountered in Ningbo aretoo generic to find context-specific solutions (for example, the desilting of the lake bottom).
In literature other problems are identified:

- Pests, since they reduce productivity and yield of the crop plants as gardeners may lack knowledge of interrelationships between crops and animals;Inadequate microclimate or weather conditions, including the unpredictability of the local weather and inadequate sunlight or wind conditions, so the right location and spatial orientation of the gardens are important;Lack of access to basic equipment and facilities for a proper (long-term) operation of gardens including sheds and toilets.

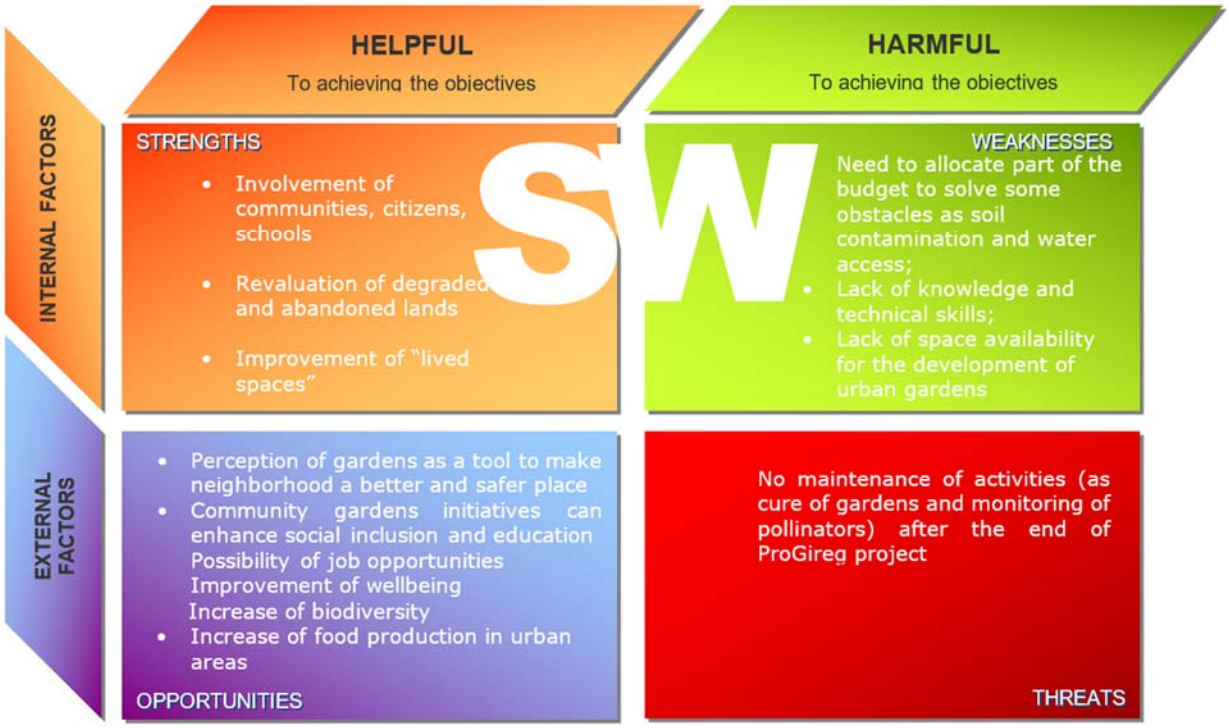

Figure 4. SWOT analysis of NBS 3

7. NBS 4: Aquaponics

7.1. Introduction

An aquaponics system can be seen as a union between a conventional recirculating aquaculture systems (RAS) and a hydroponic cultivation. The water recirculates in a loop as it flows from the fish tank to filtration units, before it is pumped into the hydroponic beds that are used as water reprocessing units. Essential elements are fish-rearing tanks, solid removal components (mechanical filtration, e.g. clarifiers, microscreens), biofilters (nitrification unit), a hydroponic component and a sump.

Aquaponic technology is considered to be ecologically friendly: it uses nonrenewable resources with very high efficacy as indicated by near zero-waste discharge [4]. In addition to its value as a food production system, smaller aquaponic units can be great assets as teaching tools for a wide range of subjects [5], demonstrating ecological cycles and may have roles as decorative elements at home or in public places. Moreover, the principle of combining fish and plant production can be implemented from low-tech level [6] to a high-tech state-of-art system.

[4] Sommerville et al. 2014
[5] Junge et al. 2014
[6] Trang and Brix 2014

Aquaponics implemented either as professional urban agriculture or as community farming could help alleviate the food deserts. Food produced locally by locals can lead to healthier diets and contribute to community-building. However, in urban settings, aquaponics can fulfill other functions besides food production. For example, it may serve as an educational tool in schools [7], interior greening (providing better climate in public buildings and homes), and as a unit in social institutions. In Italy, for example, a psychotherapy hospital implements aquaponics in rehabilitation for people after shock [8]. In Hungary, a passive house aquaponic system is used as part of the housing for autistic people [9].

7.2. Technological barriers and safety issues

Based on interviews collected, three cities have embarked on aquaponics systems, Dortmund (Germany), Zagreb (Croatia) and Turin (Italy).

In Dortmund two aquaponics greenhouses based on deep water culture (DWC) beds will be built on part of the site of Hansa coking plant in Dortmund Huckarde (area of 200 m^2 per greenhouses).
The greenhouses are intended to produce sustainable food for Huckarde, to advance the concept of aquaponics from a technical point of view and serve as a citizens learning venue for workshops . One of the two greenhouses will be modified to include passive solar technology. It is planned to integrate the cultivation products of one greenhouse in the form of rental garden concepts for the citizens of Huckarde, while the goods from the other greenhouse are to be sold to the future gastronomy/catering company located at the Hansa coking plant. Stakeholders to be involved are: Industrial Monument Foundation (IDS), the owner of the area, the residents of Huckarde district, schools and scouts.

Zagreb City, supported by the city of Dortmund and its partners from a technological point of view and the expertise provided by the University of Zagreb's Faculty of Agriculture, will also test the potential of an aquaponics system on a 100m^2 former industrial site. This process is still in the planning phase, and is expected to kick-off after the start of the implementation of the Therapeutic Garden.

Considering that aquaponics implementation is the focal point for the city of Dortmund, Turin will test its first ever aquaponics system, with the potential for future replication, supported by the Dortmund Living Lab. The aim is to develop and test innovative systems for horticulture: a collaborative system for the production and consumption of vegetables based on "aquaponic" cultivation techniques to demonstrate the feasibility of shared system at citizens' service and the sustainability of bio cultivation in urban area.

The three cities have developed or are developing NBS4 in different ways (Table 14).

[7] Junge et al. 2014
[8] Dr. Maurizio Borin, personal communication on April 24, 2015
[9] Otto Olajos, personal communication on December 11, 2015

City	Realization of NBS4	Current status of the NBS implementation
Dortmund	Community managed aquaponis system on the site of the Hansa- coking plant	Planning phase
Zagreb	Aquaponics test system	Planning phase
Turin	Aquaponics test system	Planning phase

Table 14. Outline of how NBS4 is or was implemented for each city involved and degree of implementation

Turin and Dortmund in developing this NBS have encountered different technological barriers (Table 15).

City	Technological barriers	Phase	Qualitative ranking of barriers
Dortmund	Soil contamination	Planning phase	Barrier causes the development of alternative NBS
	Technical planning of aquaponic system	Planning phase	Minor barrier (could be overcome with some more efforts)
	Seasonality	-	Minor barrier (could be overcome with some more efforts)
	Infiltration	Planning phase	-
Zagreb	Lack of technical expertise	Planning phase	
	Seasonality	Planning phase	Minor barrier (could be overcome with some more efforts)
Turin	Continuous maintenance and surveillance (biological live system)	Operating phase	Major barrier (could be overcome with significantly more efforts)

Table 15. Technological barriers and relative ranking encountered by each city in developing NBS4 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 16).

City	Safety issues	People involved
Dortmund	Drowing in the water basins (children)	Visitors
	Chemicals	Workers/Users
	Electricity	Workers/Users and visitors
	Gas pipeline	Workers/Users
	Underground/substrate	Workers/Users and visitors

Table 16. Safety problems that are critical for the successful implementation of NBS4

7.3. Possible solutions

Table 17 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
Dortmund	Soil contamination	The issue was overcome by selecting greenhouses that work with ground anchors and nothing that requires any kind of foundation.	
	Technical planning of aquaponic system	Involvement of experts	Some solutions can be taken by state of art of scientific literature
	Seasonality (low capacity of biofilter in winter)	Use of a moving bed filter or a filter where the medium is filtered, at least partly out of the filter in the place of a trickle filter	
	Necessity to have swamp tank as low as possible	Copy of a concept from aquaculture manufacturer: open channels	
	Infiltration	Problem solved thanks to the presence of a rainwater retention basin	
	Drowing in the water basins (children)	Children should not be left unattended	Danger label or physical barrier
	Chemicals	Safety training for the operator and use of DPI, as glasses and protective clothing	
	Electricity		Panels with information regarding the danger
	Gas pipeline (local gas line)	Construction of a fence	
	Underground/substrate	Everything is to be covered with topsoil, and paths with wood chips can be provided	
Turin	Continuous maintenance and surveillance (biological live system)		Involvement of dedicated staff.

			Some solutions can be taken by state of art of scientific literature

Table 17. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS4)

The interviewees suggest some solutions to overcome additional technological barriers that may occur at a later stage of implementation of this NBS.
In Dortmund an intelligent control system that relieves the operator of know-how and work is considered interesting, for example the implementation of the automatic feeder, as well as the involvement of trained fish farmers and gardener in order to move to the highest level of efficiency. Also, the implementation of energy-saving measures could be taken in account.

7.4. Conclusions

Dortmund is still in the planning phase because of land negotiations and the submission of preliminary building application documents. The technological barriers identified concerns several concrete issues often encountered in aquaponics systems; in general, good solutions are provided.
The soil contamination of the coking plant didn't affect the planning (greenhouses with ground anchors were selected), however it is important that everything can be decoupled by the contaminated soil; finally the solution in Dortmund has been to implement a different operational concepts, avoiding aquaponic implementation and converting it in a therapy garden.
This is currently in the planning phase.
Aquaponik Manufaktur and SWUAS are working on increasing the TRL by improving energy and resource optimization.

Turin and Zagreb were both still in the planning phase at the time of the interviews, therefore only one technical barrier was identified. In Zagreb, the city partners would expect some guidance from Dortmund and proGIreg partners on further development of aquaponics systems.

Literature offers many examples of aquaponic systems' technological barriers and suggestions for possible solutions; some of them are described below.

Seasonality can be taken in consideration since fluctuations in temperature might harm fish, plants, and nitrifying microorganisms [10]. The energy requirements of aquaponics are likely to be based on system configuration (design, species, scale, technologies) and geographic location (climate, available resources). This requirement constitutes a mandatory factor in regions with constantly and seasonally changing climatic conditions as well as in hot and arid climatic zones. Ensuring stable conditions may be achievable in equatorial areas without additional technology. Harnessing solar energy can be beneficial in order to either run climate control systems within greenhouses (e.g., via air conditioning operated by solar photovoltaic modules),

[10] Stark, 1996; Zhu, 2002

or to heat up a low-energy greenhouse with passive solar heating [11] . The latter option is practicable for small sized non-commercial (passive solar) greenhouses, but may not be suitable for larger greenhouses because of the high thermal resistance and high energy losses, associated with medium and large greenhouses. These larger structures may require alternative solutions. In countries such as Iceland and Japan, near-surface geothermal energy can be used by means of heat pumps and direct geothermal heat for maintaining the indoor temperature at the desired level [12]. Countries with comparatively unfavorable geological conditions still might assess possible options in terms of using waste heat of combined heat and power (CHP) units to heat the greenhouse during cold days [13] or cool them down during hot days. Those CHP units can mostly be found in combination with agricultural biogas plants (regarding this aspect there is quite potential in Germany) whereby surplus heat is fairly cheap for further disposal. Alternatively, they might consider using fish and plant species that are more suitable for the respective climatic conditions in order to avoid the expensive heating or cooling down of the water system [14].

Another technical issue is the large amount of energy consumption. In particular electricity represents the highest energetic cost. In order to reduce energy consumption two different strategies could be adopted: (1) using renewable energy sources and (2) reducing water pumping, using automatic systems for water dosing and positioning high efficiency pumps with inverters.

Moreover, it is suggested to increase the number of grow beds served by each pump. In fact, the right equilibrium between these two factors could limit the energy consumption, thus increasing the profitability of the system.

In aquaponic systems, emissions are mainly constituted by nitrogen and phosphorous released in the environment, as consequence of suspended solids and of dead lettuces removal and disposal. However, these wastes could be easily recycled in the farm and, according to circular economy strategies, used to produce co-products. Moreover, dead vegetables could be used for the production of humus through their mineralization by earthworms [15].

Regarding infrastructure, this technology could be upscaled at any farm size because it can be modular. The size of urban farms is determined by:

- ✓ The characteristic of the available area, which is necessarily fragmented in a city (brownfield sites, underutilized buildings and rooftops);
- ✓ The constraints posed by required crop production to achieve the targeted result. As a rule of thumb, the area required to break even for commercial operations is around 5000-6000 m^2.

Aquaponics farms can grow/expand by increasing the number of operating systems (or modules) or by going vertical: although they cannot be scaled up too far without steeply increasing construction and energy costs.

[11] Chan, 2010
[12] Bakos, 1999; Ragnarsson, 2003
[13] Ismail, 2009
[14] Goddek, 2015
[15] Forchino, 2017

Another crucial point is pH stabilization, as it is critical to all living organisms within a cycling system that includes fish, plants and bacteria. Two methods are suggested:

1) Nutritional supplementation is the most applied method in use. By adding carbonate, bicarbonate or hydroxide to the system, the pH value can temporarily be adjusted in line with the requirements. Also, they increase the alkalinity parameter that prevents large fluctuations in pH and thus keeps the system stable. The buffers should preferably be based on calcium, potassium, and magnesium compounds, since they compensate for a possible nutritional deficiency of those essential nutrients for plants [16]. Regarding the composition of the supplementation, it is important to seek a balance between those three elements.

2) A proposed alternative approach is the implementation of the fluidized lime-bed reactor concept [17] into the field of aquaponics. This water neutralization concept consists of the controlled addition of dissolved limestone ($CaCO_3$) to the acid water that leads to a continuous pH-rising effect due to carbonate solubilization that releases hydroxide anions (OH^-).

A characteristic problem in the field of aquaponics is the nutrient balance. Several studies have tackled this problem by decoupling fish and plant systems. However, in order to achieve both high nutrient levels for the plants and low nutrient and particulate loading in the fish tanks, suspended matter in the aquaculture component needs to be discharged and fertilizer needs to be added to the plants continuously. Seasonal differences between nutrients availability and demand intensify this problem. A possible solution could be developing desalination technology that can contribute to the nitrate balances in multi-loop aquaponics systems to attain optimal growth conditions for both fish and plants, by concentrating the hydroponic nutrient solution while diluting the RAS process water [18].

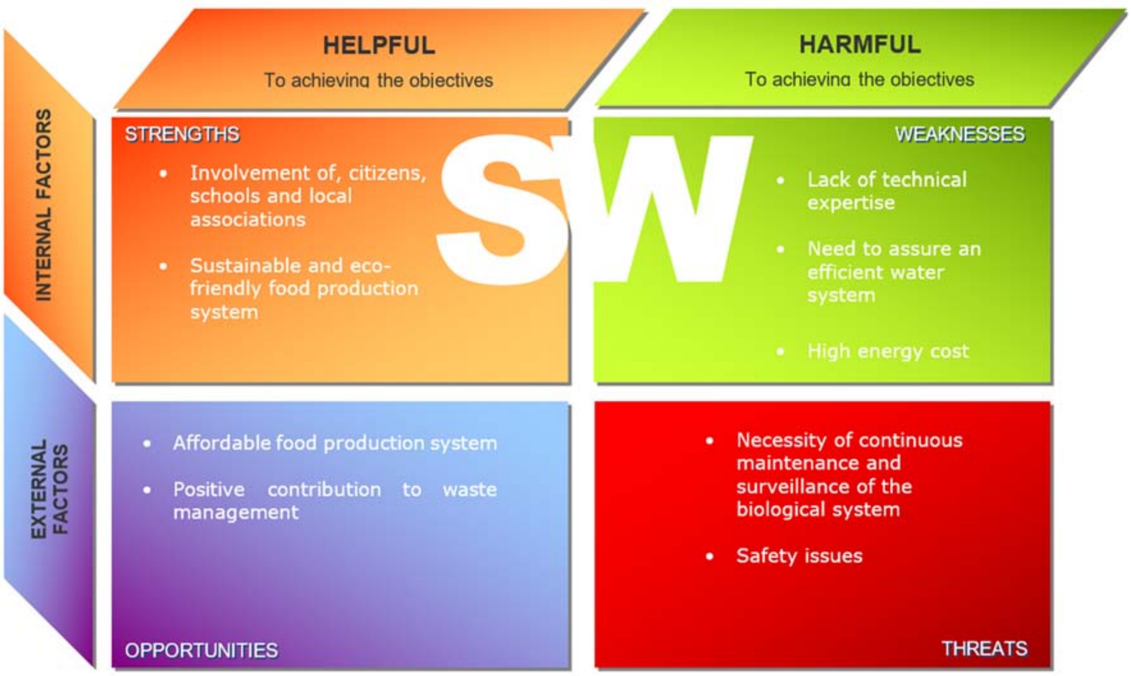

Figure 5. SWOT analysis of NBS 4

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[16] Rakocy, 2007
[17] Sverdrup, 1981
[18] Goddek, 2018

8. NBS 5: Capillary GI on walls and roofs

8.1. Introduction

Green roofs and green walls are building elements that conserve natural ecosystem values and functions.

Green roofs can be particularly effective in dense, urban environments, where they can compensate the increasing urbanization and the consequent degradation of the natural landscape. There are several benefits of green roofs, including longer roof lifespan, decreased noise pollution, reduced heating and cooling requirements (and consequently decreased energy consumption costs of the building), reduced and slowed stormwater runoff, capture of gaseous and particulate pollutants, alleviation of urban heat island effects and increased biodiversity.

Green walls are vertical gardens inside or outside a building. Their main benefit, in addition to many of those already listed for green roofs, is to reduce the surface temperature of a wall through evapotranspiration and shading.

8.2. Technological barriers and safety issues

Based on interviews collected, three cities have embarked on capillary GI on walls and roofs, Turin (Italy) and Zagreb (Croatia) as front-runner cities, and Zenica (Bosnia and Herzegovina), as follower city.

In Turin there are several projects on this NBS. The first activity focused on the realization of a new access to green roof on top of "Casa nel Parco". The "Casa nel Parco" is a building built in 2010, as part of the Urban Renewal Program of Via Artom, owned by the City of Turin: located in Via Panetti 1, it acts as the gateway to Colonnetti Park (Mirafiori Sud district). Creating a physical access and improving the existing green roof at "Casa nel Parco" could enhance its use for recreational activities by citizens, including disabled and aged people. Another purpose of this NBS is the preparation and construction of two green walls to be placed in an atrium of the "IC Salvemini" primary school. Specifically, the project foresees setting up a green wall with dimensions of 20 m^2; it will be positioned between 0 and 3 m above the ground floor. Another activity includes the realization of an outdoor green wall of 80 m^2 (made with self-supporting structure compared to the anchor wall) on a dormitory for homeless people, placed between 0 and 3 m above the ground floor; a clear space between the green wall and the building is guaranteed to allow any future maintenance work on the facade.

For the outdoor installation, the botanical characteristics of the seedlings will be chosen considering both the aesthetic elements and the species' origins, identifying local cultivar able to attract pollinator insects (bees, bumblebees and butterflies). This green wall will include an irrigation system; the Administration will prepare a water intake at a distance not exceeding 10 m from the point of preparation of the vertical wall. Lastly, a further activity concerns the realization of an extensive green roof on a public building, currently abandoned. It is realized using the green roof technology supplied by Harpo Group, composed by layered materials: antiroot waterproofing, water retention felt, drainage, storage and ventilation elements, filter sheet and 14 cm of substrate, produced by Harpo specifically for green roofs, mainly made by mineral-based material (volcanic lapillus, pumice). The green roof is intended to be a "natural lawn" obtained by sowing a proper mixture of seeds, that allows the use of this system to most of Italy. The kind of vegetation (at least 20 species belonging to the association *Chamaecytisus hirsutus* - *Chrysopogonetum grylli*) has been conceived in order to be a pasture for the bees hosted in the hives located nearby the building. A sub-irrigation system has been installed on the roof, under the substrate, realized by a serpentine of 16 mm pvc pipes with a pitch of 30 cm. The system is fed by a cistern placed in the nearby garden, with a capacity of 11.000 l for the accumulation of rainwater, pumped to the roof and connected to the downpipes of the building.

In Zenica, this NBS comprises vertical landscaping of walls and landscaping of roofs with adequate plants installed in appropriate supports and pots.

The cities have developed or are developing NBS5 in different ways (Table 18).

City	Realization of NBS5	Current status of the NBS implementation
Turin	Green roof at Casa nel Parco	Operating/Maintenance phase (after physical implementation)
	Green wall indoor at school	Planning phase (before physical implementation)
	Green wall outdoor on a homeless dormitory	Planning phase (before physical implementation)
	Green roof at WOW	Operating/Maintenance phase (after physical implementation)
Zagreb	Green Roof and Wall at Sljeme meat-processing factory	Planning phase (before physical implementation)
	Green Roof and Wall on other factory buildings at the same site.	Planning phase (before physical implementation)
Zenica	Green roofs and green walls	Planning phase (before physical implementation)

Table 18. Outline of how NBS5 is or was implemented for each city involved and degree of implementation

Turin, Zagreb and Zenica have encountered different technological barriers in developing this NBS (Table 19).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Turin	Structural verification on roofs (they must be structurally suitable for this kind of realization)	Planning phase	1	Barrier causes the development of alternative NBS

	Bearing capacity of the walls	Planning phase and Implementation phase	1	Major barrier (could be overcome with significantly more efforts)
	Accessibility on green roofs	Planning phase and Operating phase	1/2	Barrier causes the development of alternative NBS
	Loads on green roofs	Planning phase	2	Major barrier (could be overcome with significantly more efforts)
	Water accessibility	Planning phase	2	Minor barrier (could be overcome with some more efforts)
	Irrigation of green roofs	Planning phase	3	Minor barrier (could be overcome with some more efforts)
	Maintenance	Operating phase	3	Major barrier (could be overcome with significantly more efforts)
	Drain construction	Planning phase	3	Minor barrier (could be overcome with some more efforts)
Zagreb	Irrigation of green roofs	Planning phase	2	Minor barrier (could be overcome with some more efforts)
	Maintenance	Operating phase	3	Major barrier (could be overcome with significantly more efforts)
	Accessibility of green roof	Planning phase	3	Major barrier, as the factory is abandoned
Zenica	Lack of mechanization	Implementation phase and Operating phase	2	Major barrier (could be overcome with significantly more efforts)
	Weather	Planning phase, Implementation phase and Operating phase	2	Barrier causes the development of alternative NBS

Table 19. Technological barriers and relative ranking encountered by each city in developing NBS5 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 20).

City	Safety issues	People involved
Turin	Roof maintenance (lifeline)	Workers/Users
	Schools framework	Visitors
Zenica	Penetration of insects	Workers/Users
Zagreb	Roof maintenance	Workers/Users

Table 20. Safety problems that are critical for the successful implementation of NBS5

8.3. Possible solutions

Table 21 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	Technological barriers and safety issues	Solutions found or possible solutions from previous experiences and state of art
Turin	Loads on green roofs	It was necessary to do dimensioning and analysis of the loads; preliminary water load tests and static analyzes were needed to highlight the maximum load in cubic meters
	Irrigation of green roofs	It is linked to the type of plants chosen; for example, for green roofs a sub-irrigation system was chosen. Alternatively, a rainwater tank with booster pump can be used
	Accessibility on green roofs	Use of stairs inside the building or arrangement of external stairs (where possible)
	Structural verification on roofs (they must be structurally suitable for this kind of realization)	See the solution found for the loads
	Maintenance	Maintenance includes checking the vitality of the plants, which can be replaced if necessary, regular monitoring of the irrigation system and checking for any damage to the buildings. In particular, if there are problems of infiltration, detailed thermographic analysis must be carried out to establish where the infiltration is coming from. In some cases, it could be necessary to act radically and rebuild the drainage layer. Another solution for waterproofing the roof could be the use of silane or siloxane resins underneath the green roof layers
	Bearing capacity of the walls	Structural verification on walls or installation of self-supporting panels
	Water accessibility	In case of outdoor green wall, it is designed with an irrigation system included; it is necessary to prepare a water intake at a reasonable distance from the green wall. Alternatively, a rainwater tank with booster pump can be used
	Drain construction	
	Roof maintenance (lifeline)	A training on the use of the lifeline on the roof is needed for maintenance workers
	Schools framework	The infrastructure represented one more element against which children can run into; the solution was the creation of minimal service infrastructures (lockers etc.) not in iron but in concrete
Zagreb	Roof maintenance	Training, capacity building, hiring of experienced workers
	Water accessibility	Extension of pipeline network from neighboring buildings

Zenica	Lack of mechanization	It is necessary to build drainage channels before the realization of the green infrastructure so that the hydraulic load does not stagnate on the roof and does not overload the structure. In case of large areas, you could consider systems that collect rainwater or excess water from irrigation and then return it to circulation. In a study the construction of a sustainable green wall prototype is reported; in this prototype researchers designed and built a fertigation system that comprises two independent pipe networks: a pressurized (2-5 bar) fertigation injection system and an evacuation system that uses gravity to collect the drainage in a reserve tank from which it is later pumped, like all drainage pipes in a single end point is facilitated recirculation in the system [19]
	Weather	Choice of native plants that can withstand the local climate. It is necessary to consider that vegetation must also be used to facilitate the comfort of the environment and the thermal comfort of the building
	Penetration of insects	If there is the possibility of hive formation, beekeepers could be employed to relocate bees to appropriate locations or to green corridors

Table 21. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 5)

The interviews also revealed additional technological barriers that may occur at a later stage of implementation of this NBS:

- In Turin it may be necessary to replace plants and the problem of not having control over how natural grass grows have been highlighted.
- In Zenica the possible penetration of insects, rodents and reptiles through green walls into residential - business premises have been highlighted; the solution proposed by the interviewee is to use repellents and periodic cleaning and disinfection.

8.4. Conclusions

Turin, Zagreb and Zenica implemented this NBS in a similar way, but the obstacles that emerged from the interviews are very different. Turin faced concrete problems related to infrastructure such as accessibility to roofs, irrigation system, structural verification on roofs for loads or bearing capacities of walls. Zenica faced less problems related to the physical infrastructure but weather conditions or penetration of insects. In Zagreb, the problems are mainly connected to the nature of the buildings that have been selected for the implementation of this NBS, because abandoned buildings with limited access to their top have been chosen. Also, in Zagreb the irrigation would require the construction of a pipeline access and connection to

[19] Urrestarazu, M., & Burés, S. (2012). "Sustainable green walls in architecture", *Journal of Food, Agriculture & Environment Vol.10* (1): 792-794.

the main network or to neighboring buildings – though this would not be easy in the Sljeme Factory as land management and property issues could be arising in the long-term.

In some cases, the problems highlighted were too general, so that an adequate solution could not be found (for example, lack of mechanization).
All solutions applied to solve the obstacles encountered related to infrastructure difficulties have been listed in Table 21; in some cases, additional solutions have been provided from previous experiences or from the state of art, where possible.

Several technological barriers highlighted are not reflected in the state of art, so it is complicated to try to provide solutions from cases that have already occurred (for example, structural verification on roofs or bearing capacity of the walls).
In the state of art, it is possible to find additional technological barriers to those that emerged from the interviews.

The main barriers to green roofs that emerge from the state of art are related to the additional load, the soil media depth limited by building load restriction and the issue of water, which is a limiting factor for the rooftop environments. The solution for all these problems is the choice of specific plants, which do not need regular irrigations but have the ability to withstand drought and extreme climate conditions, needing less maintenance, ability to survive under minimal nutrients conditions; they should also be easily available and cost effective, reduce heat island phenomena and multiply rapidly. In general, sedums species are a popular choice due to good performance in different climate conditions as they are heat and drought resistant and only need a substrate depth of 7 cm for growth and performance [20].
Another barrier is the drainage layer; the main problems are the cost and disposal of this layer. The selection of an optimal, cost effective and environment-friendly drainage layer requires more research [20].
A further barrier is the fact that maintenance costs are high and green roofs require regular maintenance [20].
Moreover, most of the green roof components are usually made of polymer materials, but the construction of these polymers causes pollution. It is necessary to find another material that replaces these polymers [20].

The main barriers to implementing green walls and green facades from the state of art are related to limited plant selection or climate adaptability, slow surface coverage (plants sometimes require guidance to ensure that they cover the entire surface), spontaneous vegetation development, surface deterioration or plans detachment [21].
Other issues are maintenance problems, high installation cost, high environmental burden of some materials, high water and nutrients consumption, limited space for root development. Some examples already show sustainability concerns by using natural or recycled materials, integrating water recovery systems and sensors for water and nutrients minimization [21].

[20] Shafique, M., Kim, R., & Rafiq, M. (2018). "Green roofs benefits, opportunities and challenges- a review", *Renew. Sustain. Energy Rev. 90*: 757-773; https://doi.org/10.1016/j.rser.2018.04.006
[21] Manso, M., & Castro-Gomes, J. (2015). "Green wall systems: a review of their characteristics", *Renew. Sustain. Energy Rev. 41*: 863-871; https://doi.org/10.1016/j.rser.2014.07.203

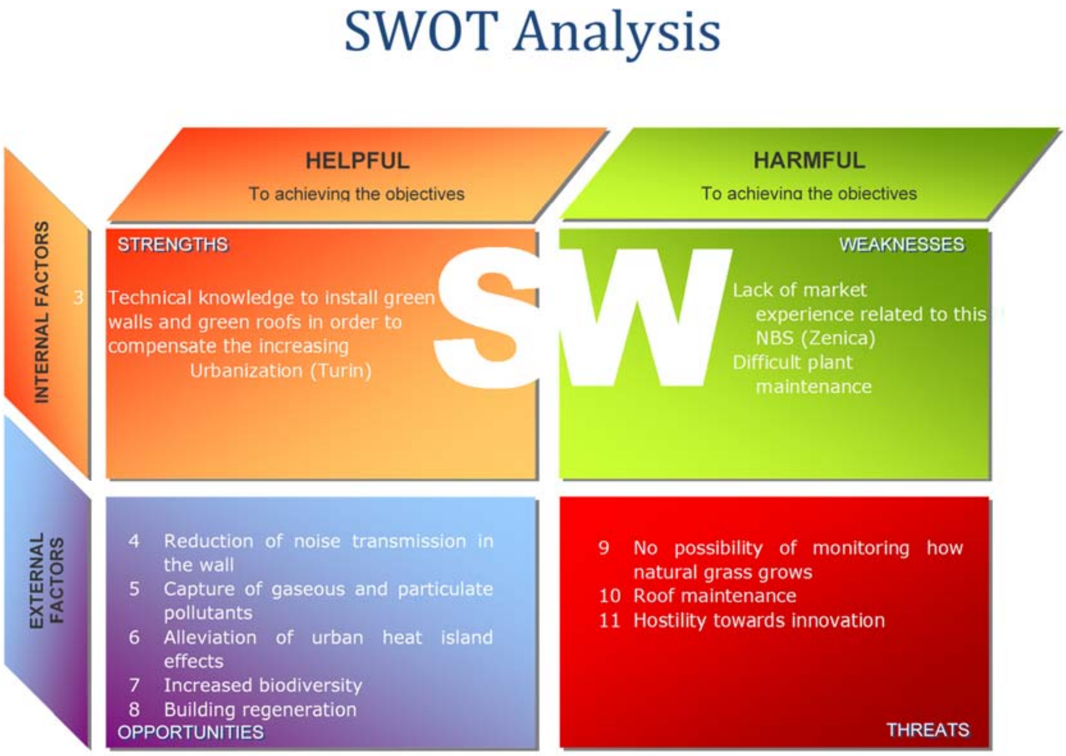

Figure 6. SWOT analysis of NBS 5

9. NBS 6: Making post-industrial sites and renatured river corridors accessible for local residents

9.1. Introduction

Rivers were an important factor during early industrialization because they were needed for transporting goods. For this reason, old-industrial areas are often part of river corridors. Nowadays in post-industrial cities rivers are often left derelict and inaccessible for locals. Derelict land on the riversides needs to be made accessible to achieve connectivity along and across the rivers. The renaturation of the rivers is not part of proGIreg; the focus of this NBS is to improve the accessibility to river corridors and post-industrial sites. The access to these areas makes the cities more livable and inclusive and helps to improve physical and mental health of residents.

9.2. Technological barriers and safety issues

Based on interviews collected, six cities have embarked on making post-industrial sites and renatured river corridors accessible for local residents, Turin (Italy), Zagreb (Croatia) and Dortmund (Germany) as front-runner cities, and Zenica (Bosnia and Herzegovina), Cluj-Napoca (Romania) and Piraeus (Greece) as follower cities.

In Turin the activity focuses on improving the green areas along the Sangone river and its connection, through green corridors, with the interior of the district, encouraging the colonization of the city by pollinator insects in order to maintain the biodiversity and making the citizens' walks more pleasant.

In Zagreb, a green corridor will connect the Living Lab to the Sava river, the ecosystems of the forest in the North with the river in the South, and the different parts of Sesvete being redeveloped. A cycling path will also connect the urban gardens to the neighbourhood of Novi Jelkovec (11,000 inhabitants).

In Dortmund, the purpose is to connect Huckarde district with Deusenberg and the Emscher bicycle path, encouraging walkability and connectivity with the Huckarde area. In fact, today Deusenberg is difficult to access for Huckarde citizens.

In Zenica the activity focused on creating green corridors by planting avenues of deciduous trees dominated by maple, linden and ash located along city roads and promenades. There are several benefits on implementing this NBS, both sanitary/hygienic (reduction of noise and harmful effects of exhaust gases, industrial gases and dust, oxygen production, reduction of temperatures extremes) and aesthetic (decorative reasons).

In Cluj-Napoca the purpose is to improve accessibility to the Someș river, integrating it in the life of the city, and to naturalize areas by providing public furniture that people can enjoy (for example, wooden structures or bench that create a specific type of interaction with the river; the materials used are easy to dismantle and move). Basically, the project consists in creating green corridors on the riverbanks (cycle paths, pedestrian alleys, but also gardens, more trees, leisure and sport areas) and to build interconnections between green areas. The main ambition is to re-naturalize the river banks in order to increase the quality of life in the city and to provide a sustainable mobility.

The cities have developed or are developing NBS6 in different ways (Table 22).

City	Realization of NBS6	Current status of the NBS implementation
Turin	Green corridors and local natural heritage enhancement	Implementation phase
Zagreb	Green corridor to connect Sesvete with Novi Jelkovec	Planning phase (before physical implementation)

Dortmund	Connection of Huckarde borough with the renatured Emscher river and Deusenberg sites	Planning phase (before physical implementation)
Zenica	Green corridors (avenues of trees along city roads and promenades)	Operating/Maintenance phase (after physical implementation)
Cluj-Napoca	Green corridors on river banks (cycle paths, pedestrian alleys)	Implementation phase
	Green interconnections between green spaces	-

Table 22. Outline of how NBS6 is or was implemented for each city involved and degree of implementation

The cities involved in developing this NBS have encountered different technological barriers (Table 23).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Turin	Difficulty finding some species (not present in local nurseries) and spontaneous plants	Implementation phase	1	Minor barriers (could be overcome with some more efforts)
Dortmund	Soil contamination	-	1	-
Zagreb	Soil contamination	-	1	
	Connection to streets and roads	-	1	Minor barrier (new updated plan underway)
Zenica	Soil	Operating phase	1/2	Major barrier (could be overcome with significantly more efforts)
	Lack of space (narrow streets)	Planning phase and Implementation phase	2	Barrier causes the development of alternative NBS
	Road maintenance	Operating phase	2/3	Major barrier (could be overcome with significantly more efforts)
	Anthropological soil	Implementation phase and Operating phase	2	Barrier causes the development of alternative NBS
	Difficulties to transform knowledge, practices and technologies into easy-replicable solutions	no information was received (NI)	(NI)	(NI)

Piraeus	Limited flexibility and adaptation mechanisms from a pilot project to permanent solutions	(NI)	(NI)	(NI)

Table 23. Technological barriers and relative ranking encountered by each city in developing NBS6 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 24).

City	Safety issues	People involved
Turin	Problems linked with allergy manifestation (plants and insects)	Workers/Users, Visitors
Zenica	Falling of trees branches	Workers/Users
Zagreb	Floor risk	Visitors
	Maintenance of corridor, holes and soil issues	Visitors
Cluj-Napoca	Drowning risk	Visitors
	Misuse of water sport equipment	Visitors
	Visitors not knowing how to interact with the temporary items	Visitors
	Flood risk	Visitors
	The hydroelectrical company infrastructure	Workers/Users, Visitors

Table 24. Safety problems that are critical for the successful implementation of NBS6

9.3. Possible solutions

The Table 25 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and the safety issues that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
Turin	Difficulty finding some species (not present in local nurseries) and spontaneous plants		Training of nurserymen on specific plants species
	Problems linked with allergy manifestation (plants and insects)		The use of antihistamines could be recommended. It would also be helpful to install information panels on the plants stimulating allergic reactions and on the periods of pollen production. Another useful measure could be the installation of weather stations to monitor the pollen count.

			It would be helpful to install information panels about the insect species that are present in green corridors that can cause allergy manifestation. It would be also useful to have stations with first aid kits, also containing antihistamines
Dortmund	Soil contamination		Soil remediation after characterization
Zagreb	Soil contamination		Soil remediation
Zenica	Soil		If the problem is the soil contamination, a solution could be the soil remediation after characterization
	Lack of space (narrow streets)		
	Road maintenance		If the problem is planning the road maintenance, it could be necessary making a general plan for routine, periodic and urgent maintenance
	Anthropological soil		If the problem is the soil contamination, a solution could be the soil remediation after characterization
	Falling of trees branches	If the problem is due to bad weather conditions, it could be partially alleviated by the use of a diagnostic tomograph	Regular pruning could be necessary
Cluj-Napoca	Drowning risk		In case of furniture in the water – platforms –, a solution could be installing railings along the perimeter of each furniture
	Misuse of water sport equipment		It could be helpful to install explanatory panels
	Visitors not knowing how to interact with the temporary items		It could be helpful to install explanatory panels
	Flood risk	Come up with an early warning system or something similar	

	The hydroelectrical company infrastructure		If there is a hydroelectrical infrastructure near the areas involved in the project, it could be necessary to secure the site
Piraeus	Difficulties to transform knowledge, practices and technologies into easy to replicate solutions	NI	NI
	Limited flexibility and adaptation mechanisms from a pilot project to permanent solutions	NI	NI

Table 25. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 6)

The interviews also revealed additional technological barriers and safety issues that may occur at a later stage of implementation of NBS.
In Zenica the risk of falling of branches due to tree diseases or bad weather conditions that could damage property or people has been highlighted. It is an almost unavoidable risk; it could be reduced by a regular pruning, but the risk still remains.

9.4. Conclusions

The cities involved in making post-industrial sites and renatured river corridors accessible for local residents, while implementing the NBS in a similar way, experienced different types of technological barriers.

Various technological barriers emerged from interviews resulted too generic to find proper solutions (for example, the issues encountered in Piraeus). In Zagreb, it seems that there are not major issues or barriers for the implementation of the green corridor between Sesvete and Novi Jelkovec.
In other cases, problems are unavoidable (for example, lack of space in Zenica) or almost unavoidable (for example, the risk of misuse of water sport equipment in Cluj-Napoca; it could be reduced by the installation of explanatory panels, but the risk still remains).
In some situations, possible solutions are given, even if the issue is not very clear (for example, the item “hydroelectrical company infrastructure” in Cluj-Napoca, or the items “soil” and “anthropological soil” in Zenica).

With regard to the specific case of Cluj-Napoca, the barriers that emerged from the interviews were purely administrative and bureaucratic; in fact, no strictly technological barriers were highlighted.

In addition, the technological barriers that emerged from the interviews are not reflected in the state of art, so it is complicated to try to provide solutions from cases that have already occurred.

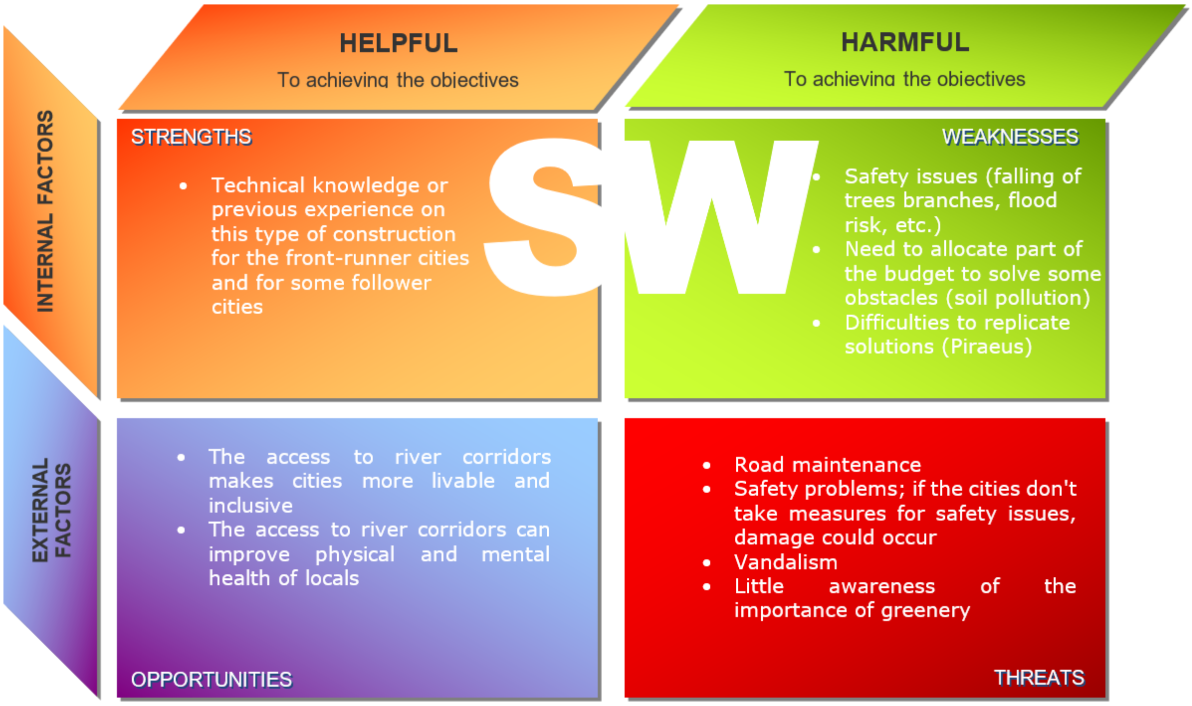

Figure 7. SWOT analysis of NBS 6

10. NBS 7: Establishing protocols and procedures for environmental compensation at local level

10.1. Introduction

Environmental compensation is the provision of positive environmental measures to correct, balance or otherwise make up for the loss of environmental resources [22]. The underlying idea is to maintain the overall quality of the environment in cases where environmental assets are damaged [22].

Current practices tend to be sporadic and insufficiently elaborated to be a quality basis for defining protocols or procedures for environmental compensation at local level.

[22] Persson, J. (2013). "Perceptions of environmental compensation in different scientific fields", *The International Journal of Environmental Studies 70*(4): 611-628.

The major focus of NBS7 is on finding instruments, policies, resources in order to integrate the measures for environmental compensation in traditional policies and urban planning procedures and to unlock funds, for example via adaptation funds, taxes or public- private partnerships.

10.2. Technological barriers and safety issues

Based on interviews collected, three cities have embarked on establishing procedures for environmental compensation al local level, the front-runner cities of Turin (Italy), Zagreb (Croatia) and Ningbo (China).

In Turin the activity deals with new environmental compensation instruments. The acquired supporting IT instrumentation is intended to provide a common framework to develop data collection and transformation workflows and, eventually, automate them. This is a prerequisite for the construction of thematic territorial databases of interest for different targets (internal and external to the PA). It is considered functional to the strategic planning of the project and its future spin-offs on a city and metropolitan scale.
This activity aims to provide IT tools and technologies able to allow the collection and systematization of all spatial and non-spatial data that will be considered of interest, on common cartographic databases for the project proGIreg team and, in the future, the City and the territory. The educational services together with the ICT department have recently started a similar path aimed at equipping themselves with territorial information tools (a GIS project, in this case) to geo-referencing administrative information on school infrastructures. The approach with which they are managing the process can be borrowed.

In Ningbo the activity focused on the restoration and monitoring of the water quality of Moon Lake, which is located in the center of Ningbo city. The restoration of the water quality is important because it can improve the living environment of citizens, enhance the happiness index, and contribute to the sustainable development of the city.

Zagreb will monitor and evaluate the environmental and social benefits of the proGIreg nature-based solutions implemented and, if successful, integrate nature-based solutions into planning procedures and policy development at local level. This process was still at planning phase at the period that interviews were conducted. There will be more updating during the second round of interviews in Spring 2021.

The three cities have developed or are developing NBS7 in different ways (Table 26).

City	Realization of NBS7	Current status of the NBS implementation
Turin	Tools for environmental compensation processes (School forest)	Implementation phase
Zagreb	Tools for environmental compensation processes	Planning phase

Ningbo	Restoration and monitoring of the water quality of Moon Lake	Operating/Maintenance phase (after physical implementation)

Table 26. Outline of how NBS7 is or was implemented for each city involved and degree of implementation

While Turin encountered no technological barriers during the development of this NBS, Ningbo encountered several ones (Table 27).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Ningbo	Maintain long-term stability of water quality	Operating phase	1	Major barrier (could be overcome with significantly efforts)
	The results of water quality monitoring at different sites are biased	Implementation phase	2	Major barrier (could be overcome with significantly efforts)
	Total nitrogen (TN) is too high	Operating phase	-	Major barrier (could be overcome with significantly efforts)
	Test results are susceptible to weather	Operating phase	-	Major barrier (could be overcome with significantly efforts)
	The desilting of the lake bottom (removal and utilization of lake bottom silt)	Implementation phase	1	Major barrier (could be overcome with significantly efforts)/ Minor barrier (could be overcome with some more efforts)
	The cultivation of lake shore vegetation (selection and maintenance of vegetation)	Implementation phase	2	Minor barrier (could be overcome with some more efforts)/ Major barrier (could be overcome with significantly efforts)

Table 27. Technological barriers and relative ranking encountered by each city in developing NBS7 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 28).

City	Safety issues	People involved
Ningbo	Experimental risks related to quality monitoring	Workers
	Safety education	Workers

Table 28. Safety problems that are critical for the successful implementation of NBS7

10.3. Possible solutions

The Table 29 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the obstacles that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
Ningbo	Maintain long-term stability of water quality		Monitoring the characteristics of the ecological and environmental conditions of the lake. If the problem is the presence of algae, a solution could be the integration of bioremediation with fish [23]
	The results of water quality monitoring at different sites are biased	Outliers can be eliminated by long time series detection	A solution is to take multiple samples in different points of the lake, characterizing in this way multiple portions of the lake. Another solution is to use an automatic sampler; the device, at pre-established time intervals, carries out the sampling
	Total nitrogen (TN) is too high		Phytodepuration
	Test results are susceptible to weather		
	The desilting of the lake bottom (removal and utilization of lake bottom silt)		For bottom removal interventions, a characterization of the bottom itself is necessary to avoid increasing concentration of dissolved contaminants. To use silt, a characterization of the lake sediment is necessary to establish whether it is suitable for use as it is or needs further interventions
	The cultivation of lake shore vegetation (selection and maintenance of vegetation)		If the problem is what kind of plants to grow, a solution could be the installation of phytodepurative plants on the lakeshore; these plants can help in purifying contaminated water. If the problem is vegetation maintenance, a solution might be to train gardeners on specific plants species

[23] Peng, G., Zhou, X., Xie, B., Huang, C., Uddin, M.M., Chen, X., & Huang, L. (2021). "Ecosystem stability and water quality improvement in a eutrophic shallow lake via long-term integrated biomanipulation in Southeast China", *Ecological Engineering Vol. 159*. https://doi.org/10.1016/j.ecoleng.2020.106119

	Experimental risks related to quality monitoring	Strengthen the training of water quality monitors to reduce experimental risks	
	Safety education of workers	Strengthen safety education of workers	

Table 29. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 7)

10.4. Conclusions

The cities involved in NBS7 implemented or are implementing the project in completely different ways. In fact, Turin and Zagreb developed tools for environmental compensation processes, while Ningbo focused on the restoration and monitoring of the water quality of a city lake.

As already noted, Turin and Zagreb have not encountered any technological barriers or security issues in implementing this NBS, in contrast to Ningbo.

Several technological barriers encountered in Ningbo are too generic to find appropriate solutions (for example, the desilting of the lake bottom).

In other cases, problems are unavoidable (for example, the fact that tests results are susceptible to weather conditions or that the results of water quality monitoring at different sites are biased, in fact it is quite normal that in lakes there is not a good mixing).

In addition, several technological barriers are not reflected in the state of art, so it is complicated to try to provide solutions from cases that have already occurred.

With regard to the safety issues detected, problems that emerged from interviews can be solved by holding specific training courses or safety training for workers, as revealed by the interviews.

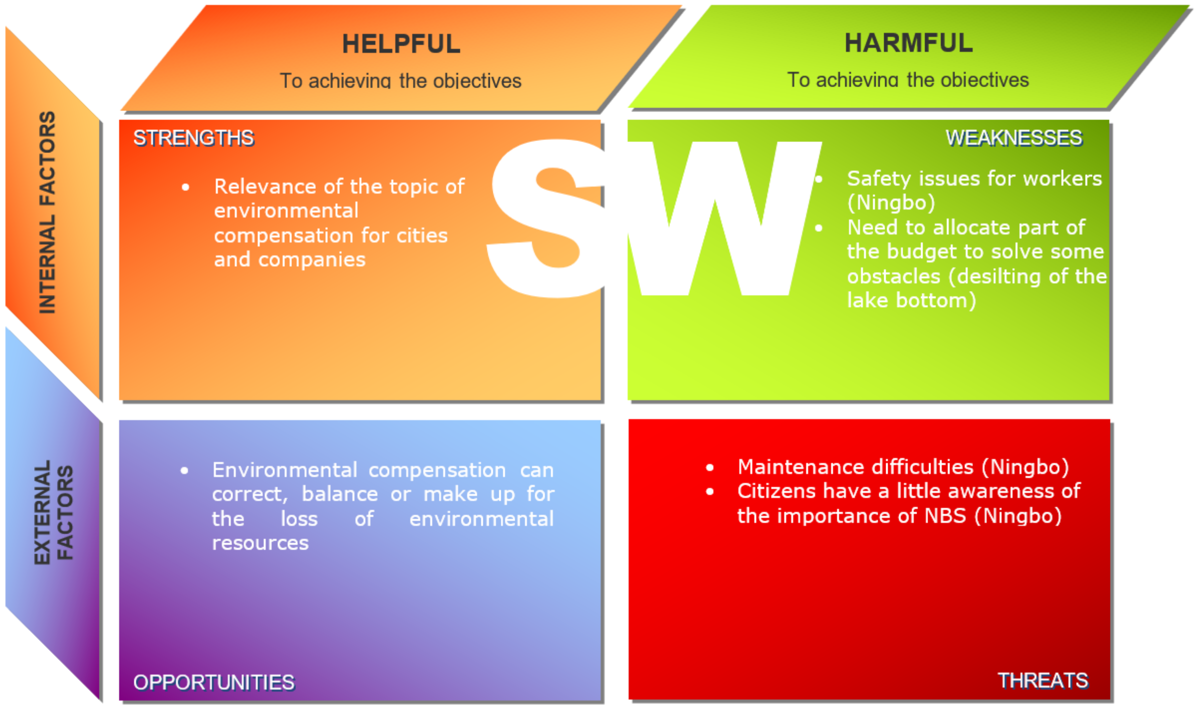

Figure 8. SWOT analysis of NBS 7

11. NBS 8: Pollinator biodiversity improvement activities and citizen science project

11.1. Introduction

Urbanization has caused the decline of pollinator populations, a threat not only to biodiversity but also to the agriculture industry: pollinators, in particular, benefit from the abundance of flowers while also providing a key step for fruit production. The ecology of urbanized landscapes is radically altered as surfaces are made impermeable [24], soil chemistry is altered, heat islands are formed [25] and species are lost [26,Fehler! Textmarke nicht definiert.]. Urban development has

[24] Montgomery, M. R. (2008). The urban transformation of the developing world. *Science 319*:761.

[25]Grimm NB, Faeth SH, Golubiewski NE, Redman CL, Wu JG, et al. (2008). Global change and the ecology of cities. *Science 319*: 756–760

[26] Czech, B. (2004). Urbanization as a threat to biodiversity: Trophic theory, economic geography, and implications for conservation land acquisition. Policies for managing urban growth and landscape change: a key to conservation in the 21st Century 265:8–13

increased rapidly since the onset of the industrial and agricultural revolutions [27]. Urbanization is known to have substantial negative effects on species diversity and carbon pools at a global scale [28,29]. Evidence suggesting the decline of pollinators is associated with a decline of insect-pollinated plants [30]. Research in urban environments has demonstrated a positive correlation between greenspace composition and pollinator frequency [31,Fehler! Textmarke nicht definiert.] ; comparing urban "green roofs", natural prairies and traditional greenspace parks, a high correlation between bee and plant community composition was find. Indeed, the more diverse the plant community the greater benefit to bees **Fehler! Textmarke nicht definiert.**[,Fehler! Textmarke nicht definiert.].

This NBS creates a network of green areas in cooperation with public and private social institutions (schools, mental health centres, social housing residents, refugee accommodation homes) actively involved in care, which provide places for people to meet and create new relationships and at the same time transform urban areas into a habitat for pollinator insects like bees and butterflies. These green spaces will be liveable areas not only as beautiful and shaded areas for humans but as feeding and nesting areas for pollinators. The success of the project will be evaluated trough monitoring pollinators that visit the new green areas to take nectar and to reproduce through a citizen and science approach.

Pollination is a model system for biodiversity-ecosystem functioning. As urban areas are growing, raising their value for pollinators must be considered as part of international biodiversity strategies. Urban areas can be made more pollinator-friendly by offering green areas as refuges and corridors of favourable habitat in a hostile matrix habitat.
Analysing bee biodiversity and biomonitoring (little, medium and big bees, honey, and pollen samples) are strategic methods to assess the environmental quality in a city.
Urban greening can support bees with trees, shrubs, herbaceous plants, flower beds, weeds as well as horticultural plants. The extent of green areas, plant species diversity and floral density can have positive effects on plant-pollinator interactions.
Many improvements can be made to the current practice in cities: increasing the availability of pollinator flora, reduction and suppression of pesticide use, education and awareness rising around the topic of pollination and beekeeping, monitoring campaigns using bees, bee products and butterflies as bio-indicators.

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[27] Lawson, Laura. 2005. City Bountiful: A Century of Community Gardening in America. Berkeley: University of California Press.

[28] Foley J.A DeFries R, Asner GP, Barford C, Bonan G, et al. (2005). Global consequences of land use. *Science 309*: 570–574

[29] Seto, K.C., Fragkias, M., Güneralp, B., & Reilly, M.K. (2011). A Meta-Analysis of Global Urban Land Expansion. *PLoS ONE 6*(8): e23777. doi:10.1371/journal.pone.0023777

[30] Biesmeijer J.C., Roberts, S. P. M., Reemer, M., Ohlemüller, R., Edwards, M., Peeters, T., Schaffers, A. P., Potts, S. G., Kleukers, R., Thomas, C. D., & Settele, J. (2006). Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science. 313*, 351–354. doi:10.1126/science.1127863.

[31] Tonietto, R., Fant, J., Ascher, J., Ellis, K., & Larkin, D. (2011). A comparison of be communities of Chicago green roofs, parks and prairies. *Landscape and Urban Planning, 103*(1), 102-108. Doi: 10.1016/j.landurban.2011.07.004. !

11.2. Technological barriers and safety issues

Based on interviews collected, three cities have embarked on pollinator gardens implementation, Turin (Italy) and Dortmund (Germany), as front runners Cities, and Piraeus as follower city.

In Turin the project has been developed in cooperation with a project named 'Farfalle in ToUr' a project initiated in Turin in 2014 by the collaboration between Local Health Company (LHC), Mental Health Centers and University of Turin (Department of Life Sciences and Systems Biology). People affected by mental or physical diseases become scientific disseminators after a training course supported by university researchers and carry out all the project activities in Mirafiori district: they create and take care of pollinator gardens, observe and record butterfly species, manage a website, breed caterpillars, taking part in public events and educational activities in schools, refugee centers, social housing, shelter facilities for the elderly. Pollinator gardens were implemented at several locations: Centro Aquilone, Scuola Torrazza, Casa Farinelli, Casa del Mondo Unito and Presidio Valletta for butterfly gardens and Orti Generali for transects. Each butterfly garden is created by an association or community that will take care of it. The main beneficiaries of this project are psychically and mentally disabled people. Other categories of disadvantaged people are involved: refugees, social housing guests, Alzheimer patients. In Turin, biodiversity monitoring involves floral, bees and butterfly surveys, in agreement with the EU Pollinators Initiative (2018). Pollinator monitoring focus area is Cascina Piemonte, a large green area (19 hectares) in Mirafiori Sud, located along the Sangone river.
Notably, biodiversity surveys in Cascina Piemonte represent the first Italian urban transect to be part of the European Butterfly Monitoring Scheme (eBMS), representing the only example of coupled monitoring between butterflies and bees in an urban context.

In Dortmund pollinator-friendly plants are introduced to the open slopes of the former-landfill site Deusenberg and the neighboring permaculture orchard. Local citizens will help monitoring numbers and species variety. During the planning phase a lawn of approximately one-hectare size on the eastern side near the top of the Deusenberg, the former landfill, had been selected for the implementation of this NBS. An on-site survey, conducted with biodiversity experts revealed that the selected site is already valuable for its biodiversity. Several protected plants and birds were identified. Due to the Corona virus pandemic the start of the implementation had to be shifted from spring 2020 to fall 2020. The sites that have been selected in the co-design process are under management of the same entity that is also going to perform the actual implementation. The seeds have been collectively chosen with input of the biodiversity experts.
One major obstacle of the Living Lab Dortmund is the lack of available implementation spaces. Therefore, the main effort has been put into the procurement of project area spaces. So far, the implementation stakeholder has been identified and has been active in developing the implementation details. Resources, in this case seeds, are in the procurement process. Depending on whether, kindergartens and elementary schools are going to open in the coming weeks and it would theoretically be possible to attempt to activate young citizens for monitoring the biodiversity in this pre-implementation summer. Biodiversity monitoring is a time-

consuming task that has no immediate monetary benefit. The lack of monetary incentive is the main barrier for biodiversity monitoring.

Piraeus, inspired by the actions for NBS 8 implemented into motion by Front Runner city – Turin, proposed to modify their current plan and shift planning and implementation of NBS 3- Community based Urban farms and gardens into NBS 8. No implementation has taken place so far being a follower city.

The cities have developed or are developing NBS8 in different ways (Table 30).

City	Realization of NBS8	Current status of the NBS implementation
Turin	Creation of six pollinator gardens	Operating and monitoring phase (after physical implementation)
Dortmund	Creation of one pollinator garden	Implementation phase
Piraeus	Creation of one pollinator garden	Pre-planning activities (follower city)

Table 30. Outline of how NBS8 is or was implemented for each city involved and degree of implementation

Turin and Dortmund in developing this NBS8 have encountered different technological barriers (Table 31).

City	Technological barriers	Phase	Rank	Qualitative ranking of barriers
Turin	Maintenance and irrigation - Attribution of responsibilities	Operating phase	1	Major barrier (could be overcome with significantly more efforts)
	Find native Cultivars – plant selection	Planning phase and implementation phase	3	Minor barrier (could be overcome with some more efforts)
	Space availability	Planning phase	3	Minor barrier (could be overcome with some more efforts)
	Need to establish a specific species-specific plant insect interaction	Planning phase		
	Selection of suitable nurseryman	Planning phase	no information was received	
Dortmund	Identification of suitable location	Planning phase		
	Maintenance based on volunteers	Operating phase		
	Selection of the right methods for mowing	Operating phase		

	Right preparation of soil and selection of plants	Planning and operation phases	
Piraeus	There is limited knowledge base for NBS	Planning phase	
	There are no established ways on how to approach the municipality when you have suggestions on innovation	Planning phase	
	Arising difficulties in planning and implementing NBS, especially when it would consider more permanent solutions and not only a pilot project	Planning phase	
	Difficulties to transform knowledge, practices and technologies into easy to replicate solutions	Planning phase	
	Limited flexibility and adaptation mechanisms from a pilot project to permanent solutions	Planning phase	

Table 31. Technological barriers and relative ranking encountered by each city in developing NBS8 (Note rank 1: "most relevant barrier"; rank 2: "2nd most relevant barrier"; rank 3: "3rd most relevant barrier")

Critical safety issues have also emerged during the implementation of the NBS (Table 32).

City	Safety issues	People involved
Turin	Allergy manifestation especially in schools	Workers and visitors
Dortmund	Insect/bee/bloom allergies	Workers and visitors
	Handling of devices	Workers

Table 32. Safety problems that are critical for the successful implementation of NBS8

11.3. Possible solutions

The Table 33 shows the solutions found or the possible solutions from previous experiences that can be eventually implemented to overcome the technological barriers and security problems that have emerged.

City	Technological barriers and safety issues	Solutions found	Possible solutions from previous experiences and state of art
	Selection of native cultivars suitable for pollinators	Work with nurserymen who believed in the project	Increase knowledge and culture about pollinators. Important environmental factors for bee richness and abundance were a high diversity of flowering plants, amount of grass or herbaceous cover and solar radiation within the areas of neighborhood[8].
	Maintenance and irrigation - Attribution of responsibilities	Realization of a management plan at urban level during the planning phase. Strong involvement of neighborhood and citizen committees.	
	Need to establish a specific species-specific plant insect interaction		Maintaining or restoring ecological community. Stopping use of pesticides
Turin	Allergy manifestation especially in schools	Only the butterflies were kept and not the bees to avoid allergy problems. In some European cities the selection of pollinators that do not generate allergy problems is a law.	Selection of non-dangerous insects (e.g butterflies). Moreover, a partial solution could be the positioning of information panels that inform about characteristics of the garden area and alert the most allergic people of the presence of insects in the garden.
	Maintenance based on volunteers	Involving schools day care centers and other entities interested in this topic. Introduce in each public office the figure of biodiversity manager to ensure that this topic is present in	Increasing the awareness of the local population about wild insects and of their significant pollinating role. Could be of help the organization of several exhibitions in which explain what a pollinator garden is and show urban social and environmental advantages of these NBS.

		many offices responsible for the planning of urban green spaces	
	Selection of the right methods for mowing	Selection of double layer mowing plants	Training about the green urban area best management for make it favorable to wild insects. Consider to involve experts in the team that manage the urban green design in Municipalities
	Right preparation of soil and selection of plants	Involve in the project biodiversity experts.	Fostering biodiversity
	Insect/bee/bloom allergies		Selection of non-dangerous insects (e.g butterflies). Moreover, a partial solution could be the positioning of information panels that inform about characteristics of the garden area and alert the most allergic people of the presence of insects in the garden.
	Handling of devices	Apply usual and relevant industrial safety regulation	Apply usual and relevant industrial safety regulation
Piraeus	There is limited technological knowledge	Provide information and concrete data for green infrastructures; increase awareness about the potential business opportunities offered by NBS; increase technical expertise in the Municipal departments	Increasing the awareness of the local population about wild insects and of their significant pollinating role. Could be of help the organization of several exhibitions in which explain what a pollinator garden is and show urban social and environmental advantages of these NBS.
	Arising difficulties in planning and implementing NBS, especially when it would consider more permanent solutions and not only a pilot project	Increase quantitative evidence of NBS success stories	Refer to previous success stories in Europe that refers and provide evaluation on how pollinators gardens could increase city quality of life and environments. Implement in the planning phase a strong citizens involvement for take advantages of public acceptance and cooperation (make more widespread the implementation thanks to private gardens). Make more

			and more evident how, with implementation of this low-cost practice politicians could gain public consent.

Table 33. Solutions found and other possible solutions to overcome technological barriers and safety issues (NBS 8)

11.4. Conclusions

The barriers, especially when looking at previous experiences developed (e.g Farfalle in ToUr), have so far been overcome thanks to a strong involvement of the parties and many dialogues aimed at increasing awareness of the importance of implementing these solutions for environmental and social welfare.

At European level, a relevant study has been published that provides useful information for the development of an EU initiative on pollinators that informs stakeholders about current initiatives and information sources [32]. This report highlights the lack of information about trends in pollinator abundance in the EU, but losses are probably significant. There are still important gaps in the knowledge of pollinator species distributions and how these are changing in response to climate change and land use change. There is currently no systematic monitoring of wild bees or hoverflies in any EU country but there are butterfly monitoring schemes in 17 EU countries. A systematic wild bee and hoverfly monitoring scheme has just been set up in the UK (Great Britain only), which could be replicated.

The UK scheme combines three approaches to gathering information:

1) Systematic sampling of pollinator diversity and abundance, varying in % of farm and semi-natural land cover, using a 1-person 1-day protocol comprising pan trapping, flower-insect timed counts, floral abundance counts and rapid habitat classification, targeting 4 visits per site per year;

2) Flower-insect timed counts carried out by volunteers in any urban or countryside location who observe insect flower visitation for a standard amount of time with online submission using the iRecord platform;

3) Support to ongoing non-systematic collection of pollinator occurrence by volunteer expert taxonomists belonging to biological recording societies, with refinement and development of statistical models by scientists/statisticians to extract trend estimates and develop indices from these long-term data sets.

Monitoring schemes require experts who validate and coordinate the information gathered, even if they rely on volunteers to gather data. There is a deficit of skilled bee and hoverfly

[32] Underwood, E., Darwin, G., & Gerritsen, E. (2017). Pollinator initiatives in EU Member States: Success factors and gaps. Report for European Commission under contract for provision of technical support related to Target 2 of the EU Biodiversity Strategy to 2020 – maintaining and restoring ecosystems and their services ENV.B.2/SER/2016/0018. Institute for European Environmental Policy, Brussels

identifiers to support research projects in most countries and many of the expert bee taxonomists in the EU are elderly. Several initiatives are addressing this issue by providing training courses in bee identification, some aimed at beginners, some at competent naturalists who wish to become experts, for example the SUPER-B network, BienABest in Germany, and the Bumblebee Conservation Trust in the UK. Pilot projects with innovative recording applications have demonstrated that website applications can, for example combined with picture-identification, increase the contribution to monitoring by non-experts especially for common species, by increasing the ease, timeliness and accuracy of field observations and enabling joint validation and quality control within a large community of observers.
A wide range of taxa can potentially play a role as pollinators of flowers, but in most situations, the most effective pollinators are bees, whilst flies and moths are important for some flower types. There is however a need for better understanding of the functional roles and status of different pollinator taxa groups for different flowering species. Urban initiatives are also important for the numbers of people they can reach with awareness raising activities, for example influencing private garden and public space management and consumer choices. Some good practices are to include pollinator needs in certifications or standards for public green spaces, set up award schemes or other public recognition of community initiatives that benefit pollinators, and incorporate pollinators and habitat creation in school programmes.

Despite the fact that NBS8 is not a solution particularly subject to technological barriers, some small obstacles are to be taken into consideration when it is decided to implement it at city level. The identification of the area to be used for this type of construction is not always simple at an administrative level. It is more a problem of urban architecture and public green choices than a technological one.

Technological solutions that could help to increase pollinating gardens are for example those of coupling this solution with that of green roofs and walls. In fact, if the construction of green roofs and walls is planned at urban level, these surfaces can be used for the planting of species useful for the proliferation of pollinating insects. Therefore, the second predominant problem mentioned by the stakeholders involved is the management and maintenance of the pollinating garden once it has been built. In the case of implementation on roofs and walls these must be accessible to allow shared management.
A solution envisaged could be that of strong social involvement: schools and centres for the disabled represent an excellent opportunity for mutual symbiosis by offering training and social integration to young people and disadvantaged groups in exchange for management support that would otherwise be onerous if managed privately. Current pollinator monitoring is still mostly done by scientists.
For achieving greater diffusion of the pollinating gardens, more training courses are needed (some have been made in proGIreg framework). Nevertheless, these trainings require many human resources. It would be necessary to dedicate time to training citizens to ensure the monitoring of the areas over time (more people and more economic resources).
One of the greatest challenges that needs to be faced is the lack of education and ongoing misconceptions. Most people do not know that there are many different groups of insects that have similar physical characteristics such as, bees, wasps, and hornets; however, these insects have significantly different ecological roles. However, with education, honeybees are

usually seen in a new, and completely separate light. A biodiversity monitoring scheme based also on general public could provide larger datasets; citizen science programs offer several advantages compared with traditional ones. Firstly, by relying on particular type of observers (gardeners monitoring butterfly in their garden) it is possible to access to potentially restricted areas. In fact, although representing a large part of the green spaces in urban areas, private gardens are hardly studied because of access restriction to private properties. Secondly, monitoring programs involving non-specialists allow gathering data over large spatial and temporal scales that could not be done by specialist as there is not enough manpower, and even if there was, the cost would be prohibitive [33]. Finally, taking part in such a scheme involves awareness raising, and hopefully, changes in observers' daily behaviour towards environment [34].

The final aim would be to reach autonomous self-managed green pollinators friendly areas. These kind of management agreements in relation to insect monitoring become even more important in the operational phase.
A solution that could however partially compensate for the lack of space is also to create widespread pollinating gardens by offering private individuals who have a garden (houses, condominiums and companies) the planting of species useful for the proliferation of pollinators. In this case the maintenance would be paid by the private individuals, who would be compensated by a free training support and, if necessary, the supply of the plants by the municipality. The solutions shown schematically in table 33 for overcoming the barriers highlighted are methodologies described in the literature and results of previous experiences.
The methods that allow to overcome the barriers in the implementation and diffusion of pollinator gardens at urban level can be summarized in the following key measures:
1. Implementing an ecological green space management plan
- Stopping the use of pesticides and introducing alternative methods of pest control;
- Introducing differentiated green space management, adapted to the various types of land use;
- Spacing out cutting work to leave green surfaces to grow taller, using centrifugal patterns and cutting the stems higher up;
- Maintaining natural environments and introducing specialized pro-biodiversity devices such as ponds, hedges, fallows, and insect hotels.

2. Providing high-quality food resources: adult bees mainly feed on nectar and pollen, and they feed their larvae a mixture of nectar and pollen; therefore, one of the fundamental elements of protecting wild bees involves encouraging the growth of suitable flora:
- Choose mostly native plants, adapted to the needs of native bee species and to the pedoclimatic conditions of the surrounding environment;
- Keep exotic plants to a strict minimum and shy away from horticultural plants with highly-modified flowers;

[33] Levrel, H., Fontaine, B., Henry, P. H., Jiguet, F., Julliard, R., Kerbiriou, C., & Couvet, D. (2010). Balancing state and volunteer investment in biodiversity monitoring for the implementation of CBD indicators: A French example. *Ecological Economics*, *69*, 1580–1586.

[34] Couvet, D., Jiguet, F., Julliard, R., Levrel, H., & Teyssedre, A. (2008). Enhancing citizen contributions to biodiversity science and public policy.*Interdisciplinary Science Reviews*, *33*(1), 95–103. !

- In plantings and flowerbeds, seek to gain a variety of plant species and flowering periods;
- Encourage the growth of self-seeding plants in numerous areas spread out across the entire territory.

3. Providing nesting sites: given that swathes of natural habitats are being destroyed in agricultural areas, such as hedges and thickets, certain wild bee species are homing in our cities to find refuge in our walls and along our pathways. Therefore, it is more and more needed to increase favourable natural habitats for bees:

- Replace neatly clipped mowing techniques by cutting higher up the stems;
- The number of cuts during the flying season resulted a key factor that heavily affects insects' richness and abundance [35]. High mowing rates produce a reduction in the availability of larval host plants, as well as a drastic decrease of nectar sources [36,37]. Some techniques, such as flail or rotary cutting, usually kill the larvae during mowing operations [38]. Shrub-rich hedgerows improve habitat quality by providing shelter and, depending on the floristic composition, also by providing nectar and host plants.
- Conserve unmanaged areas by letting fallow to grow over naturally, or plant wild hedgerows;
- Limit waterproof surfaces as much as possible.

Despite greater management problems for public gardens in urban areas, recent scientific findings show that given the destruction of habitats in agricultural and semi-natural zones areas, and with the level of pesticide contamination of our environments, urban and residential areas can provide a welcome refuge for numerous species. And this applies especially to wild bees in particular. Indeed, urban and peri-urban areas offer several advantageous features to wild bees:

- There are fewer pesticide applications than in conventional intensive farming areas;
- Cities are 2 to 3 degrees warmer than the surrounding countryside, and bees are generally thermophilic insects that are attracted to warm environments for building their nests;
- Cities also provide surprising nesting opportunities: cracks in uneven walls, piles of wood or sand, patches of exposed dirt and trampled ground.

Yet these advantages should be further reinforced by appropriate measures designed to meet the basic needs of wild bees to increase their abundance and diversity. Indeed, green spaces

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[35] Bruppacher, L., Pellet, J., Arlettaz, R., & Humbert, J.-Y. (2016). Simple modifications of mowing regime promote butterflies in extensively managed meadows: evidence from field-scale experiments. *Biol. Conserv. 196*, 196–202. **http://dx.doi.org/10.1016/j.biocon.2016.02.018**.

[36] Bubová, T., Vrabec, V., Kulma, M., & Nowicki, P. (2015). Land management impacts on European butterflies of conservation concern: a review. *J. Insect Conserv. 19*, 805–821. **http://dx.doi.org/10.1007/s10841-015-9819-9**.

[37] Halbritter, D.A., Daniels, J.C., Whitaker, D.C., & Huang, L. (2015). Reducing mowing frequency increases floral resource and butterfly (Lepidoptera: Hesperioidea and Papilionoidea) abundance in managed roadside margins. *Florida Entomol. 98*,1081–1092. **http://dx.doi.org/10.1653/024.098.0412**.

[38] Humbert, J.-Y., Ghazoul, J., & Walter, T. (2009). Meadow harvesting techniques and their impacts on field fauna. *Agric. Ecosyst. Environ. 130*, 1–8. **http://dx.doi.org/10.1016/j.agee.2008.11.014**.

are not all automatically pro-biodiversity environments by their very nature alone. Their positive impact depends heavily on the specific choices made in terms of management and urban greening.

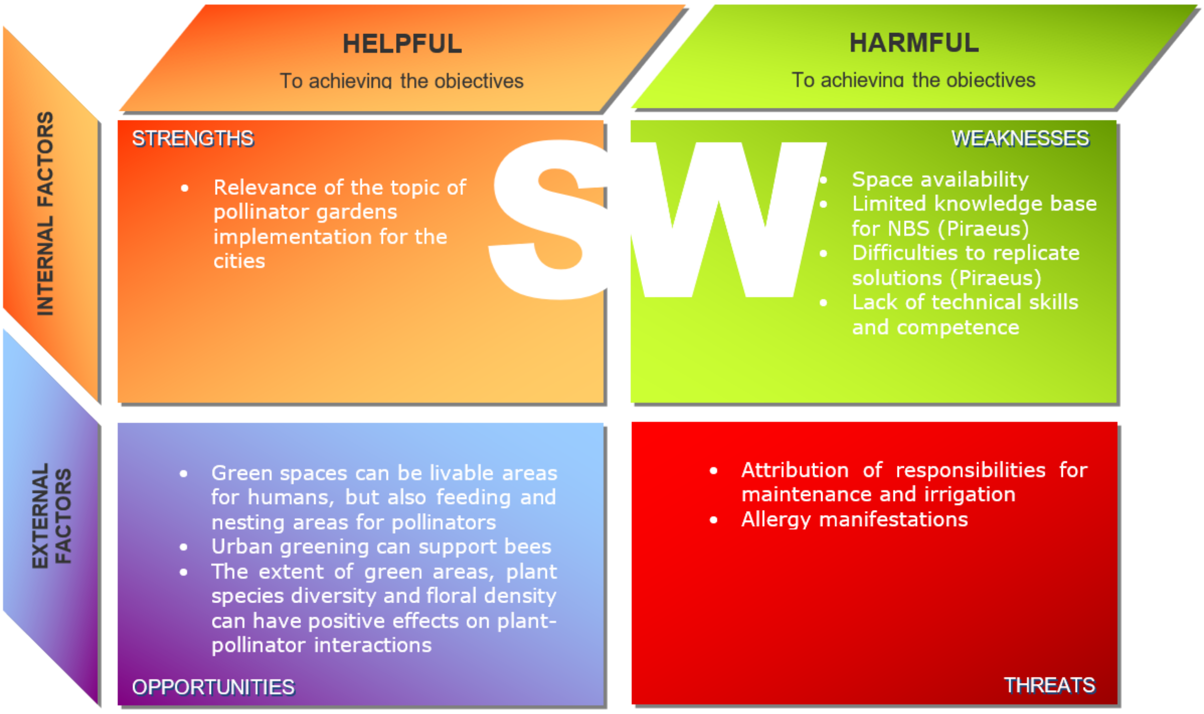

Figure 9. SWOT analysis of NBS 8

12. GENERAL CONCLUSION

In general, since these are solutions that involve the use of plants, they are subject to and regulated by the life cycle of plants and therefore require constant maintenance. and this, if not automated, involves the use of human resources who must be involved in the management beyond the useful life of the implementation projects.

Safety issues that emerged from the interviews can be solved by holding specific training courses or safety, providing the appropriate personal protective equipment and training for workers. As far as the visitors are concerned, it almost never highlighted problems except for allergic situations that can be easily overcome by informing users through information panels and by selecting less dangerous pollinating insects such as butterflies.

Main results arising from the analysis of the interviews at a general level are:

- There is a high technological readiness level of the construction techniques to support the realization of the nature-based solutions; however, at urban level, these applications are not yet widespread
- Success in management terms when associations of citizens and/or schoolchildren or communities of disabled people are involved directly in operating and maintenance with mutual benefits in terms of increasing knowledge and decreasing costs.
- Impacts monitoring is still ongoing in all cases

General outcomes and considerations could be summarised as follow:

- the realization of nature-based solutions does not present univocal technological solutions but must be tailored to the different urban framework and so must be analysed in each reference context
- despite lessons learned providing guidelines from previous cases of similar applications, it will not always be sufficient to avoid context-specific problems

The main recommendations common to all NBS are:

→ the need of an initial strategic plan at urban level when applying an NBS
→ the preliminary creation of a multidisciplinary work team that also includes representatives of the citizens of the identified area who can inform citizens about benefits for them of the new envisaged implementations;
→ a good analysis of the territory that allows to immediately identify the most suitable spaces;
→ the creation of a support at the municipal administration level that helps creating the legislative and authorization framework essential for the development of NBS.