proGIreg

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Deliverable 5.5

Collective scheme / report of technological and non-technological barriers

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Partner organisations

No.	Name	Short name	Country
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2	Local Governments for Sustainability	ICLEI	Germany
3	Environment Park	ENVIPARK	Italy

Abbreviations

Del.: Deliverable

FC: Follower Cities

FRC: Front-Runner Cities

NBS: nature-based solutions

proGIreg: productive Green Infrastructure for post-industrial urban regeneration

TRL: Technology Readiness Level

WP: Work Package

Executive Summary

This report bundles the proGIreg project's findings on barriers and solutions applied to overcome barriers when planning, implementing, and maintaining NBS. Based on the previous four Deliverables of WP5 "Market readiness, barriers, and upscaling", the findings and discussions are built on two rounds of empirical research. Firstly, interviews with key stakeholders for each NBS in proGIreg's FRC and FC in 2020 and, secondly, NBS-specific workshops with FRC representatives in 2021. Synthesised results of the interviews on technological and non-technological barriers served as starting point for the workshops in 2021. The workshops took place between June and September 2021. In early summer, the workshops focused on the further progressed NBS developments, while the NBS, which are still in its planning or early implementation phase, were discussed in September 2021. The workshops focused on the FRC only; the Follower Cities are learning from the experiences of the FRC. Follower Cities can take this report on barriers and applied solutions to overcome them when developing NBS. They are currently implementing the roadmap to urban planning via knowledge transfer from the experiences of the FRC (s. WP 2, Task 2.3). The intended replication activities, including the replication events, of project's WP 6 are building an important format for this. Each of the barrier workshops focused on one specific NBS, except the merged NBS 4 and 5 workshop. All workshops followed the same structure by using the online collaborative whiteboard platform *miro*. Each workshop consisted of three main topics:

- → Update on the assessment of barriers reported already during the interviews of 2020,
- → Nomination and assessment of newly emerged barriers, and
- → Nomination and assessment of solutions identified/applied to overcome barriers.

The workshops' *miro* board outcomes as well as the verbal discussions were used as the main resources to synthesise the barriers and solutions.

The interviews' and workshops' outcomes on barriers and solutions show similarities, but also differences between NBS – also with regard to the advancement of NBS development (co-design, co-implementation or co-maintenance phase). Administrative/institutional barriers build the main challenges during the planning/co-design phase of NBS developments – partly exacerbated by additional barriers: administrative/institutional and technological barriers prevail in the planning/co-design phase of NBS 2 (new soil), 4 (Aquaponics), and 5 (capillary GI). This dominance of administrative/institutional barriers is no longer true for the implementation and maintenance phase of NBS developments. Suitable and well-defined implementation plans and co-design processes allow overcoming administrative/institutional barriers – including also required permissions from municipalities. During implementation, interviewees and workshop participants emphasized strongly the importance of technological barriers, often NBS-specific, and financial barriers. At this stage, it is too early to detect specific patterns during the co-maintenance phase of the NBS due to delays of some NBS interventions. So far, most barriers concern social, technological, but also financial challenges risking longer-term NBS advancements. Apart from the time of NBS development (planning/co-design, co-implementation, and co-maintenance/co-management) barriers occur partly very specifically for one or few NBS, while other barriers are named more often allowing the

conclusion that these barriers tend to be of overarching nature. Barriers that apply to several NBS are:

- → bureaucracy/lengthy municipal processes (administrative/institutional barrier),
- → soil contamination, pollution (technological barrier),
- → lack of expertise, knowledge, and skills (technological barrier),
- → limited budget (financial barrier),
- → long-term maintenance (technological and financial barrier), and
- → Covid19-related restrictions.

This report's chapters on all eight NBS implemented in proGIreg as well as the discussions are dedicated to frequently raised, but also additional barriers, and solutions. Additionally, the findings from the proGIreg cities are cross-referenced with knowledge from outside the project. Given the available and justifiable level of detail, the findings substantiate the main results of the empirical research on barriers and solutions to overcome them.

Administrative/institutional barriers have to be solved mainly internally in municipalities or other public authorities. This can be done via networking and cooperation, but it is also needed to inform other departments on the advantages and benefits of NBS developments. The key to overcome technological barriers is for many NBS the consultation of experts and hiring/ordering of externals, including companies. Furthermore, in some cases peer education, training, and capacity building could also achieve the knowledge required to continue with the NBS development successfully. Increasing costs for NBS implementations could for some NBS be solved by recruiting additional budgets outside proGIreg. Suitable negotiation processes are needed to bring together different interests and stand points for joint decision-making processes.

Overall, it appears of utmost importance to integrate (productive) Green Infrastructure and NBS into administrative and institutional frameworks. Here, it is fundamental not only to add these new green interventions into existing standards, norms, and regulations, but providing appropriate protocols and procedures to allow widespread distribution and replication of NBS on post-industrial sites, but more generally in densely populated urban areas. This is building one of the core activities in the project's Follower Cities with the aim to set up strategies to help the integration of NBS into the local urban planning framework (Task 2.3; Deliverable 2.7). Replication activities (WP 6), including replication events, are key formats for that. Political will, successful and convincing case study examples from proGIreg and other NBS EU HORIZON 2020 sister projects, and a shift in performing administrative processes, such as building permissions or other types of required planning permissions to approve NBS developments and advancements, are important step stones on this path. While the majority of proGIreg's NBS provide individual solutions for specific sites with specific green implementations, NBS 7 aims to establish protocols and procedures, which demonstrate how to integrate NBS into legal frameworks, regulatory and planning domains. Thus, when being successful with NBS 7 in the cities concerned, this shift towards co-governance is potentially one of the main achievements – together with other key components of the project, mainly the TRL increase for the eight NBS, detailed benefit assessments, and integration of NBS into (partly) self-sustained business models.

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:

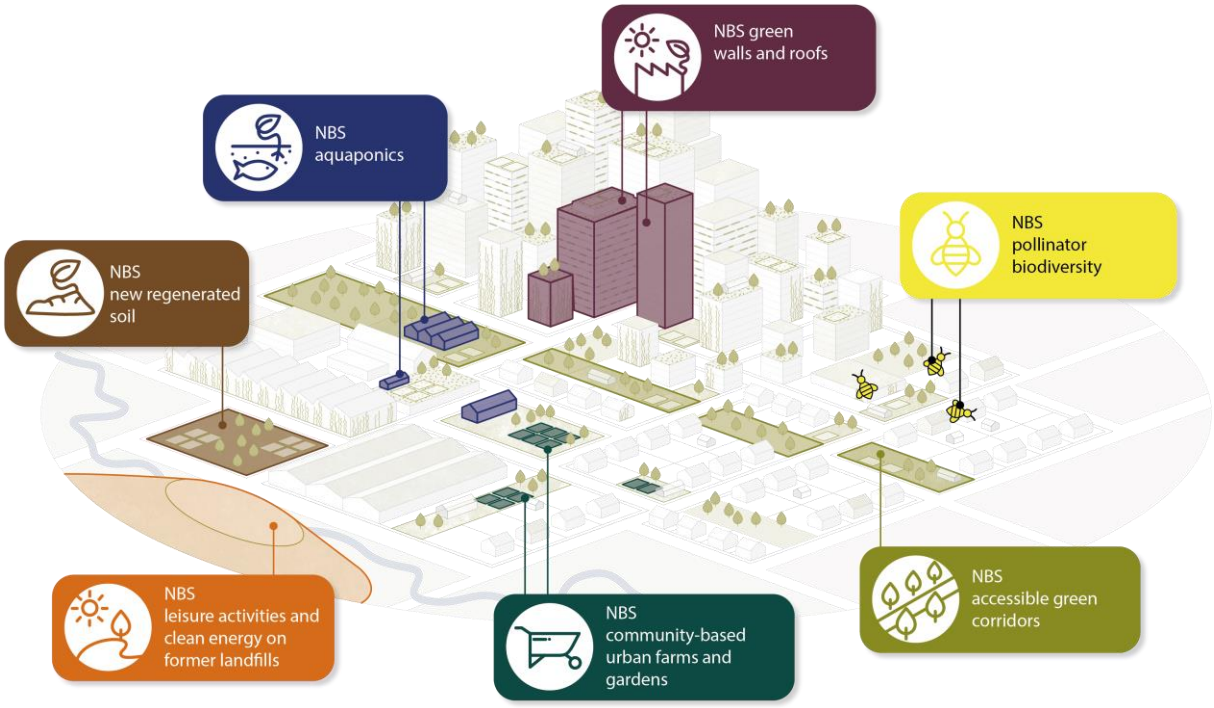

Figure 1. Spatial representation of proGIreg NBS (RWTH)

- → 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 collective scheme/report of technological and non-technological barriers (Del. 5.5) is part of WP 5 “Market readiness, barriers, and upscaling” of the EU HORIZON 2020 project proGIreg. WP 5 aims at detecting barriers to implement NBS, to find solutions to overcome them, and to develop a catalogue of business models for NBS, 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 require 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?**

WP 5 consists of three tasks, whereof two focus on barriers (s. Figure 2): 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. Following the development of a standardized questionnaire (Del. 5.1), personal interviews were carried out with key actors involved in and responsible for the NBS development in each FRC. These interviews build the primary data for the reports on technological (Del. 5.2) and non-technological barriers (Del. 5.3). Additionally, barriers beyond proGIreg were collected and analysed by taking advantage of the global city network of WP 5 task leader ICLEI (Del. 5.4). The collective scheme/report of technological and non-technological barriers (Del. 5.5) represents the fifth and final report on barriers, providing a synopsis of barriers and solutions to overcome them with the aim to support urban regeneration with NBS.

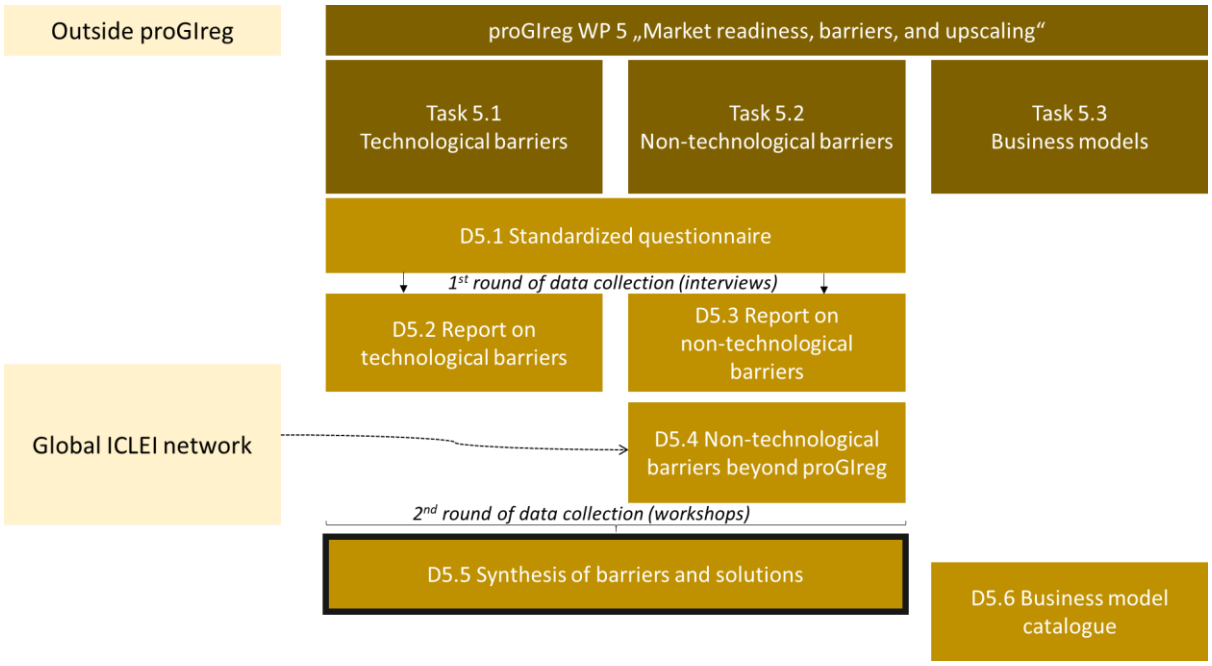

Figure 2. Sequence of WP5 deliverables on barriers and business models

2. Structure of the collective scheme/report

This report provides a synthesis of the barriers encountered and solutions applied to overcome the barriers when co-designing, co-implementing, and co-maintaining different NBS. It is the fifth Deliverable bundling proGIreg's Tasks 5.1 and 5.2 on technological and non-technological barriers. The report builds on earlier studies and findings (Del. 5.1, 5.2, 5.3) obtained in the project's FRC and partly FC, but – in the discussion of this synthesis report – beyond by taking advantage of ICLEI's global network of cities (Del. 5.4).

Following the executive summary and introduction, this chapter 2 briefly presents the report's structure followed by the methodological approach (chapter 3). Subsequently, chapters 4-11 are dedicated to each NBS with an overview of barriers encountered and solutions applied to overcome them. Each NBS-specific chapter starts with short introductory information on the NBS developments and their status in the FRCs of Dortmund, Ningbo, Turin, and Zagreb. Following, the encountered barriers and solutions are presented for each NBS. This report focuses firstly on an update of already known barriers and newly emerged barriers and, secondly, on solutions found and applied to overcome specific barriers. Finally, the findings are discussed and concluded. The discussion positions the barriers and solutions between the FRC and the NBS, but also with regard to the Follower Cities and cities outside proGIreg.

3. Methodological approach

Primary data from the Front Runner Cities (FRC) Living Labs (LL) as well as the Follower Cities (FC) provide the main source of information in the two WP 5 tasks on barriers, namely technological barriers (Task 5.1) and non-technological barriers (Task 5.2). Two rounds of data collection took place:

- → Firstly, interviews with key stakeholders for each NBS in FRC and FC in the course of 2020.The first round of data collection (interviews) is reported in the Deliverables 5.2 (focus on technological barriers) and 5.3 (focus on non-technological barriers) following a standardized questionnaire (Del. 5.1).
- → Secondly, NBS-specific workshops with FRC representatives in 2021.

Synthesised results of the first interview round on technological and non-technological barriers served as starting point for the second round of primary data collection, the workshops in 2021. The interview findings are the basis for workshops with key stakeholders of NBS developments in proGIreg's FRC. The workshops took place between June and September 2021. In early summer, the workshops focused on the further progressed NBS developments, while the NBS, which are still in its planning or early implementation phase, were discussed only in September 2021 (s. Figure 3). The workshops in 2021 focused on the FRC only; the Follower Cities are learning from the experiences of the FRC when implementing NBS including the occurring barriers and applied solutions to overcome the barriers. Administrative issues, communication barriers, and lack of funds are the most present obstacles among FC, while social components

such as the spontaneous formation of local groups is a driver for promoting NBS at local level (s. Deliverable 2.7 for further details). For each NBS one dedicated workshop was organized, except for the NBS 4 (Aquaponics) and NBS 5 (capillary GI), which were jointly performed in September 2021. The reasons are (in parts) double responsibilities of the same persons in the LL for both NBS, merging of NBS 4 and 5 in Zagreb, but also similar expertise as well as the occurrence of similar barriers based on the interviews of 2020.

All workshops followed the same structure. After welcoming and introducing all participants, the information based on the interviews on barriers in 2020 was re-capped for a common basis and starting point for the further tasks in the workshop. Following, key stakeholders of NBS developments in the FRC LL discussed with support of the WP 5 team three main topics:

- → Update on the assessment of barriers reported already during the interviews of 2020,
- → Nomination and assessment of barriers, which meanwhile emerged newly, and
- → Nomination and assessment of solutions identified/applied to overcome barriers.

The online collaborative whiteboard platform *miro* was used for joint and interactive activities of all participants during the workshops. The workshops' outcomes of the *miro* board as well as the verbal discussion formed the main resources to synthesise the barriers and solutions to overcome them when planning, implementing, and maintaining NBS on post-industrial sites.

The following NBS-specific chapters on barriers and solutions follow a common order building on three figures each:

- → Figure showing the synthesised barriers based on the interviews in 2020,
- → Updated figure comprising a renewed assessment of the barriers reported already in 2020 as well as a classification of newly reported and assessed barriers, which emerged meanwhile, and
- → Summarizing figure on solutions applied to overcome barriers.

Each type of barrier (administrative/institutional, social/cultural, technological, financial/market, other) is depicted with an individual symbol. Furthermore, each FRC is presented with an individual colour. The barriers summarized in the first two figures per NBS (first, based on interviews in 2020 and, second, updated figure and newly reported barriers) are positioned in three times of NBS development: co-design (before implementation), co-implementation, and co-maintenance/co-management (post-implementation). Each of the eight following NBS chapter consists of these three visualisations with additional textual descriptions.

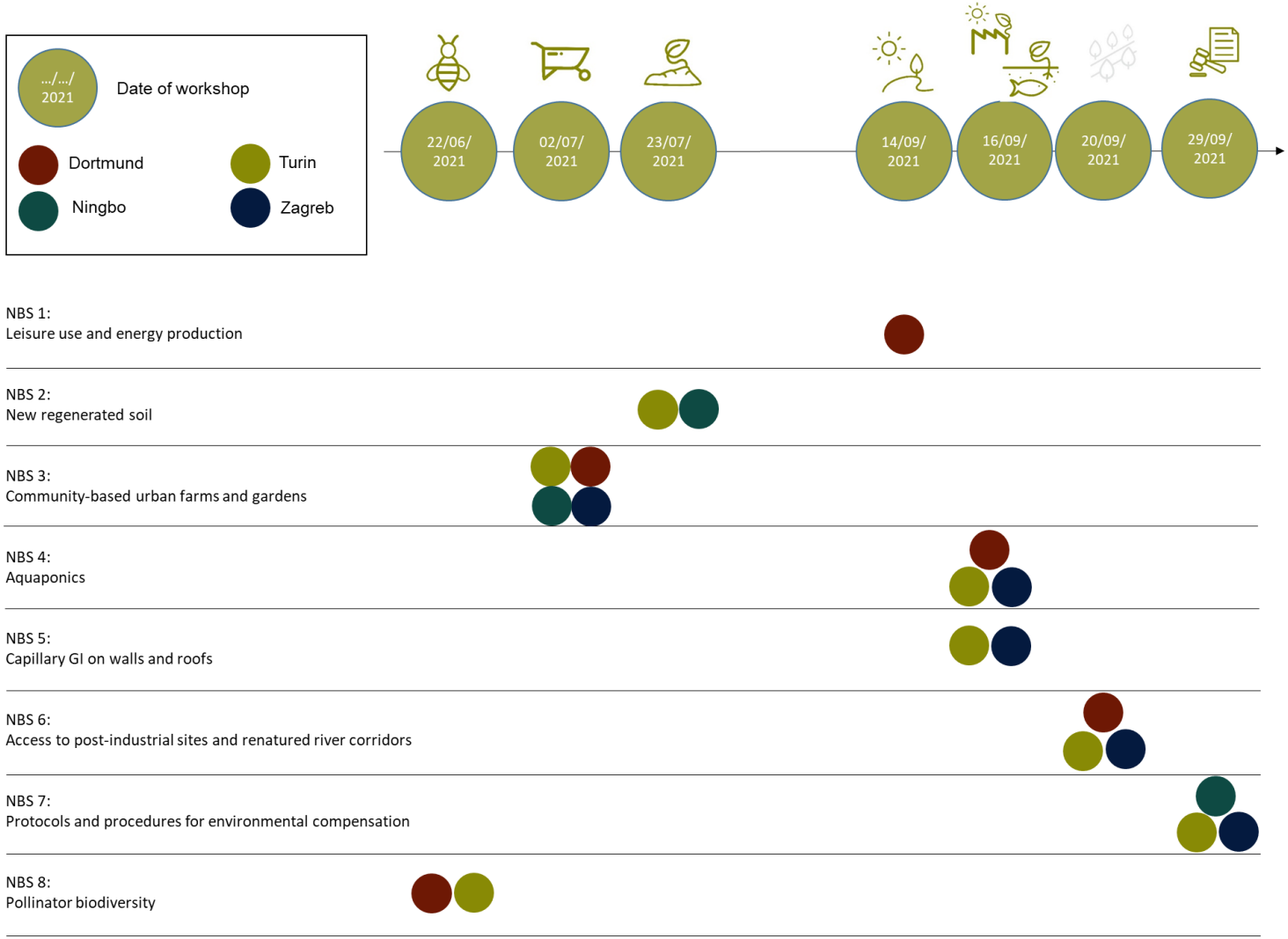

Figure 3. NBS developments in proGIreg cities. Date of workshops and indication of NBS developments for FRC and FC.

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

4.1. Introduction

Leisure use and energy production on renatured landfill sites is planned, implemented, operated, and monitored in one of the four FRC - Dortmund. The energy production (solar park) was established on the Deusenberg landfill site before the proGIreg start and has been operating since.

Thus, only part of the NBS, namely leisure activities is considered within the proGIreg framework. The core element is the installation of sport devices in a public park (Gustav-Heinemann Park) useable by Huckarde and Dortmund citizens and pupils from an adjacent school. Two Departments of the City of Dortmund (Urban Renewal; Green Spaces) manage the NBS development, which is still in its planning phase. Due to Covid19 and formal procedures, the co-design process focused on key stakeholders and multipliers instead of a wider citizen involvement. The political approval could be reached in autumn 2021 with the aim to establish the sport devices in the park in the course of 2022.

4.2. Collective scheme/report on barriers and solutions

4.2.1. Barriers

In the first round of interviews, the key stakeholders involved in the NBS 1 development in Dortmund named different types of barriers when co-designing this NBS (s. Figure 4). The International Garden Exhibition (IGA 2027) is going to take place in the project's LL area. On the one hand, this continuity of activities in the area provides chances of synergies, stepwise procedures of larger implementations of Green Infrastructure, and a longer lasting perspective. However, given the planning time lag between proGIreg and the larger and more comprehensive IGA 2027, the proGIreg team has been limited in implementing its initial ideas of the NBS and had to give way to the IGA 2027 planning period. This spatial proGIreg – IGA 2027 overlap at and around the Deusenberg landfill site resulted in the need to follow and plan alternative NBS 1 actions. Finally, it was decided to leave the Deusenberg and to move into the post-industrial Gustav-Heinemann Park situated centrally in the Huckarde district.

Additionally, named barriers included the following: soil contamination issues, internal (municipal) capacities and resources, municipal processes, Covid19, limited budget, and starting from scratch without any pre-existing ideas, plans or strategies to implement sport devices. Soil contamination and soil quality in the Gustav-Heinemann Park result generally in safety concerns when interacting with the soil causing also increasing costs. While the soil

quality is adequate for a city park, it is different for a dedicated sport area. While the soil issues were indicated as major issues, internal capacities and resources represented minor barriers: internal competition on staff and additional finances exists with other projects and tasks; especially when asking for support in other departments during the course of the year when year-round working plans had already been established.

Further barriers (municipal processes, Covid19, limited proGIreg budget, starting from scratch) could not be categorized back at the time of the interviews in 2020 for what reason they are grouped into “barriers not further specified” (s. Figure 4). Bulky and complex municipal procedures were named, for example the preparation of (small) tenders, like expert opinions, demand the involvement of several departments within the municipality to receive an approval. At the time of the interviews in 2020, it was not able to classify Covid19 more in detail. This was also true for the budget constraints as well as the challenge to start from scratch with the planning of NBS 1 under the given short project’s timeframe. This timeframe turns out to be too short for some of the construction NBS, like NBS 1.

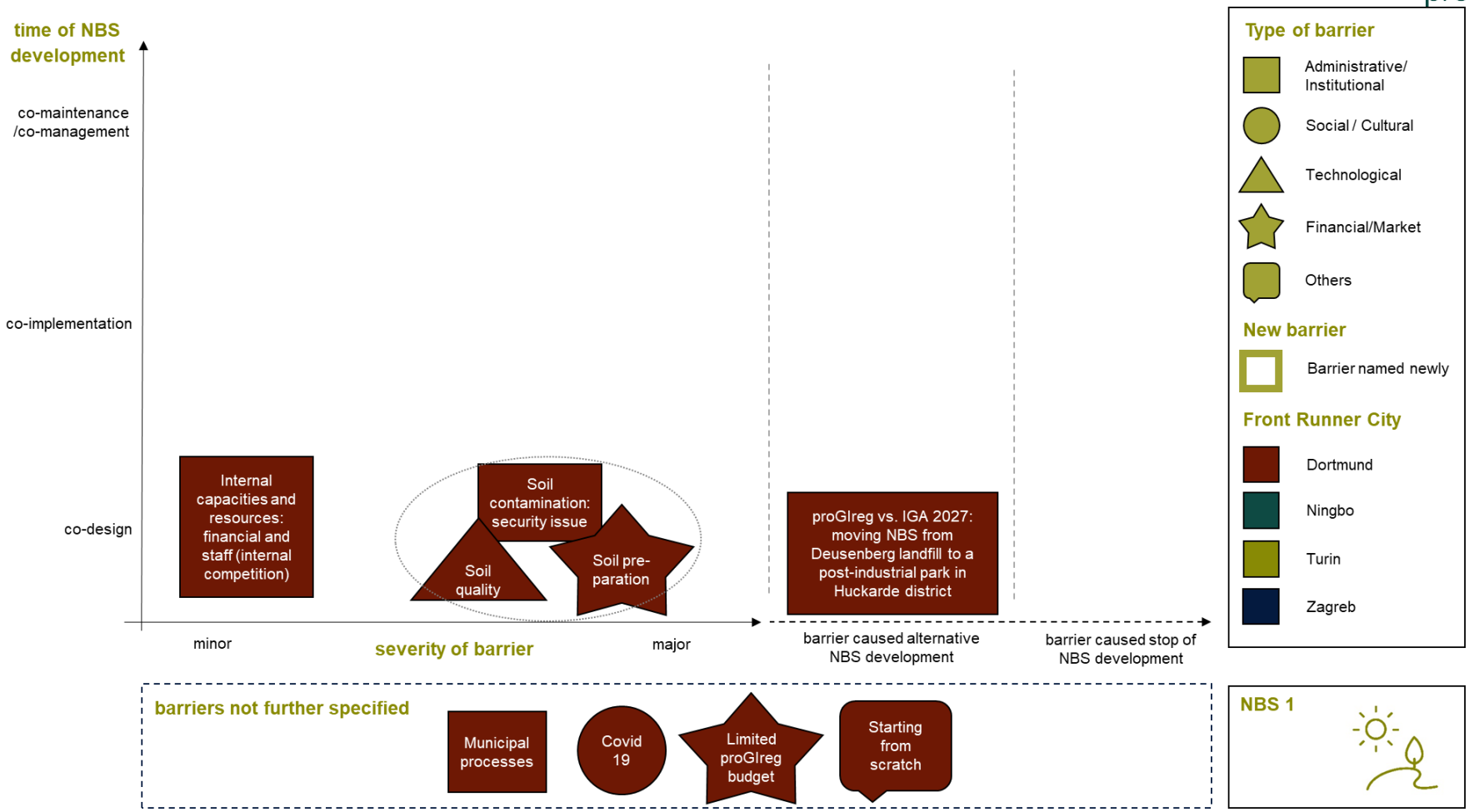

Figure 4. Synthesized barriers of NBS 1 based on the interviews in 2020

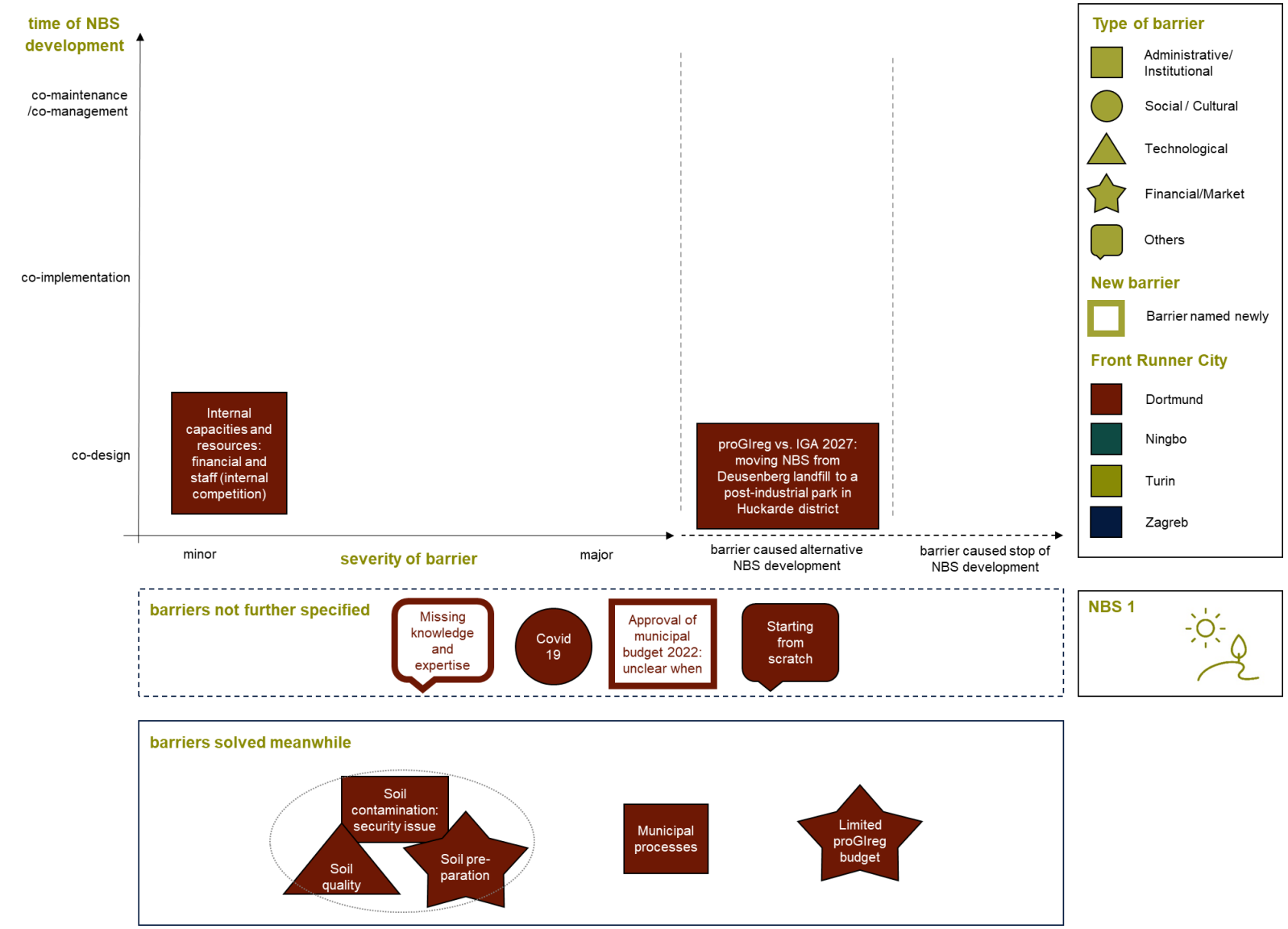

Figure 5. Update on synthesized barriers of NBS 1 including a renewed categorization and addition of newly emerged barriers.

4.2.2. Solutions to encountered barriers

Since conducting the interviews in 2020, NBS 1 partners have been successful in overcoming some of the barriers:

- → soil contamination and soil quality (administrative, technological, and financial barriers),
- → municipal processes,
- → limited proGIreg budget (s. Figure 5). The soil around the sport devices has to be removed and disposed, which requires additional financial resources. This will be covered by additional internal means. Furthermore, it is intended to apply a tender with a fixed budget, and
- → municipal construction decision concluded in autumn 2021.

In addition, the responsible partners named two more barriers: missing knowledge and expertise as well as ambiguity on the approval of the 2022 municipal budget. If this will not have been approved, no activities can be carried out in the beginning of 2022. This might prolong the NBS implementation process.

The responsible partners for Dortmund's NBS 1 were able to overcome a number of barriers by applying different solutions (s. Figure 6). Given the spatial overlap of the project's LL with IGA 2027 area, flexibility was required in terms of the NBS 1 location. In order to handle the well-established, but lengthy and hierarchical municipal processes, facilitating internal networking between departments, decision-makers, and local politicians was necessary. Covid19 stopped most of the larger physical meetings for several months, requiring a switch from a broader citizen involvement campaign to a small workshop with key stakeholders and multipliers to capture the citizens' overall mood and opinion on the proposed NBS intervention. Furthermore, limitations of the proGIreg budget were overcome in two ways: a tender with a fixed maximum budget, which includes an internal extra budget coming from the City of Dortmund.

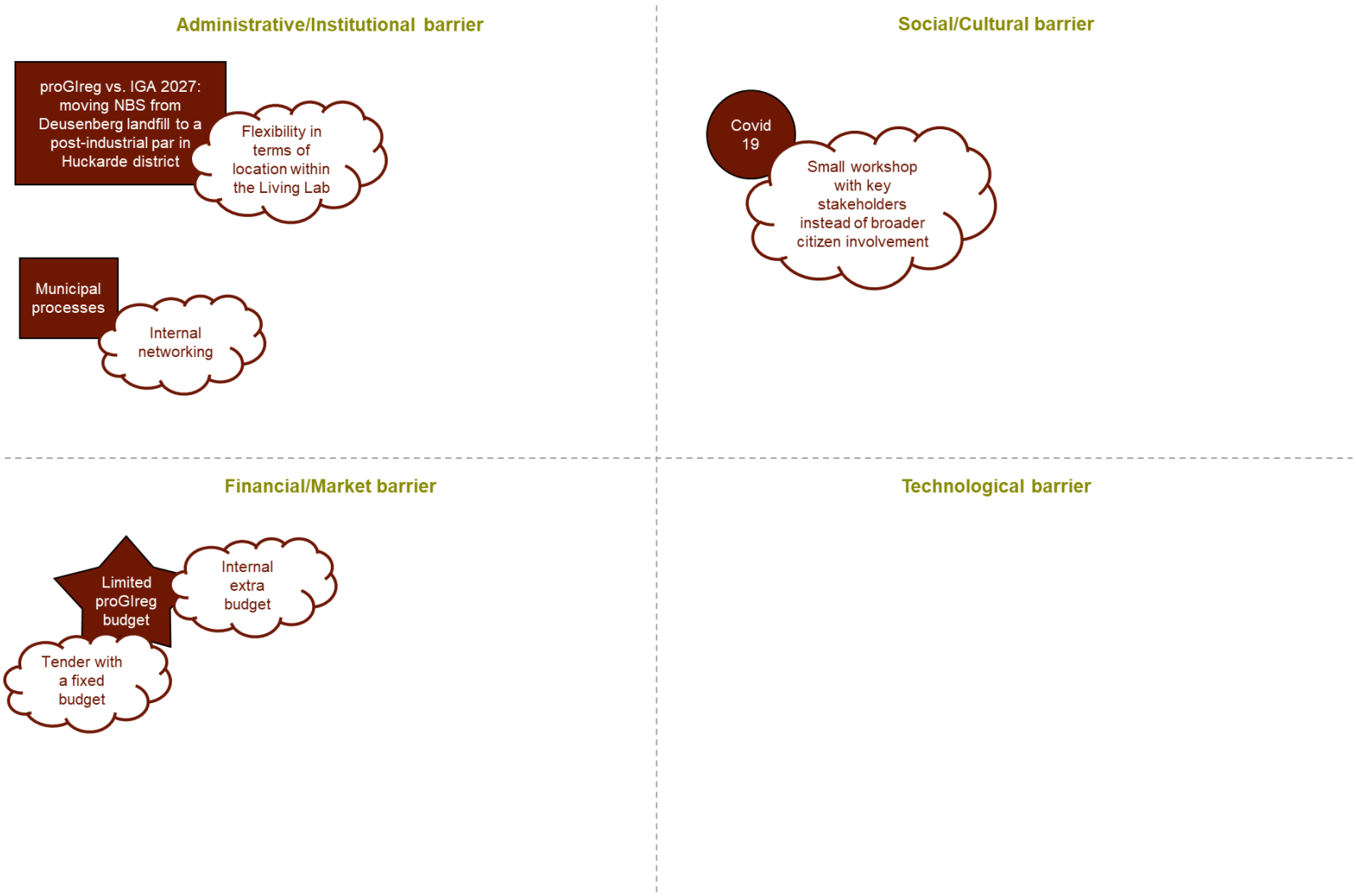

Figure 6. Solutions applied to overcome barriers.

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

5.1. Introduction

NBS 2 development was initially planned to be conducted in two of proGIreg's FRC, namely Ningbo and Turin. Due to an insurmountable barrier, Ningbo had to stop NBS 2 activities (s. Chapter 5.2). In Turin, NBS 2 is at the core of NBS implementations, named to be one of the most relevant and innovative initiatives within the proGIreg project. Main goal is the creation of an area of so-called urban forest along the Sangone riverbanks with regenerated soil, based on excavated material with the addition of compost, zeolites, and innovative biostimulants. The composition of the new soil has been defined with the main scope of minimized maintenance needs.

5.2. Collective scheme/report on barriers and solutions

5.2.1. Barriers

Ningbo had to stop the proposed and planned NBS 2 activities completely (s. Figure 7). Heavy lake sediment pollutions forced the partners to stop the transformation of lack sediments into soil fertilizers.

As many new activities, the innovative NBS development on new regenerated soil caused several barriers: already in the 2020 interviews, some were able to be categorized on the barrier severity and time of NBS development, while others were named without further specifications on severity and time of occurrence (s. Figure 7). Missing understanding of benefits related to this NBS development were named as a major social barrier. Barriers, which cover technical composition issues, are heterogeneity of the soil (technological barrier) and identification of materials, which has to comply with national legal requirements (administrative/institutional barrier). They occurred in the implementation phase of NBS development like the minor technological barrier "management of the soil building site". Furthermore, the spatial distance between excavation and destination site can turn out to be a costly barrier by increasing transportation costs. However, these later barriers were only categorized as minor barriers when being compared to the earlier mentioned ones. Additionally, two administrative/institutional issues (bureaucracy for certain approvals and lack of long-term planning and continuity in this domain's policies and decision-making procedures) as well as potential trade-offs affecting other NBS were identified as barriers.

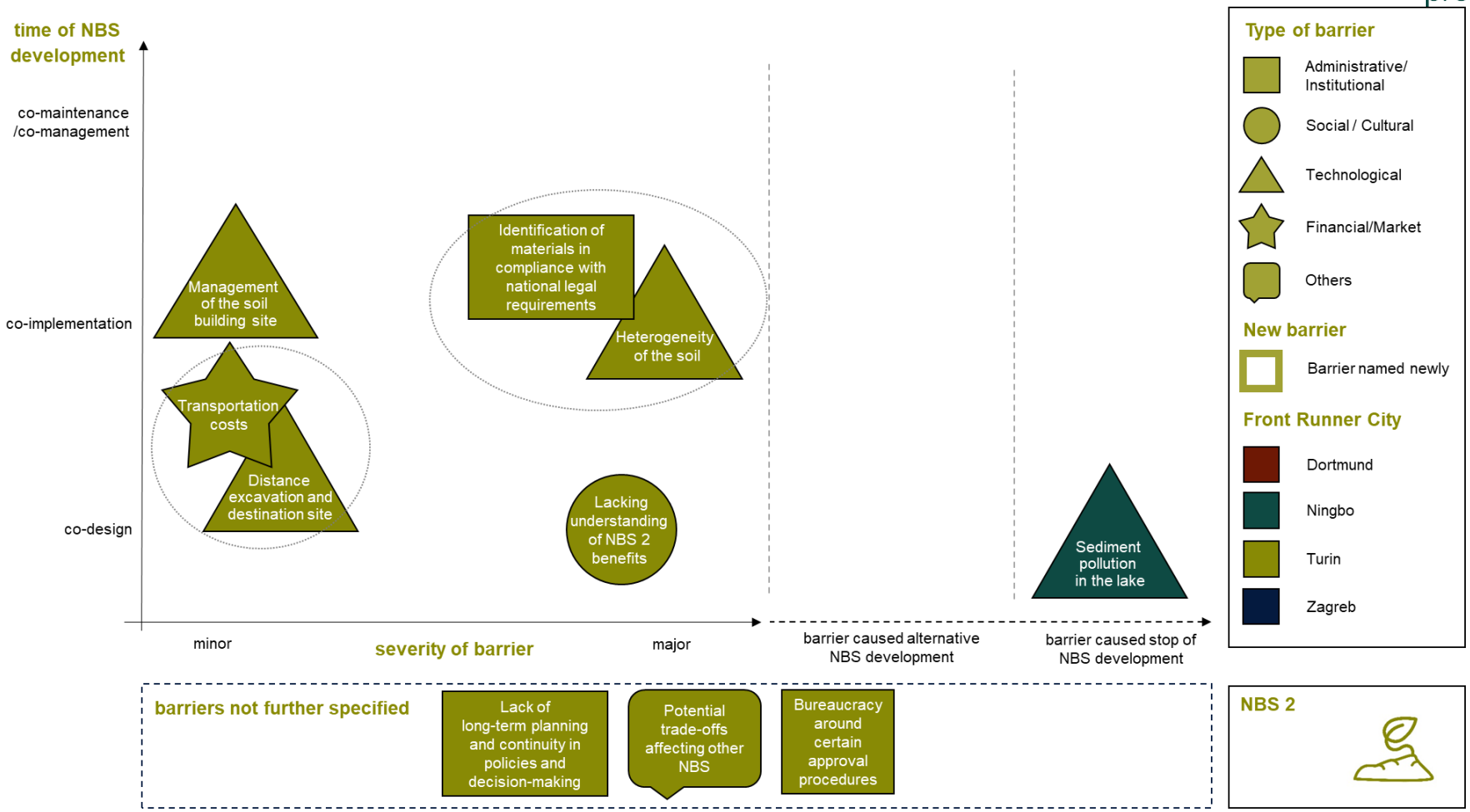

Figure 7. Synthesized barriers of NBS 2 based on the interviews in 2020

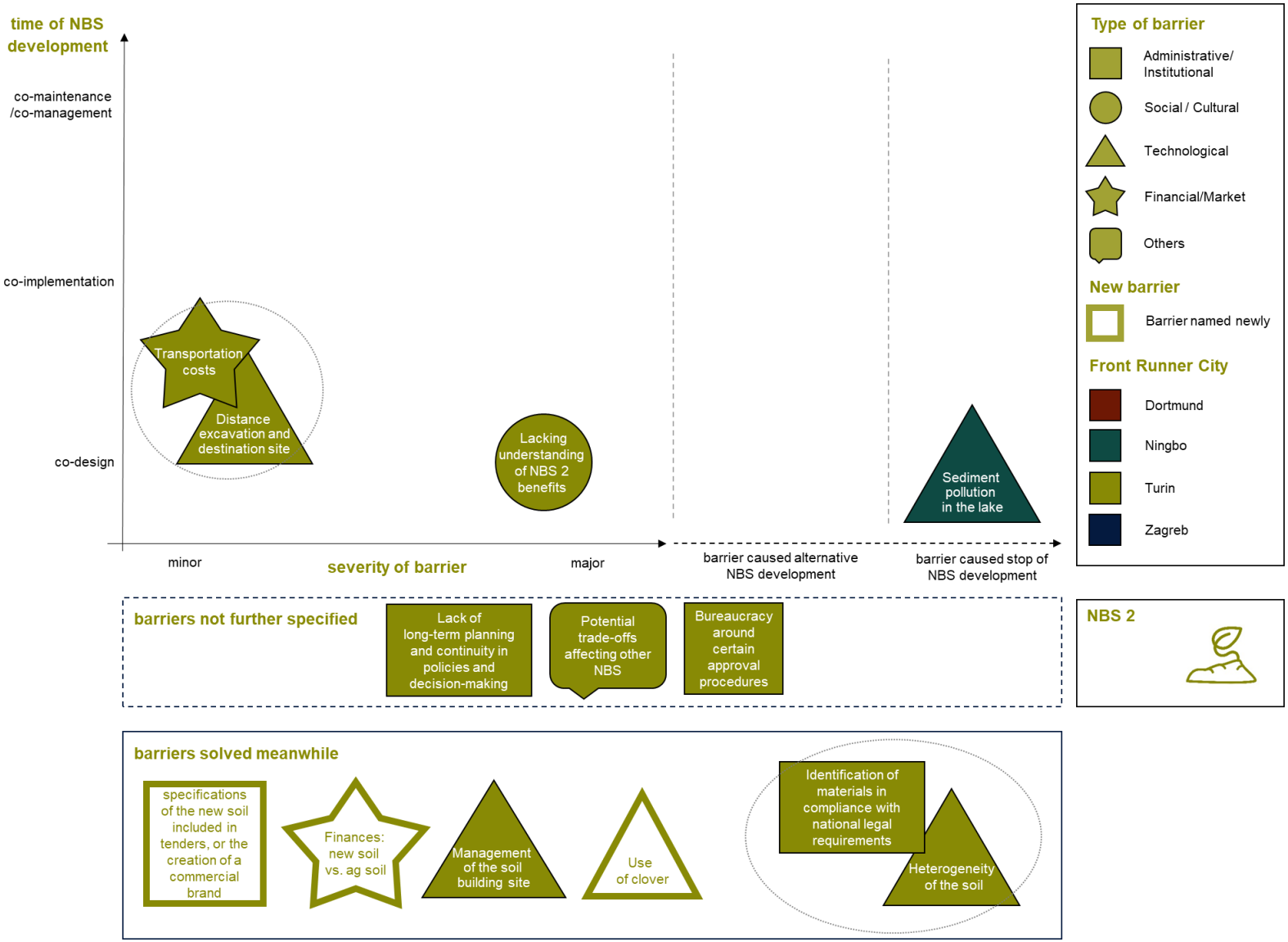

Figure 8. Update on synthesized barriers of NBS 2 including a renewed categorization and addition of newly emerged barriers.

5.2.2. Solutions to encountered barriers

Since the interview programme of 2020, the responsible NBS 2 partners in Turin have been successful in solving some encountered barriers. The heterogeneity of the soil and identification of materials in compliance with national legal requirements could be solved, at least on local level (see Figure 8 and Figure 9) through a modification of authoritative urban procedures that allows the analytical composition at destination site as reference. The Piedmont Region with D.G.R. No. 8 of 2nd of July 2021 approved a resolution establishing the natural background and concentration values of chromium, nickel and cobalt in soils. Thanks to this new resolution, the 'Natural background values' of metals in the destination site became the new legal reference within the territorial area of Turin for authorizing the new soil use. It takes the background values of the destination area as reference for the determination of the minimum analytical quality of the soil. This paves the ground for expanding possible applications of the new soil at the urban level. Currently, there is dialogue at the regional level to implement this resolution throughout the regional territory.

For the minor barrier of managing the soil building site, regular construction site's safety procedures are applied. Concerning the distance between excavation and destination and related transportation costs, individual solutions (finding nearby sites) have to be applied.

Additionally, new minor barriers emerged, which the implementation team could solve easily. One barrier emerged with regard to the specifications of the new soil to be included into tenders, or the creation of a new brand. As other construction sites outside proGIreg's LL have already been planned or implemented, this legal topic has arisen. The identified and applied solution is to use a definition of the new soil, accepted by the public specifications, 'vegetable soil sifted with vegetable amendments'. Since then, this term has been used in the transportation documents of the new soil. The team also considered another economic issue: the new soil is accepted well in public tenders instead of the agricultural land, but only if it presents a lower cost. This is possible only with very low transport costs. The solutions to be implemented in order to promote the use are therefore to identify excavation sites that are close to the areas of application of the new soil and to push the use of new soil instead of agricultural land in public tender specifications by encouraging its use for environmental reasons on top of (potential) economic ones. The use of clover in grassland has also generated some practical difficulties, like suffocating of shrubs/bushes, for what reason it is proposed to eliminate clover from lawn composites.

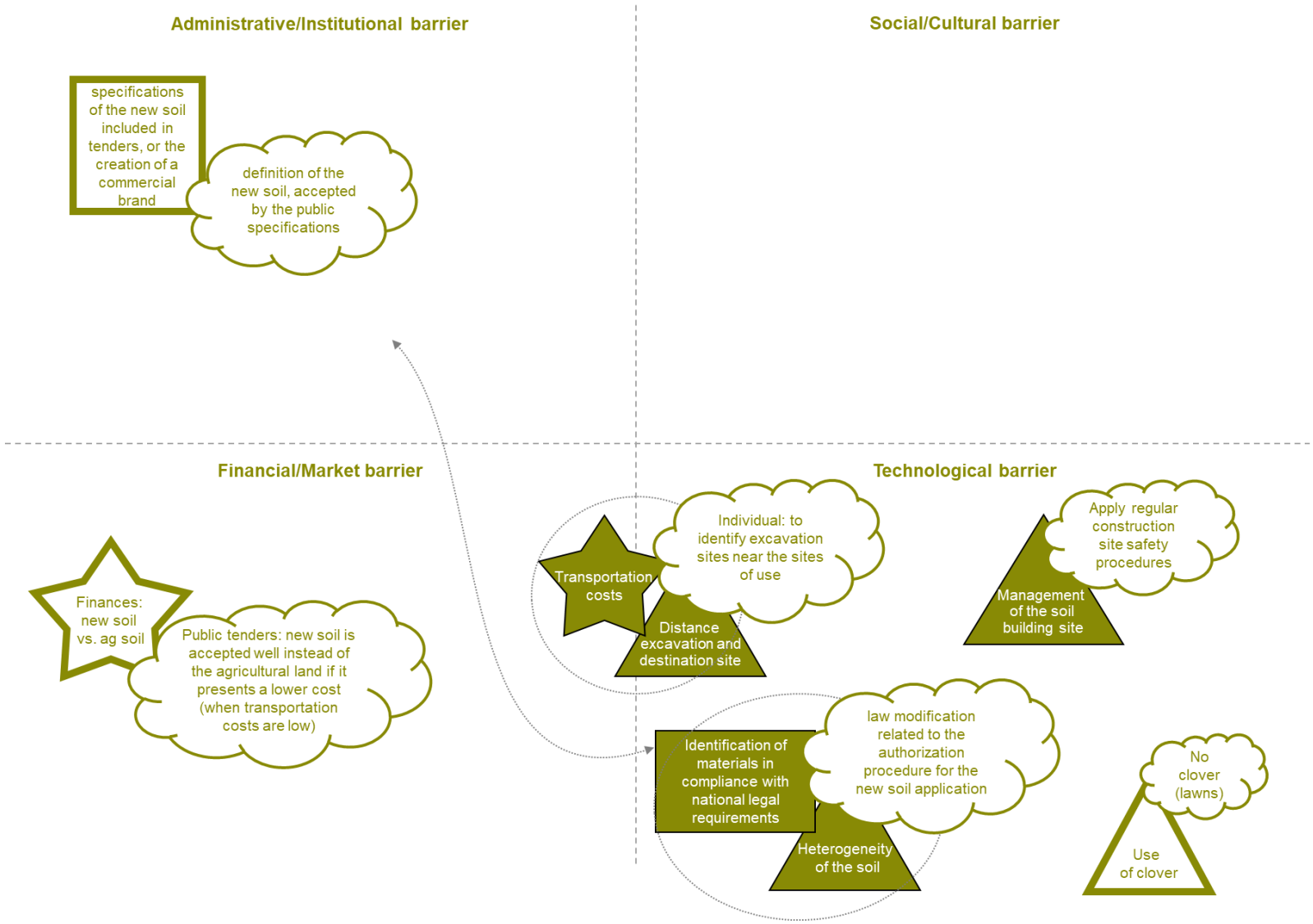

Figure 9. Solutions applied to overcome barriers.

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

6.1. Introduction

All four FRC implement NBS 3 - community-based urban farming and gardening in their determined LL. While Ningbo focuses on one activity (planting of aquatic plants along the shore of the lake), the European FRC establish urban gardens, farms, and forests at several sites in the LL. Table 1 provides an overview of the different types and status of community-based urban farms/gardens in each FRC.

Table 1: Overview of NBS3 implementations in FRC

FRC	Status	NBS 3 interventions	Description
Dortmund	√	3,000 m² food forest and permaculture orchard	NGO Urbanisten, boys and girls scouts and St. Urbanus church community are developing the food forest on church-owned land in LL Huckarde. Further urban gardening and farming activities will be spatially and conceptually connected with NBS 4 activities – aquaponics – on the premises of the Hansa coking plant (s. NBS 4). The initial intention to develop urban gardening interventions such as raised beds at Gustav-Heinemann school, day-care centres and in Gustav-Heinemann Park has been put on hold as co-design activities during Covid19 pandemic stopped, and due to internal project capacities and resources as well as external community engagement.
Ningbo	√	Planting of aquatic plants along the Moon Lake	Aims to beautify the urban environment while purifying water quality. Aquatic plants are used to re-nature a 5 km corridor surrounding the lake. Overall goal is to create a high-quality green-blue space for citizens.

Turin	√ Planned	Cascina Piemonte garden, pollinator-friendly gardens, educational gardens in schools, Community school gardens, Gardens integrated in residential areas Micro vegetable gardens ('Orto-Mobile')	Implementing NBS 3 at different LL sites with seven different foci (s. LL map) incl. the recovery of the Castello di Mirafiori ruins, where planting of roses and signposting transformed the landscape of historical-environmental interest. Gardens of Cascina Piemonte develop post-industrial and residual metropolitan farmland towards ecological sustainability and social equity. Collective gardens are rented to individual citizens – added by a common educational area for training and community activities. 160 plots of different charges and sizes have been realized are assigned to private citizens, families or collectives, with lower charges for people under 35 and for economically disadvantaged people and 330 trees planted. Pollinator-friendly garden 'Orto WOW' is composed of garden boxes with aromatic plants and other melliferous plants in the courtyard of an abandoned public building. Four local NGOs signed a 'pact of collaboration' with the city to manage the area by establishing an informal network. The educational gardens have been implemented in all primary schools, two kindergardens, and one vocational school promoting sustainable agriculture, biodiversity, and NBS. Portable school gardens 'OrtoMobile' promoted by the City of Turin and community school gardens aims at easy implementation by people of all ages allowing high degrees of socialization at different sites. The installation of wooden boxes for urban horticulture activities is ongoing on public spaces in Mirafiori South.
Zagreb	√	Upgrading existing urban garden, Therapy garden Info point to serve as a new community centre for Sesvete.	Focus on three activities in Sesvete City Garden: upgrading the existing city garden with solar purifying water pumps to reach drinking water quality to ensure citizens can grow vegetables, fruit, herbs and flowers for own consumption. Local NGOs play a crucial role (especially in the co-design process) in the new therapy garden supporting children and adults with various disabilities and was implemented in spring 2021 and is in use since June 2021. A day-care centre takes care of the garden, which is managed by the City Office of Agriculture and Forestry. All project activities are being advertised in the info point through lectures, exhibitions, discussions, film projections and other events, and the programme of the info point is published in the local media, especially the social media.

6.2. Collective scheme/report on barriers and solutions

6.2.1. Barriers

The development of community-based urban gardening and urban farming activities takes place in all four FRC. Based on the interviews in 2020, administrative/institutional barriers emerged in the planning and co-design phase (s. Figure 10). With progressing planning and during implementation and operating phase, technological barriers prevail – covering the full range from minor to major ones. A few preferably minor social barriers and a general lack of funding (financial barrier not further specified) add to the dominance of administrative/institutional and technological barriers.

Turin also named two administrative/institutional barriers in the 2020 interviews. Firstly, lengthy bureaucratic processes in administration, which was ranked as major barrier, and, secondly, missing procedures on how to approach the city (minor barrier). Both remained existing until then due to the general character of these barriers (s. Figure 10 and Figure 11). During the workshop, it was also discussed that lengthy bureaucratic processes have developed in the last decades and cannot be overcome with isolated, small interventions. In the municipal domains concerned, the administrative protocols have been developed for permissions of mainstream grey infrastructures mainly. Applications to get approval for developing green infrastructure are in many cases not existing, for what reason the same protocols are used (s. also other NBS chapters). The NBS 3 team of Dortmund highlighted one minor administrative/institutional barrier concerning mixed land uses. Based on legally binding zoning plans, certain areas are allowed for defined uses only. This hampers, for instance, in this case of NBS 3, the implementation of food production in dedicated industrial or residential areas.

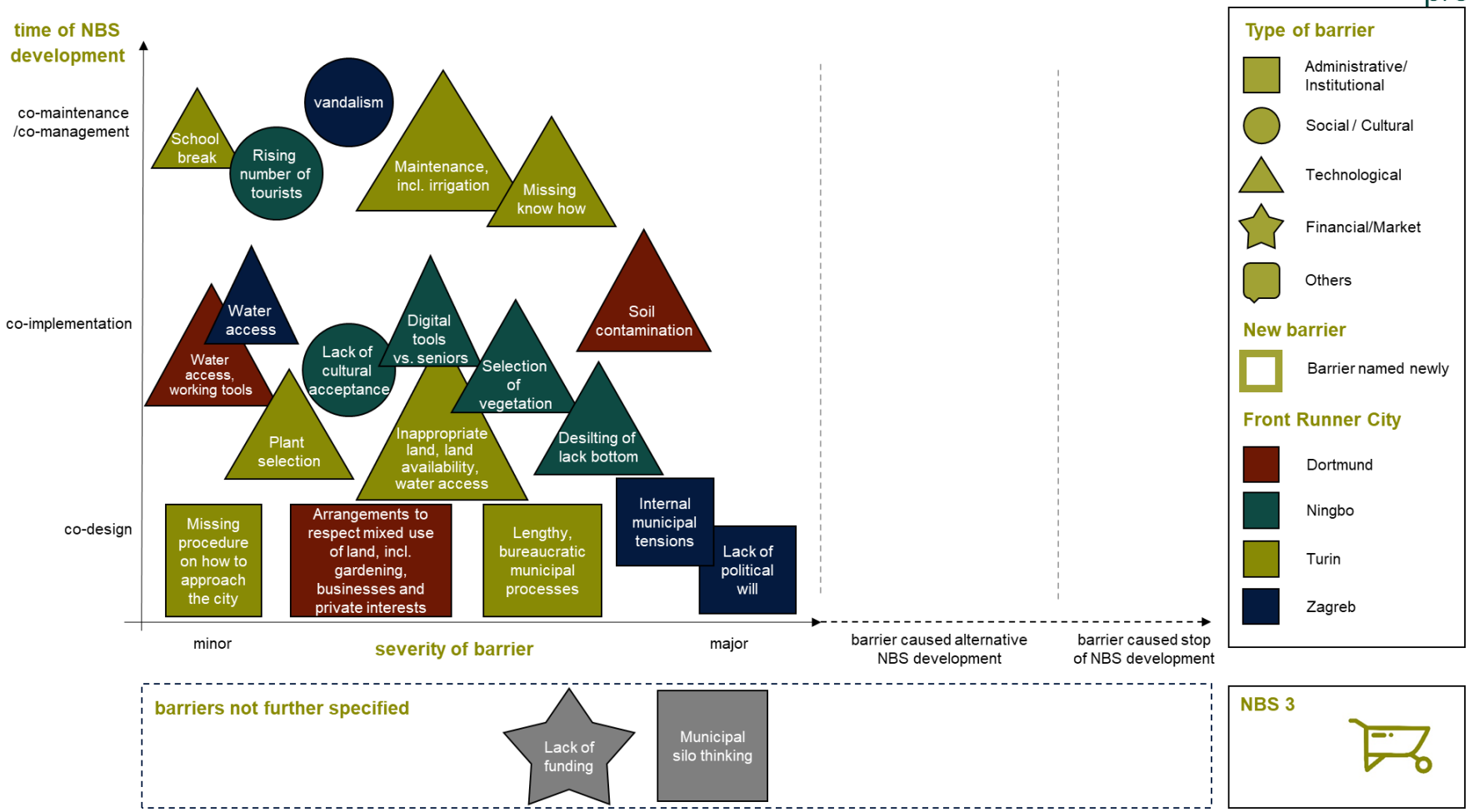

Figure 10. Synthesized barriers of NBS 3 based on the interviews in 2020

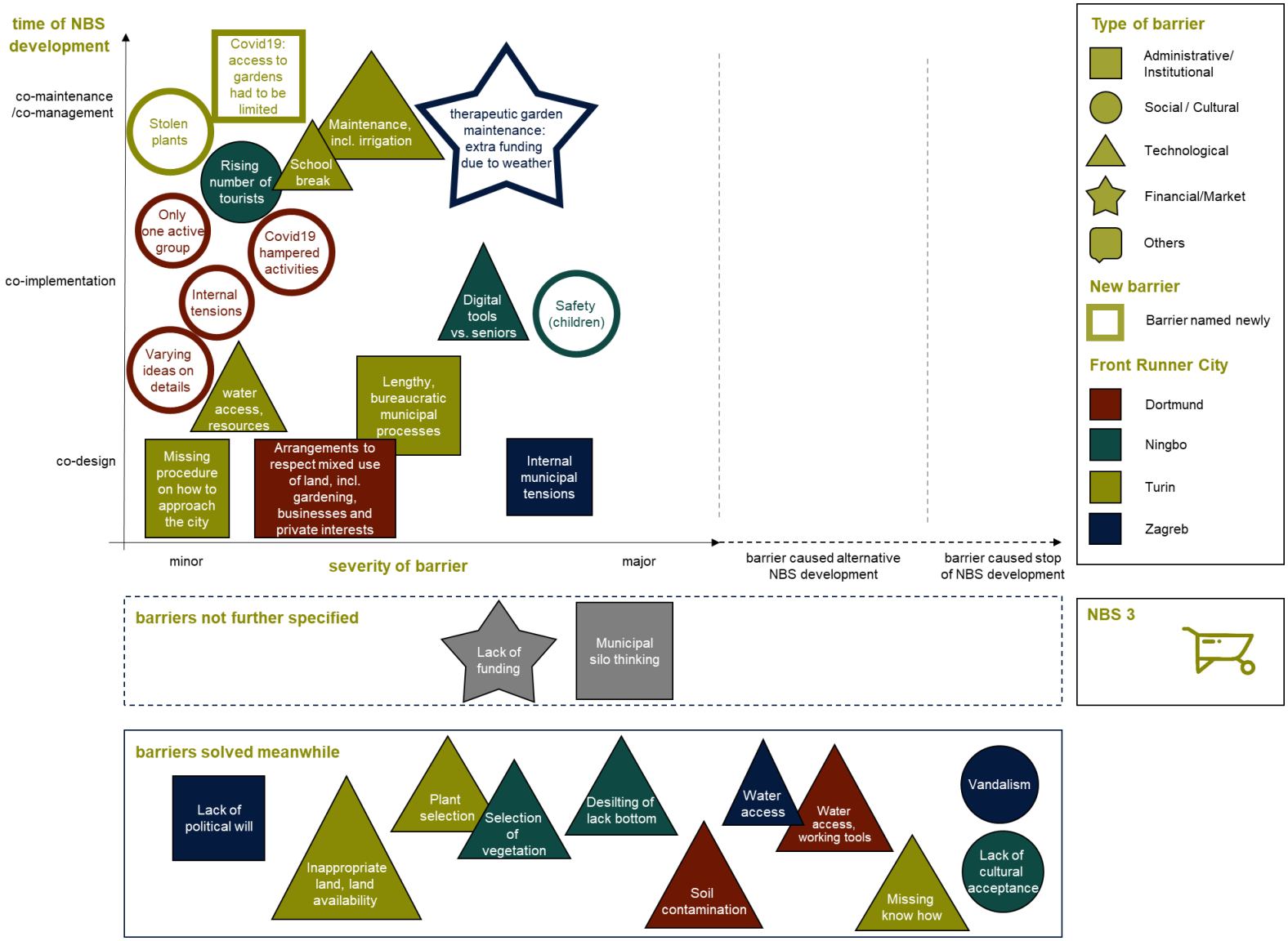

Figure 11. Update on synthesized barriers of NBS 3 including a renewed categorization and addition of newly emerged barriers.

6.2.2. Solutions to encountered barriers

Between the interviews of 2020 and the workshop in 2021, Dortmund partners were able to solve two technological barriers: soil contamination and access to water (s. Figure 10, Figure 11, Figure 12). The soil contamination of the food forest and permaculture orchard site was already investigated before the project lifetime, which was not known at the time of the interview in 2020. The necessary missing link of information between entities could be established to receive this information and overcome the barrier. Additionally, a newly installed water access point for the food forest and permaculture orchard ensures access to water. Access to water was also a minor issue in Zagreb, which could be overcome with drilling and probing of water to ensure safety and health. The Ningbo team named three technological barriers back in 2020 during the interviews: desilting of lack bottom, selection of vegetation, and digital tools vs. seniors, which could also be indicated as a social barrier instead. Seniors, who are an important target group of the NBS intervention, are partly reluctant in taking advantage of digital tools. This can result in limited community involvement and support for the measures. With the support of suitable machinery and consultation of plant experts, the first two could be solved. For the implementation and operation phase, Turin partners named several technological barriers (partly of minor, partly of major nature), of which some could already be overcome. The selection of vegetation was carried out with local stakeholders to choose appropriate and accepted plants. The sites with inappropriate land/soil as well as when land for soil-bound gardening/farming was not available, container gardening solutions were pursued. Peer education with local communities contributed to acquire missing know how. Concerning the maintenance of the NBS, in Turin two technological barriers are still present: for the urban gardening activities at schools, the open questions of how to ensure care-taking of the gardens during school breaks remains and more generally the maintenance of the NBS developments in the long run, including irrigation.

Furthermore, three minor social/cultural barriers were named in the interviews of 2020 (Ningbo and Zagreb). While some could be solved in the meanwhile, several new social/cultural barriers emerged newly (Dortmund, Ningbo, Turin). Most of them are of minor relevance and for several new barriers, solutions were found and applied to overcome them. Ningbo highlighted the lack of cultural acceptance, which could be handled with information signs raising awareness and knowledge on the topic. Vandalism (Zagreb) and rising number of tourists (Ningbo) were also named in 2020. For Ningbo, safety for children could be improved with an increase of guards' measures and warning signs. Turin added the issue of stolen plants, while the newly named social/cultural barriers from Dortmund focus on Covid19 implications and tensions within the team working on the NBS implementation – but only on a minor level (s. Figure 11). This includes for example varying ideas on details how to set up the food forest and permaculture orchard. Dortmund team was able to overcome this by setting up a compromise integrating ideas and standpoints from different members of the active team (s. Figure 12).

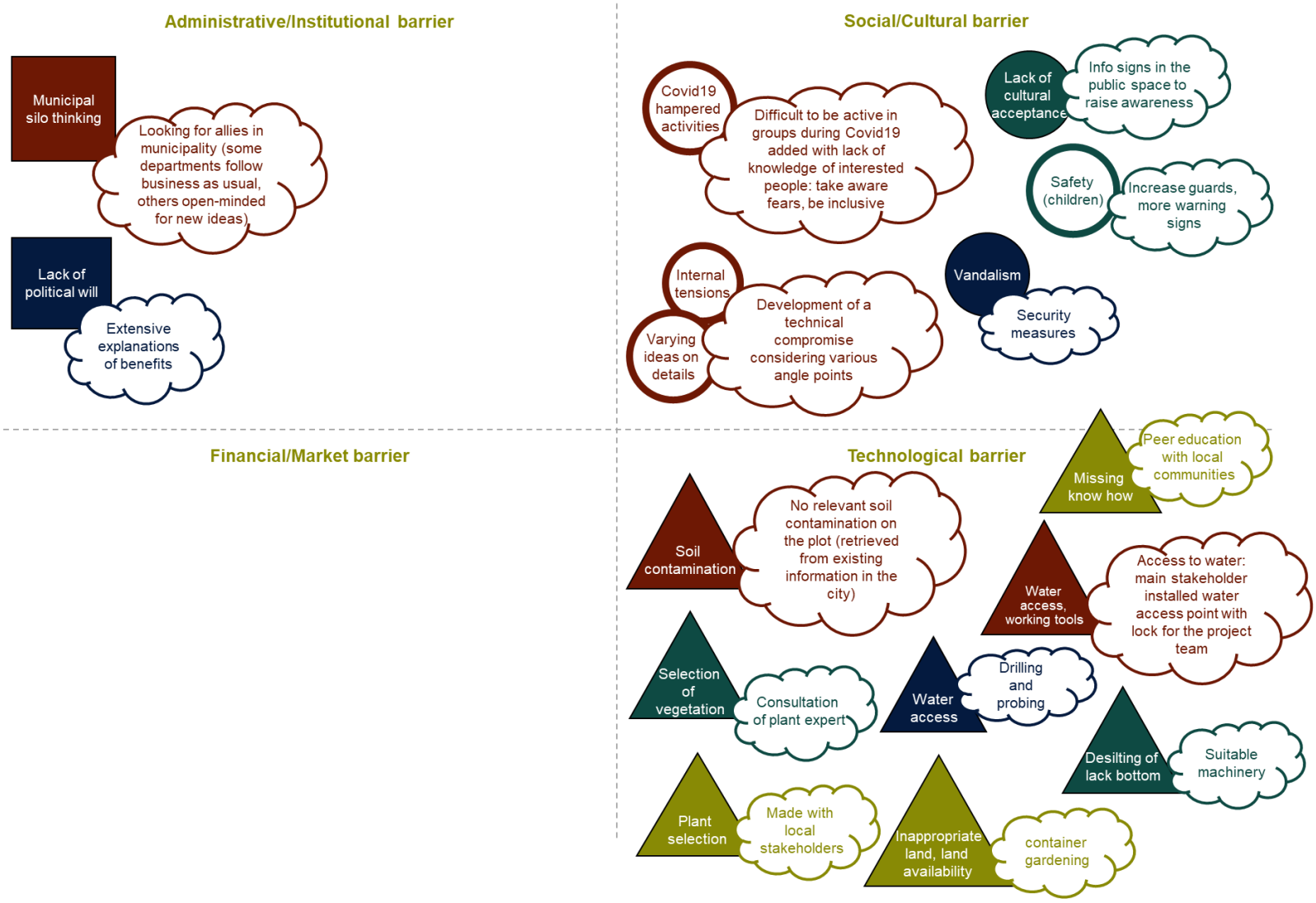

Figure 12. Solutions applied to overcome barriers.

7. NBS 4: Aquaponics

7.1. Introduction

Aquaponics produce food in a system that couples aquaculture (raising aquatic animals such as fish, snails or prawns in tanks) with hydroponics (cultivating plants in water). The nutrient rich aquaculture water is fed to hydroponic-grown plants and in the following circulated back to the tanks containing aquatic animals. Circularity is a key feature of aquaponics. It is an innovative technology allowing fish and vegetable production under controlled environment in any place, including post-industrial sites. The three European FRC Dortmund, Turin, and Zagreb all plan to implement and operate Aquaponics in their LL.

The planned Aquaponics system on the premises of former Hansa coking plant in Dortmund will consist of two greenhouses for fish and vegetable production in the end. The aim is to establish on the one hand a community managed Aquaponics system, but on the other hand contribute to R&D towards technical and market advancements promoting upscaling of this NBS. It is also intended to become a learning venue, including workshops. So far, building permission has been granted, but only with major official requirements including non-animal stock in the aquaculture part of the system and a market ban for food consumption. Permissions for both can only be obtained at a later stage by means of dedicated applications. At this stage, the building permit demands to name the system an Aquaponics simulation unit. Solutions for technological challenges could be made ready for use, based on tests in existing, yet smaller aquaponics systems of project partners, and on calculations building on theory and preparatory studies.

In Turin, a co-developed and tested Aquaponics unit aims to assess the potential access and market sustainability as well as the effects on communities. With the planned innovative Aquaponics system, the City of Turin is looking for economic sustainability and dissemination of new technologies related to urban agriculture as a response to social challenges and quality of life in the LL with the purpose of enhancing social exchanges and inclusion of vulnerable population groups. The municipality launched a call for setting up the Aquaponics unit in the near future.

It was decided in Zagreb's co-design phase – given the emergence of barriers (s. next chapter) – to merge the NBS Aquaponics with NBS 5 (Capillary GI roofs and walls). The mini urban farm is designed as a new complete solution that integrates green roof, green wall, solar panels and Aquaponics technologies. The implemented farm is a green technology center in the Sljeme factory area and has both commercial and educational functions. The basic components of such a stand-alone system are one unit measuring 6 x 6 m, including microclimate automation and control, and irrigation systems. Two sides of the unit will receive green wall structures, to protect the area from the sun and to collect excess rainfall. Completion of implementation is expected for autumn 2021. The farm will have regular educational events for schools, therapeutic garden users and the public.

7.2. Collective scheme/report on barriers and solutions

7.2.1. Barriers

Most of the barriers, which emerged in the three European FRC when developing the NBS on Aquaponics are administrative/institutional and technological ones. Two barriers already mentioned during the 2020 interviews resulted in an alternative NBS development (s. Figure 13): In Dortmund, the soil contamination forced the actors to plan a new type of Aquaponics system without interacting with the soil to avoid any harmful effects (s. Figure 15). The initially planned cooperation with a company in the LL of Zagreb failed for what reason it was decided to merge NBS 4 and 5 in an urban mini farm. Despite NBS developments in the three cities still in its planning phase at the time of the interviews in 2020, the interviewees were able to indicate barriers for both planning/co-design and implementation and operating phase given their expertise and strong involvement. Already in 2020, the partners from Zagreb named lack of technical expertise as a major barrier. Yet, the decision to combine NBS 4 and 5 in an urban mini farm allowed the team to overcome this barrier successfully (s. Figure 13, Figure 14, Figure 15). The second, yet only minor, technological barrier named from Zagreb is seasonality. The Dortmund partners, who were able to solve this issue with a dedicated technical filter solution, also raised this barrier during the interviews of 2020. Furthermore, the technical planning of the system in Dortmund resulted in challenges. Yet, the team was able to solve this with continuous knowledge acquisition, expert exchanges, and state-of-the-art presented in scientific literature. Apart from the soil contamination on the Hansa coking plant site, the building permission turned out to be a major barrier in Dortmund affecting several other fields (allowance to raise fish, infiltration of rain water, access of externals into the greenhouses) (s. Figure 13). Following a lengthy and demanding period, the responsible partners were able to receive a building permission, but so far only for Aquaponics simulations taking place in two greenhouses. To achieve this, the team decided to hire an experienced architect to take over the lead for th e building application and permission phase. However, the issue was indicated as solved, but follow-up barriers might emerge in future when asking for further permissions (raising fish, marketing the fish and vegetable food). It is clearly stated in the building permission that access is only allowed for selected people, which is in the end going to influence the business model of the initially planned community-based system. The Turin partners see barriers and challenges when it comes to the long-term perspective after proGIreg – including finances, maintenance, and surveillance (s. Figure 13, Figure 14). As the Aquaponics system is still in its planning phase, these predicted barriers did not change in the time slot between interviews and workshop. Additionally, high-energy consumption and lack of key capacities (awareness, knowledge, and skills) are named without further detailing the issues. During the workshop of NBS 4 and 5, new barriers were named and discussed among the workshop participants (s. Figure 14). In Turin, two new administrative/institutional barriers emerged: firstly, finding an appropriate location and agreeing on the land ownerships issues and, secondly, it was inhibited to involve externals, like experts from Dortmund. The Dortmund partners added two further barriers: a minor one due to bushes on the site, which had to be cleared, and a major financial one due to rising prices for the installation of Aquaponic systems in line with generally rising prices for materials and construction work. The same barrier of rapidly increasing prices was also newly highlighted from Zagreb.

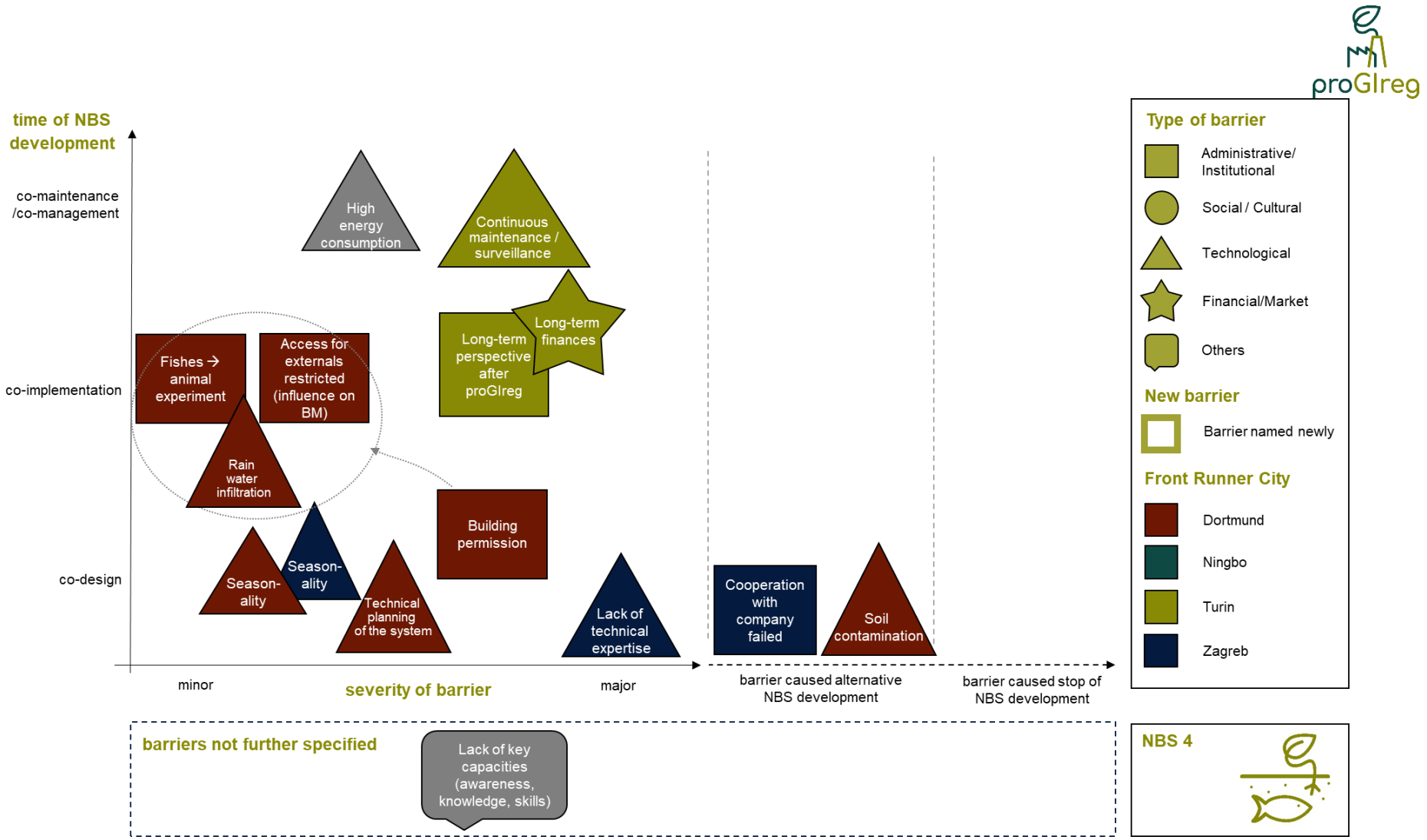

Figure 13. Synthesized barriers of NBS 4 based on the interviews in 2020

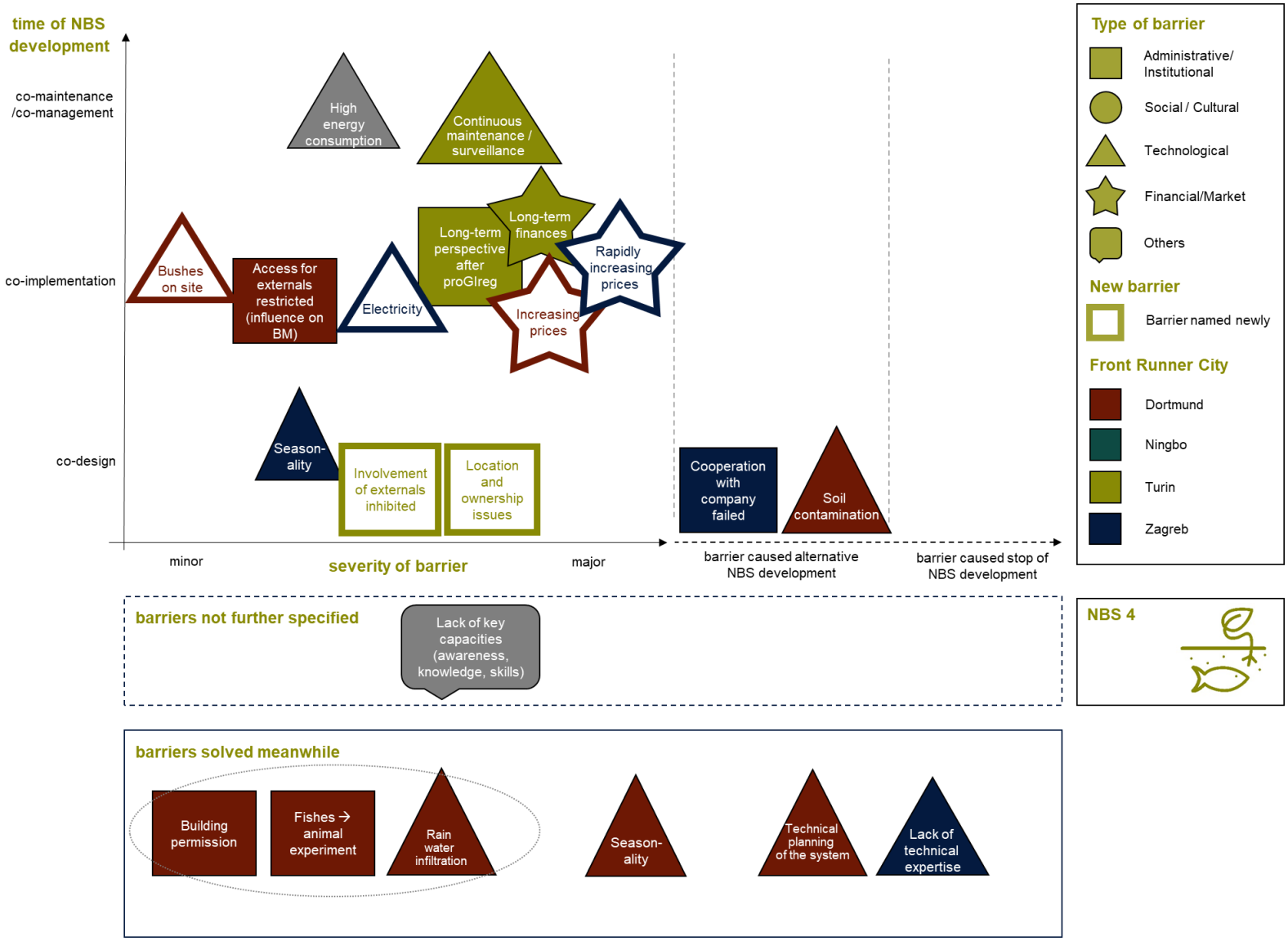

Figure 14. Update on synthesized barriers of NBS 4 including a renewed categorization and addition of newly emerged barriers.

7.2.2. Solutions to encountered barriers

Zagreb decided to combine NBS 4 and 5 in an urban mini farm, which allowed the team to overcome barriers successfully – especially to tackle the failed cooperation with a company (s. Figure 15). In Dortmund, the soil contamination forced the actors to plan a new type of Aquaponics system without interacting with the soil to avoid any harmful effects (s. also 7.2.1.). Additionally, an architect was hired to guide the NBS4 team successfully through the building application process until permission, yet still only for an Aquaponics simulation. Going beyond, some safety concerns could be solved in Dortmund. These concerns include risk of drowning (prohibition of unattended children in the greenhouses), working with chemicals, electricity and water (safety training and use of protection), and a gas pipeline (fence to be built to avoid any risk of damage/leakage). Technology-wise, Dortmund partners developed a filter solution to overcome the barriers on seasonality and rain water infiltration.

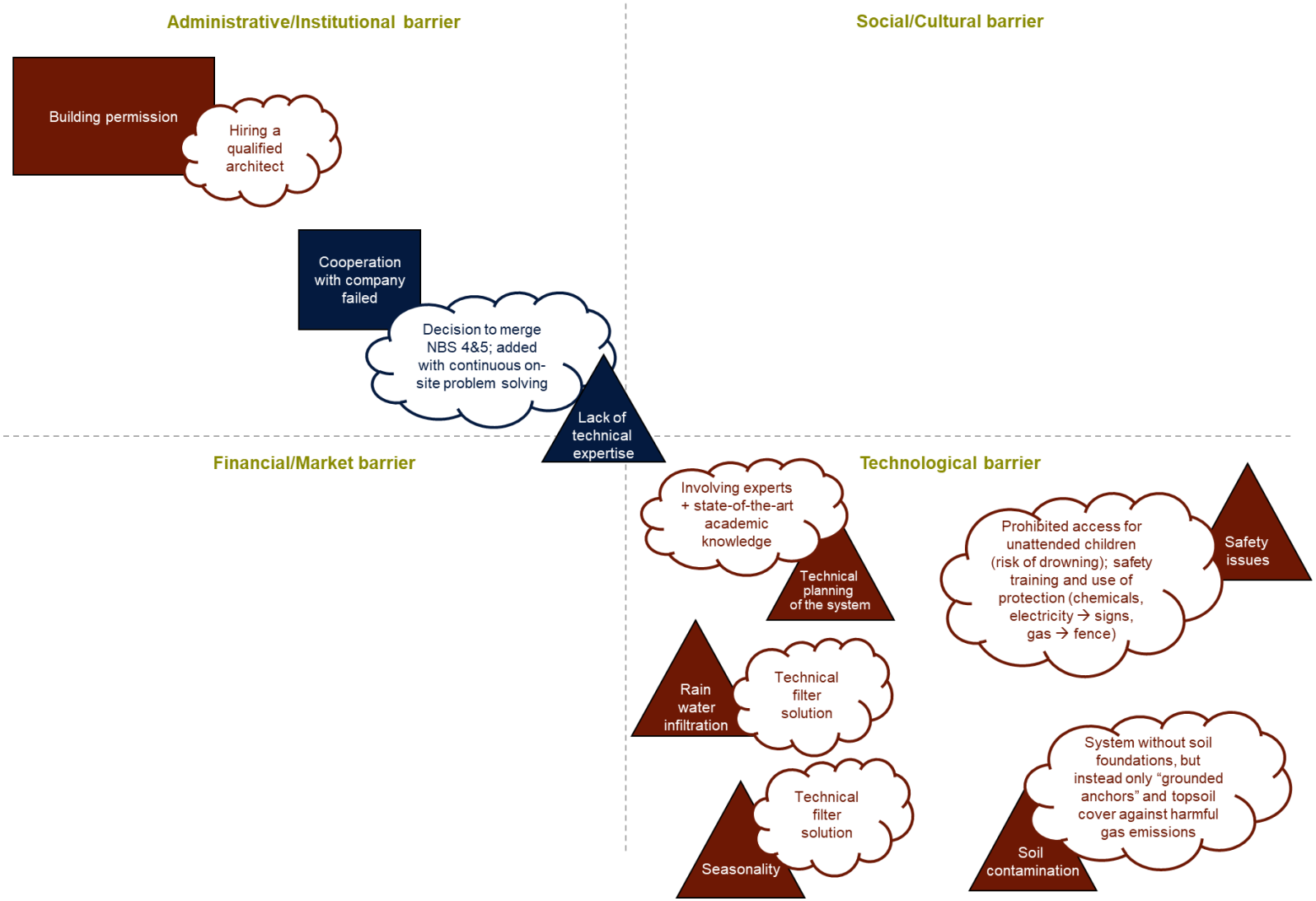

Figure 15. Solutions applied to overcome barriers.

8. NBS 5: Capillary GI on walls and roofs

8.1. Introduction

The capillary Green Infrastructures of green walls and roofs are implemented in the FRC Turin and Zagreb.

In Turin, four NBS 5 interventions have been completed, consisting of two green roofs and two green walls. One 20 m² indoor green wall is positioned in a school building, while the other green wall of 80 m² of size was implemented at a dormitory for homeless with a self-supporting structure. One green roof focused on the realization of the physical access to and improvement of the already pre-existing green roof. This activity focused on better accessibility, also for disabled and aged people. The second green roof (WOW) concerns the realization of an extensive green roof on a public building, currently abandoned. After Covid19 lockdown, in May 2020 the construction site restarted and ended in June 2020. Maintenance and accompaniment activities with citizen are ongoing.

In Zagreb, it was decided to merge NBS 4 and 5 activities (see previous chapter): The mini urban farm is designed as a new complete solution that integrates green roof, green wall, solar panels and Aquaponics technologies. The implemented farm is a green technology center in the Sljeme factory area and has both commercial and educational functions. The basic components of such a stand-alone system are one unit measuring 6 x 6m, including microclimate automation and control, and irrigation systems. Two sides of the unit will receive green wall structures, to protect the area from the sun and to collect the excess rainfall. Completion of implementation is expected for autumn 2021. The farm will have regular educational events for schools, therapeutic garden users and the public.

8.2. Collective scheme/report on barriers and solutions

8.2.1. Barriers

The development of green walls and roofs show considerable similarities and overlaps, but also some city-specific barriers in Turin and Zagreb (s. Figure 16). Technological barriers prevail, but also financial, administrative/institutional, and social/cultural barriers are each named twice. As already introduced before in NBS 4 description, cooperation with a company failed in Zagreb for what reason they decided to merge NBS 4 and 5 activities into an urban mini farm. Most of the named barriers concern the planning/co-design phase of NBS development. A minor technological barrier named by representatives from both cities is irrigation – in Turin added with similar minor barriers attached to water (drain construction, access to water). Further barriers named by Zagreb partners are bureaucracy and

accessibility. Accessibility is also an important issue in Turin, while an even stronger focus here is on loads, bearing capacities, and structural verification, leading to an alternative NBS development.

The long-term maintenance and associated predicted costs are named as major barriers in both cities. For example, the responsible partners struggle to find suitable uses for the building, including maintenance of the NBS (continuous mowing of the new green wall in Turin (WOW)). Furthermore, back at the time of the interviews in 2020, it was not possible to estimate the implications of Covid19 (s. Figure 16). All barriers affecting the planning/co-design phase could be solved in the period between interviews and workshops about a year later – except for irrigation in Zagreb (s. Figure 17). This barrier followed the NBS development into the operating phase and is still a challenge requesting consideration and handling. Like for NBS 4, three new barriers came up: rapidly increasing costs (major barrier) and electricity positioned between minor and major barrier in Zagreb as well as finding an appropriate location and agreeing on the land ownerships issues in Turin.

8.2.2. Solutions to encountered barriers

While most of the barriers and found solutions of NBS 5 in Zagreb were already discussed in the previous chapter due to the merge of NBS 4 and 5, one has to be presented here briefly (s. Figure 18). The maintenance of the NBS 4/5 urban mini farm is ensured for at least one year by contracting a company for the period from October 2021 (finalization of implementation) until October 2022. The longer-term maintenance is not decided yet and open for proposals, but at moment, two options are discussed: extending the contract with the company or handing it over to the Faculty of Agriculture, University of Zagreb.

The Turin partners were able to find and apply a series of solutions to specific technological barriers (s. Figure 18). The issues of load and structural verification were solved with dimensioning and load analyses, static calculations and water load tests. The bearing capacity (wall) could be handled by using self-supporting panels. Accessibility is ensured and will further be approved by indoor and outdoor solutions, for one NBS 5 in Turin the municipality provides mobile elevator solutions from outside the building.

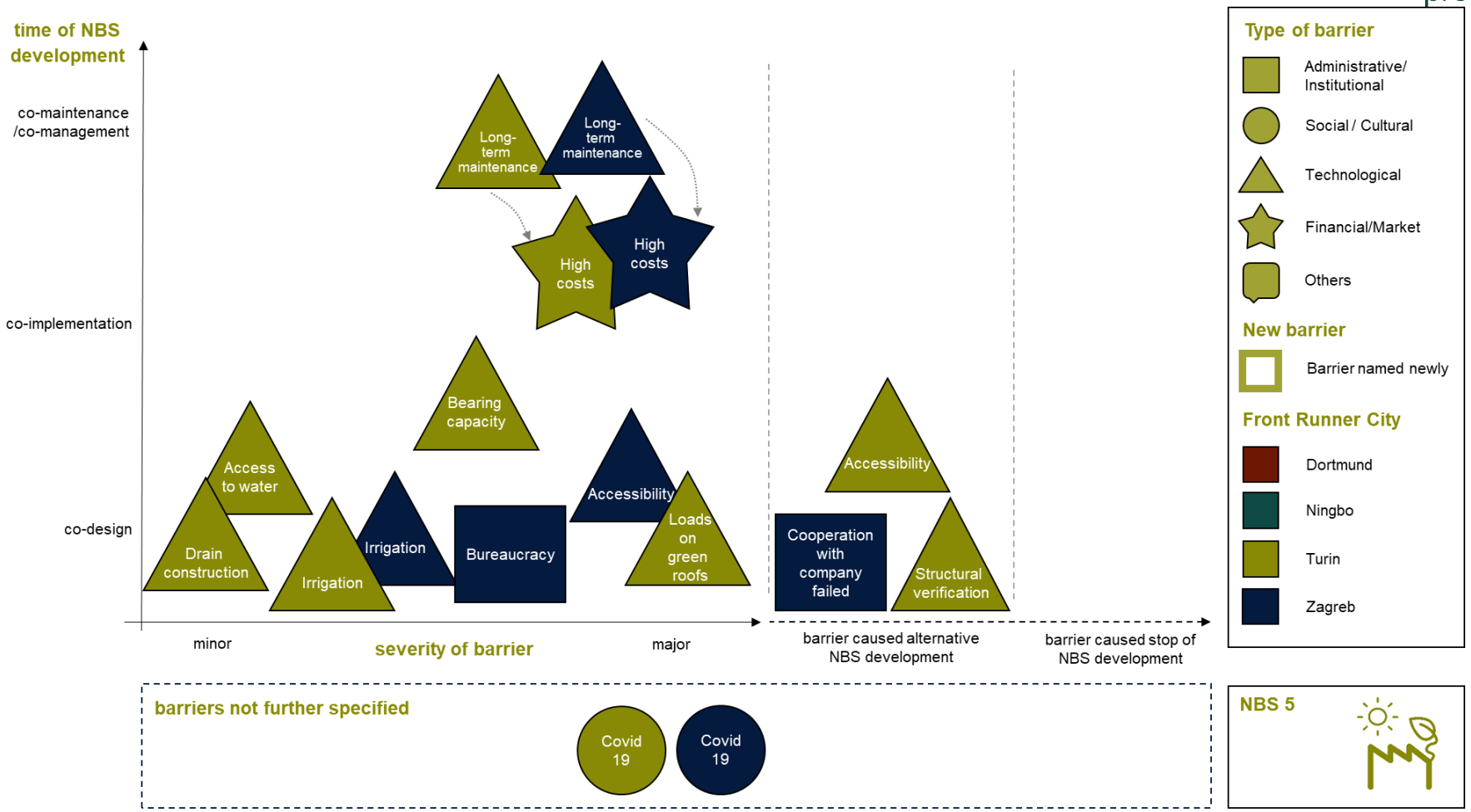

Figure 16. Synthesized barriers of NBS 5 based on the interviews in 2020

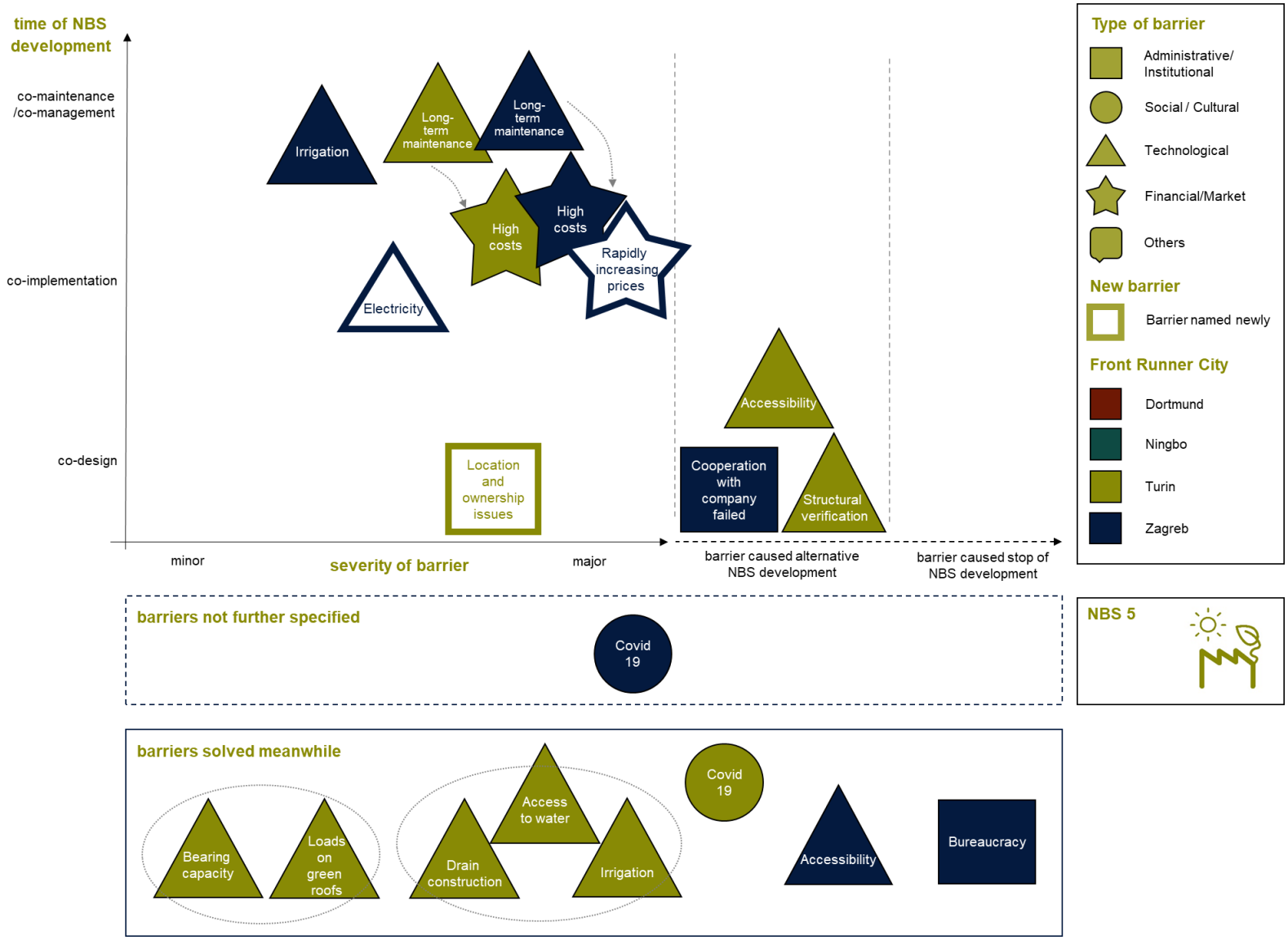

Figure 17. Update on synthesized barriers of NBS 5 including a renewed categorization and addition of newly emerged barriers.

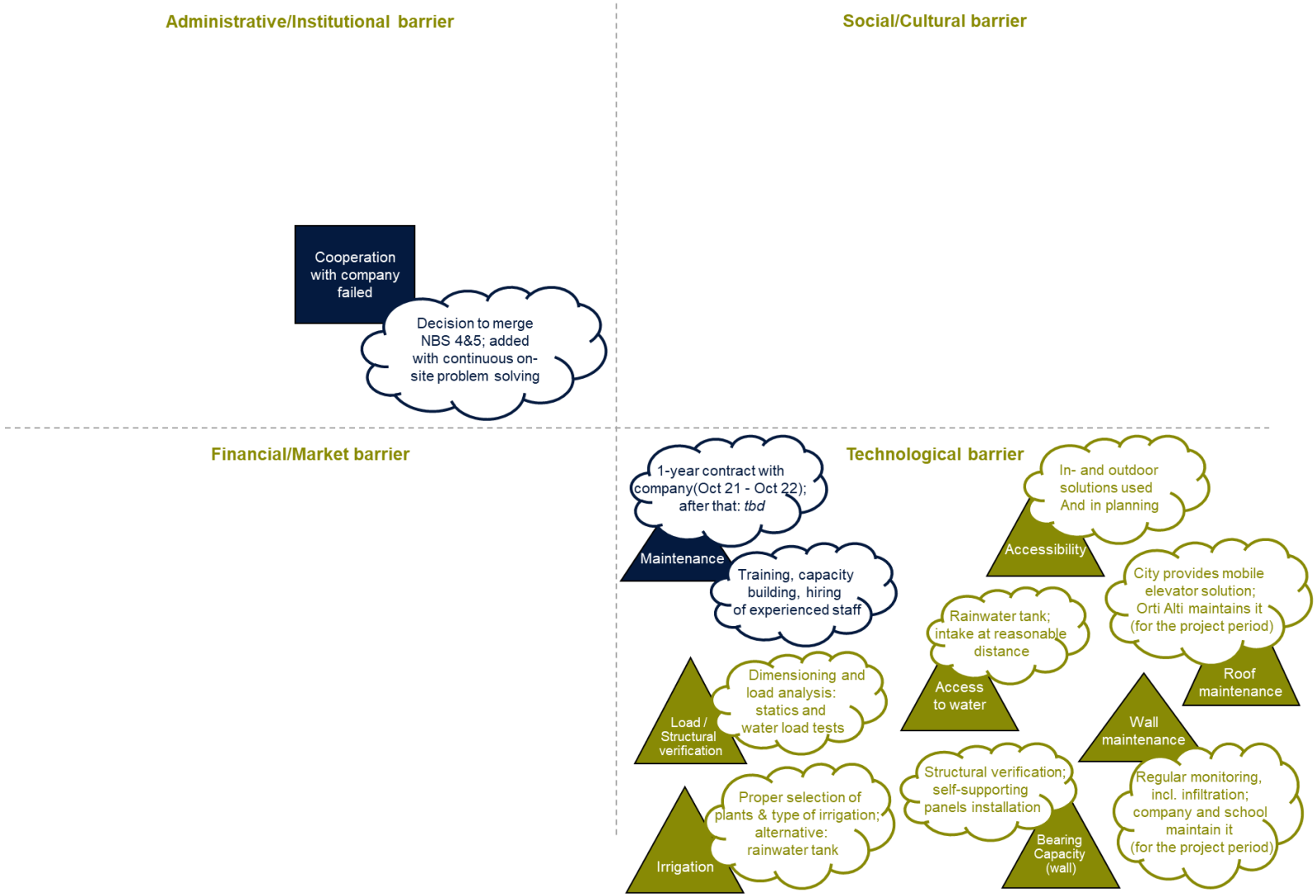

Figure 18. Solutions applied to overcome barriers.

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

9.1. Introduction

This NBS on improving accessibility of green areas is still in its planning phase in the three European FRC of Dortmund, Turin, and Zagreb.

A barrier-free construction of a 115m foot and bicycle path at Deusenberg landfill is in its planning phase in Dortmund LL. A number of challenges – including a significant cost increase, soil examinations, and land ownership issues – postpone the planned construction to 2022. EDG Dortmund GmbH already ensures maintenance following the implementation.

In Turin, a green corridor will be implemented, but it was also decided to work on the realization of signs, landmarks, and touristic information in order to enhance the corridors and the surrounding areas generally. The green corridor, a so-called ecosystem path, will provide better conditions for pollinators to enter urban areas. The composition of the intervention is designed to have pre-defined and repeatable modules allowing budget-adjusted actions in and beyond proGIreg.

Zagreb plans a new 850 m long cycling path, which will connect Sljeme brownfield area with Novi Jelkovec neighbourhood. The cycling path is part of the newly planned road, defined in the detailed plan of the former factory area. It will be part of the city street and road network, and will be maintained within the regular city road maintenance program. The construction permit will be obtained after finalisation of land acquisition.

9.2. Collective scheme/report on barriers and solutions

9.2.1. Barriers

The barriers named in the 2020 interviews focus on the co-design phase in the three European cities of Dortmund, Turin, and Zagreb (s. Figure 19). Following first consultations and exchanges of ideas, Dortmund decided to change the initially planned North-South connection into a West-East alternative at the Deusenberg foothill due to several hurdles (soil contamination, slope, ownership, costs, etc.). The two further barriers named already back in 2020 are soil contamination and vandalism. Turin partners also mentioned vandalism as a barrier (s. Figure 19 and Figure 20). Additionally, it was initially difficult to find appropriate species for the NBS 6 green corridor in Turin, but this could be solved in the meanwhile. During the the interviews of 2020, Zagreb named three barriers (s. Figure 19): land ownership issues,

soil contamination, and suitable connectivity with existing streets/roads. While the latter two could already be handled, the main barrier is the time-consuming procedure of land acquisition, and the possibility of reluctance of some of the landowners to sell the land for the purpose of NBS implementation (s. Figure 20).

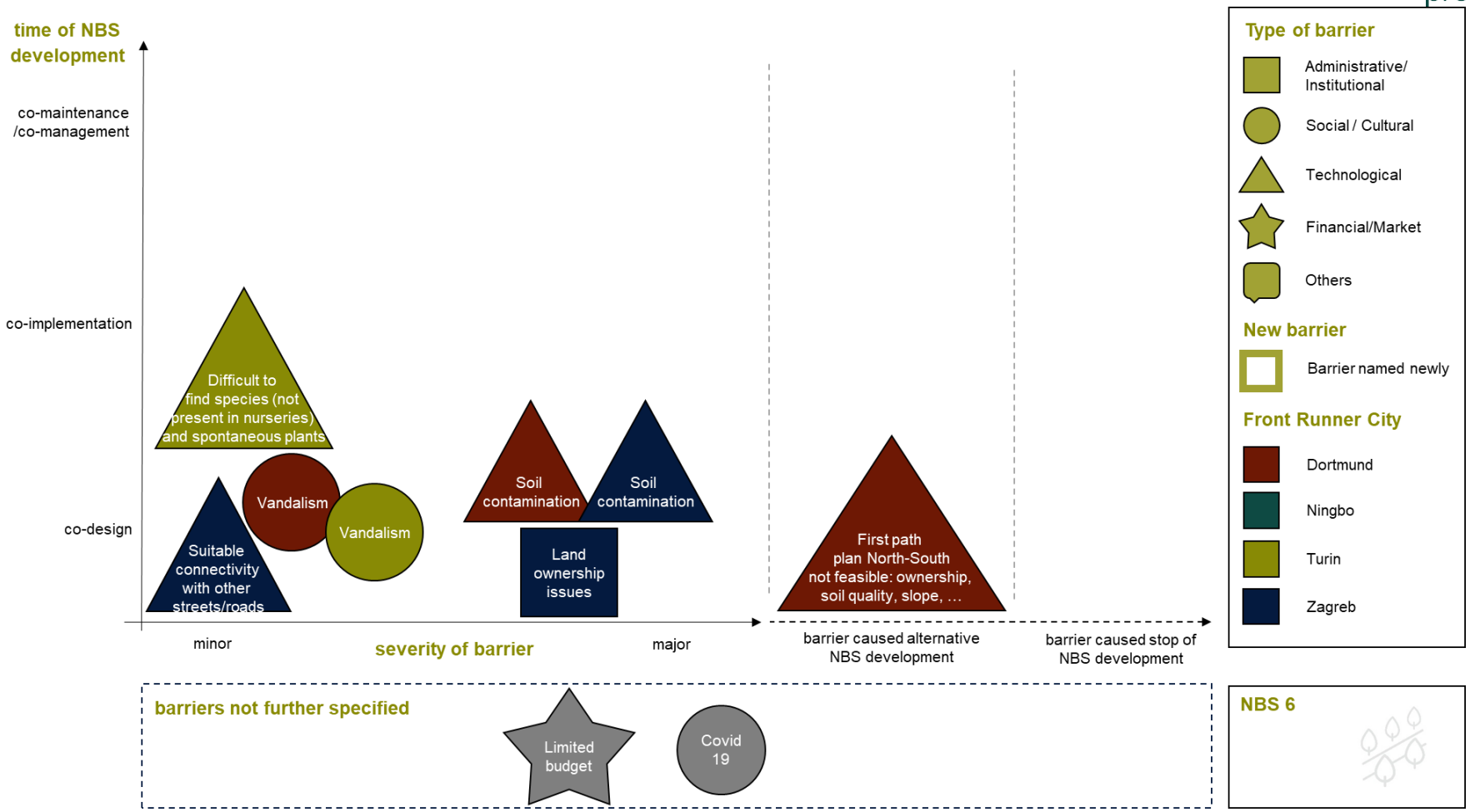

Figure 19. Synthesized barriers of NBS 6 based on the interviews in 2020

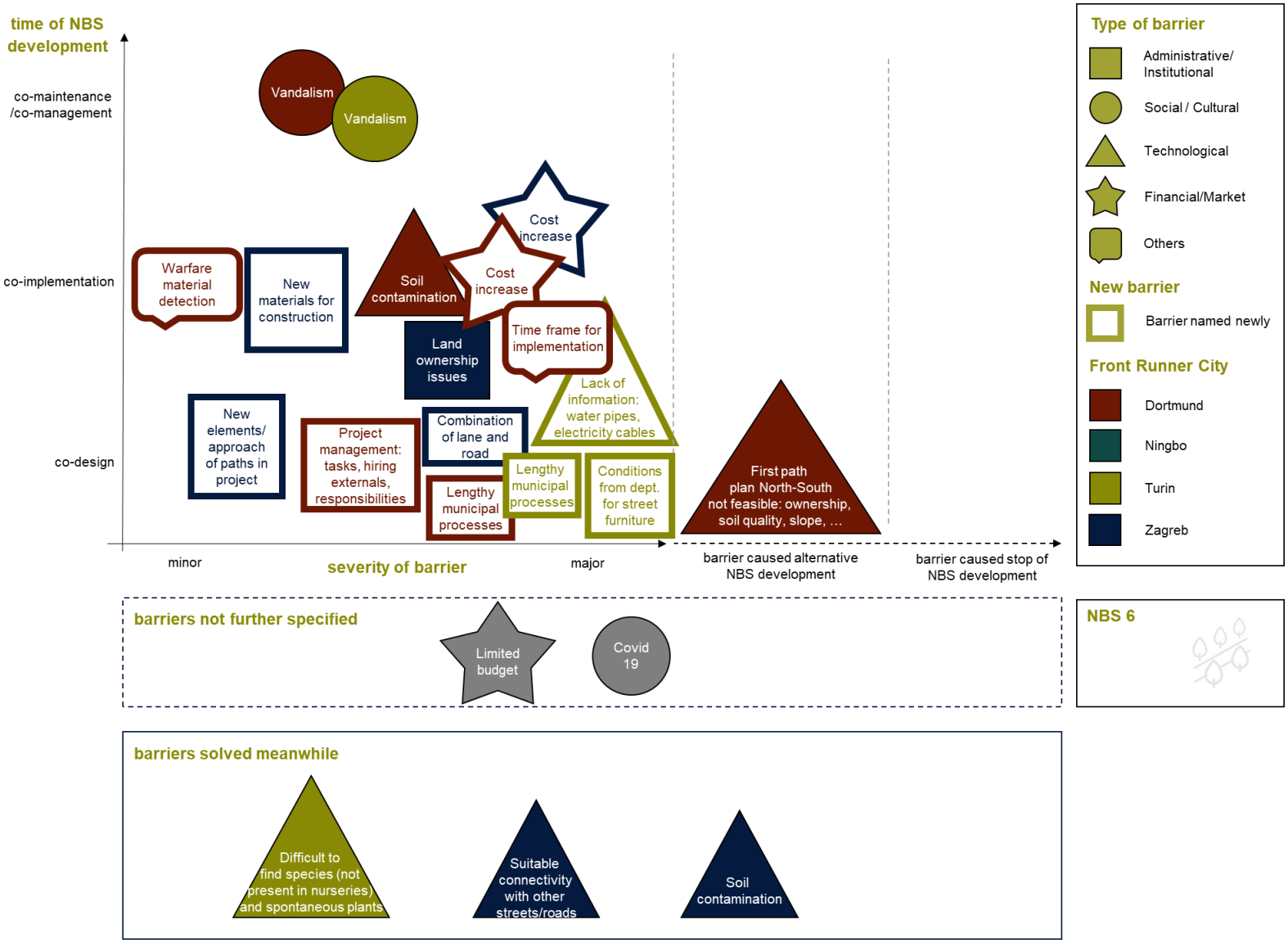

Figure 20. Update on synthesized barriers of NBS 6 including a renewed categorization and addition of newly emerged barriers.

9.2.2. Solutions to encountered barriers

The interviews of 2020 took place during the planning process in the three cities, thus the workshop of 2021 revealed a large number of new barriers challenging progress in all cities; mainly administrative/institutional barriers, but also technological, financial, and other (s. Figure 20).

Dortmund reports lengthy municipal processes and – for formal procedures – a too short proGIreg timeframe for the NBS development among others. This is indicated as a general challenge for construction NBS. Dortmund and Zagreb struggle with cost increase. Turin highlights challenging administrative conditions for street furniture and lack of information (water pipes, electricity cables in the area concerned).

While some barriers could already be solved with successful solutions (s. Figure 21), some remain in the process of being elaborated. Limited administrative capacities, project management issues, and a short timeframe for construction NBS (Dortmund) could be addressed by hiring an external company and a strict, yet dynamic time management. The latter, in the end, turns out to limit opportunities for co-design activities with the wider public. Turin also hired external expertise for detecting water pipes and electricity cables. Additionally, they moved street furniture from the streets to a courtyard to comply with street furniture regulations. Better horizontal cooperation helped to overcome administrative barriers in Zagreb. The City of Zagreb made additional municipal financial resources available to counteract the limited proGIreg budget along with a general cost increase.

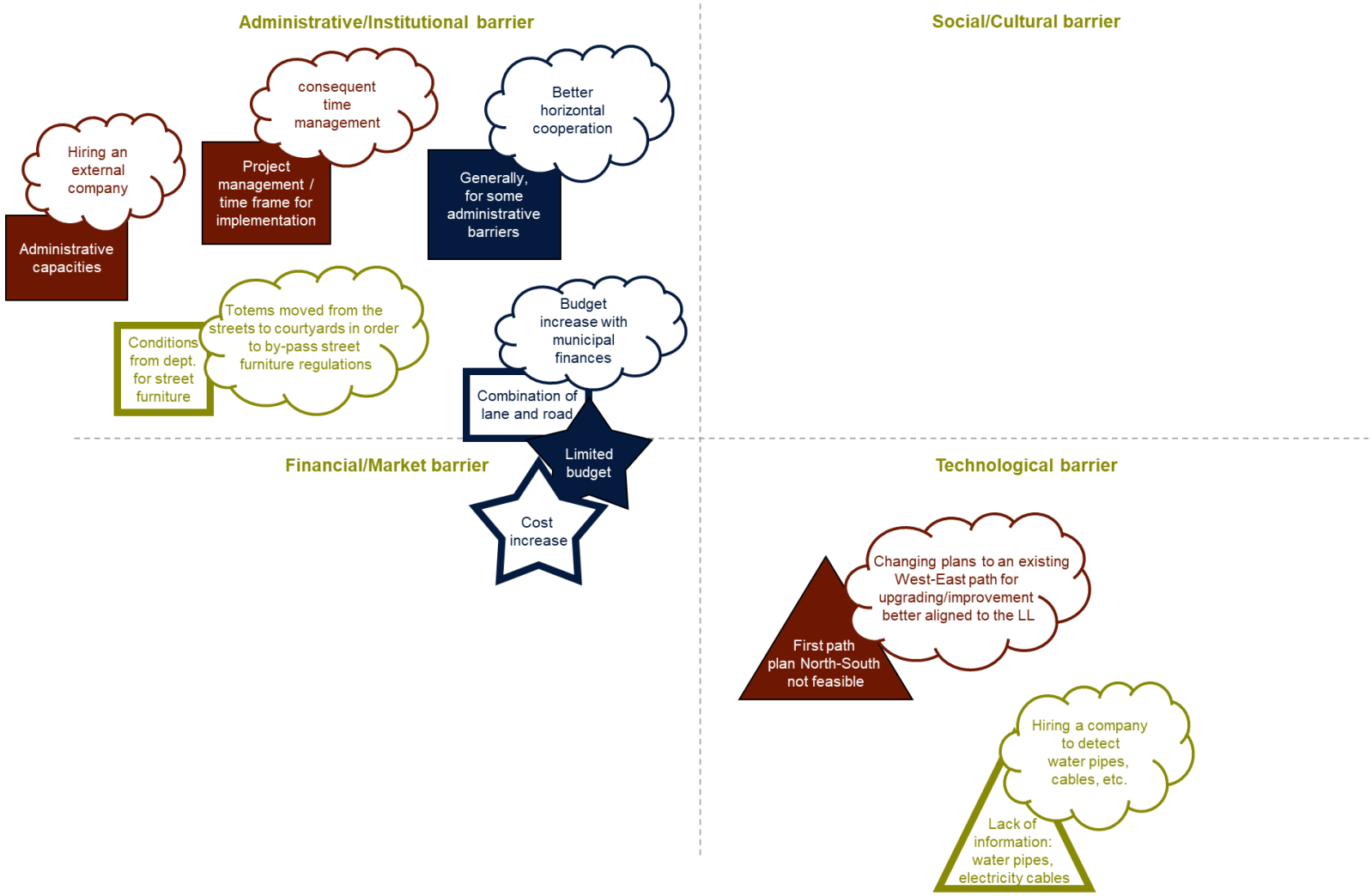

Figure 21. Solutions applied to overcome barriers.

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

10.1. Introduction

Unlike the other NBS, this NBS on protocols and procedures for environmental compensation at local level does not include physical constructions. This NBS is working on regulatory framework, procedures, and administrative protocols in Ningbo, Turin, and Zagreb. These three FRC have chosen different ways to approach the on-going topic:

In Ningbo, the Public-Private Partnership of Moon Lake Water Ecological Comprehensive Improvement Project builds the core of NBS 7 activity. Since 2019, Ningbo partners have been focusing on monitoring environmental data, namely by taking water samples once a week to monitor the lake's water quality. The sampling will continue until the end of 2021 for what they have already received part of the environmental compensation successfully.

Turin's ongoing activity is the establishment of a strategic public-private partnership for greening the city. The aim is to identify, collect and display tools and concrete opportunities in order to allow the administration to improve the green assets of the city. The engagement of the private sector can boost the development of green areas by giving win-win solutions. As an example, private companies planted trees in public parks of Mirafiori. Green areas should be considered as one of the main "urban commons" and, in contemporary cities, their shared management can become a link between different realities, helping to build a sense of community.

Zagreb has established a task force to define new green procedures. The main goal is to define the legal framework, point out the parts that can be changed on local and national level, and outline the necessary activities. All city administrative bodies, companies, institutions and associations as well as public, civil, business, and scientific sectors provide active contributions in drawing-up of the city strategic documents, while the Partners' Council, consisting of prominent experts from the scientific, public, civil, and business sectors, provide a special contribution. The Partners' Council, as the advisory expert authority, participates in every phase of preparation and drawing up of the strategic documents.

10.2. Collective scheme/report on barriers and solutions

10.2.1. Barriers

Administrative/institutional barriers dominate the planning/co-design phase in the three cities concerned, while technological and financial barriers dominate during implementation and maintenance (s.Figure 22 and Figure 23).

All three cities highlight bureaucracy as a major barrier. This is accompanied by limited flexibility for the Chinese city due to national regulations. Zagreb adds the existing focus on top-down approaches as well as the dominant practice to view GI and NBS from the perspective of existing practices, norms, and standards. The barriers named by Turin are similar (s. Figure 22): reluctance to follow new paths with Green Infrastructure and NBS (also beyond proGIreg) as well as internal tensions between departments whether to promote new green or conventional grey infrastructure actions.

Most administrative/institutional barrier have not changed between interviews in 2020 (s. Figure 22) and the workshop about one year later (s. Figure 23). Zagreb was able to establish a multidisciplinary task force, covering twelve different fields of expertise to eliminate top-down barrier, promote NBS and define the legal framework. Experts from mobility, energy, civil engineering, heritage, climate, economy, law, planning, etc. build this task force. The Turin partner sees an increase of barrier severity from minor (interview 2020) to major (workshop 2021) for the reluctance to follow new paths aiming for tools and concrete opportunities to allow the administration to improve the green assets of the city. Both, Turin and Zagreb, highlight lack of financial incentives and access to finances in this domain. As the NBS 7 are different between Ningbo on one side and Turin/Zagreb and the other side, the barriers hold different characteristics.

In Ningbo, the monitoring of environmental data in the lake result in a number of technological barriers: biased results, removal and use of lack bottom sediment, selection and maintenance of lake share vegetation, high nitrogen levels, weather sensitivity of test results, and the maintenance of stable water quality in the long run (s. Figure 22).

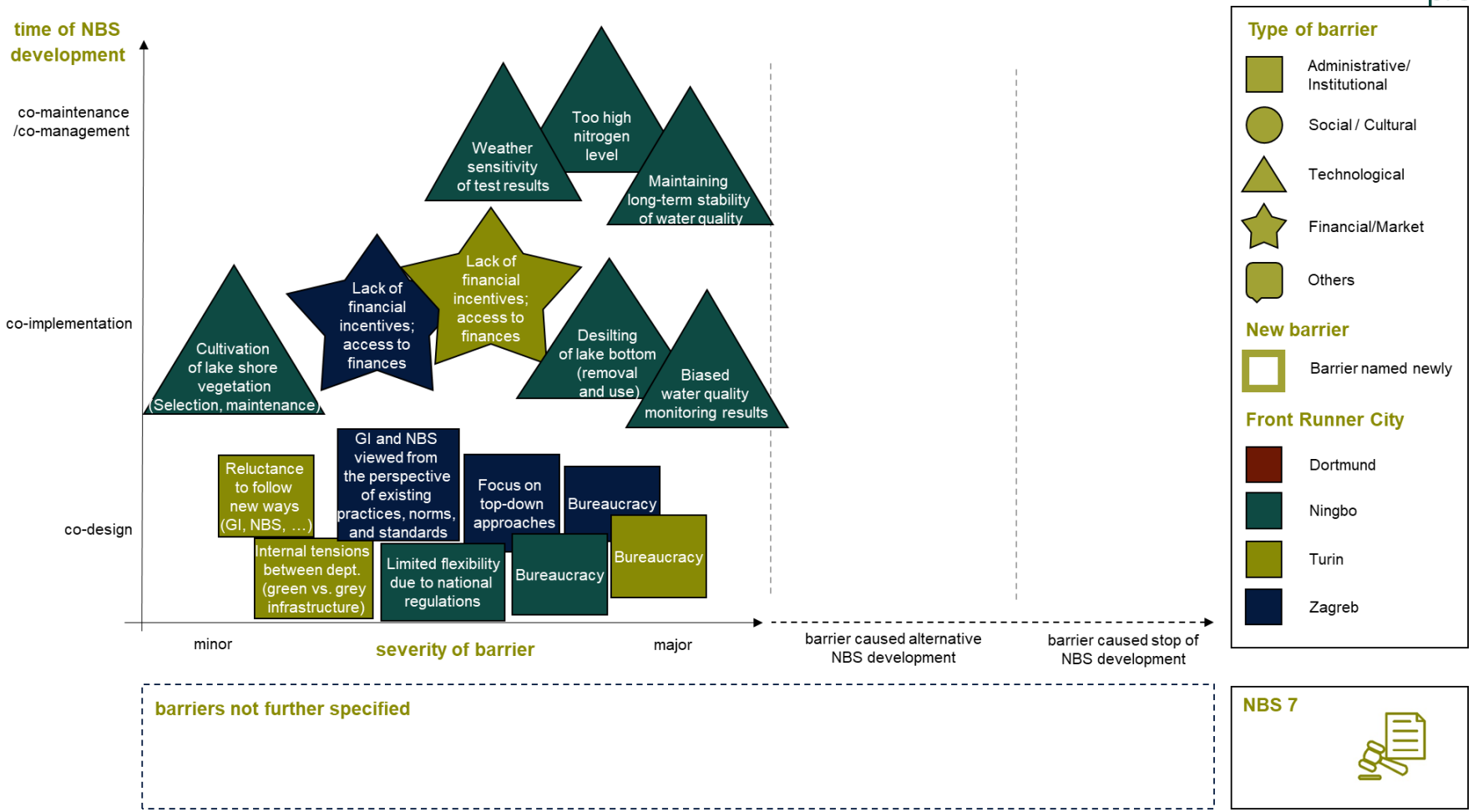

Figure 22. Synthesized barriers of NBS 7 based on the interviews in 2020

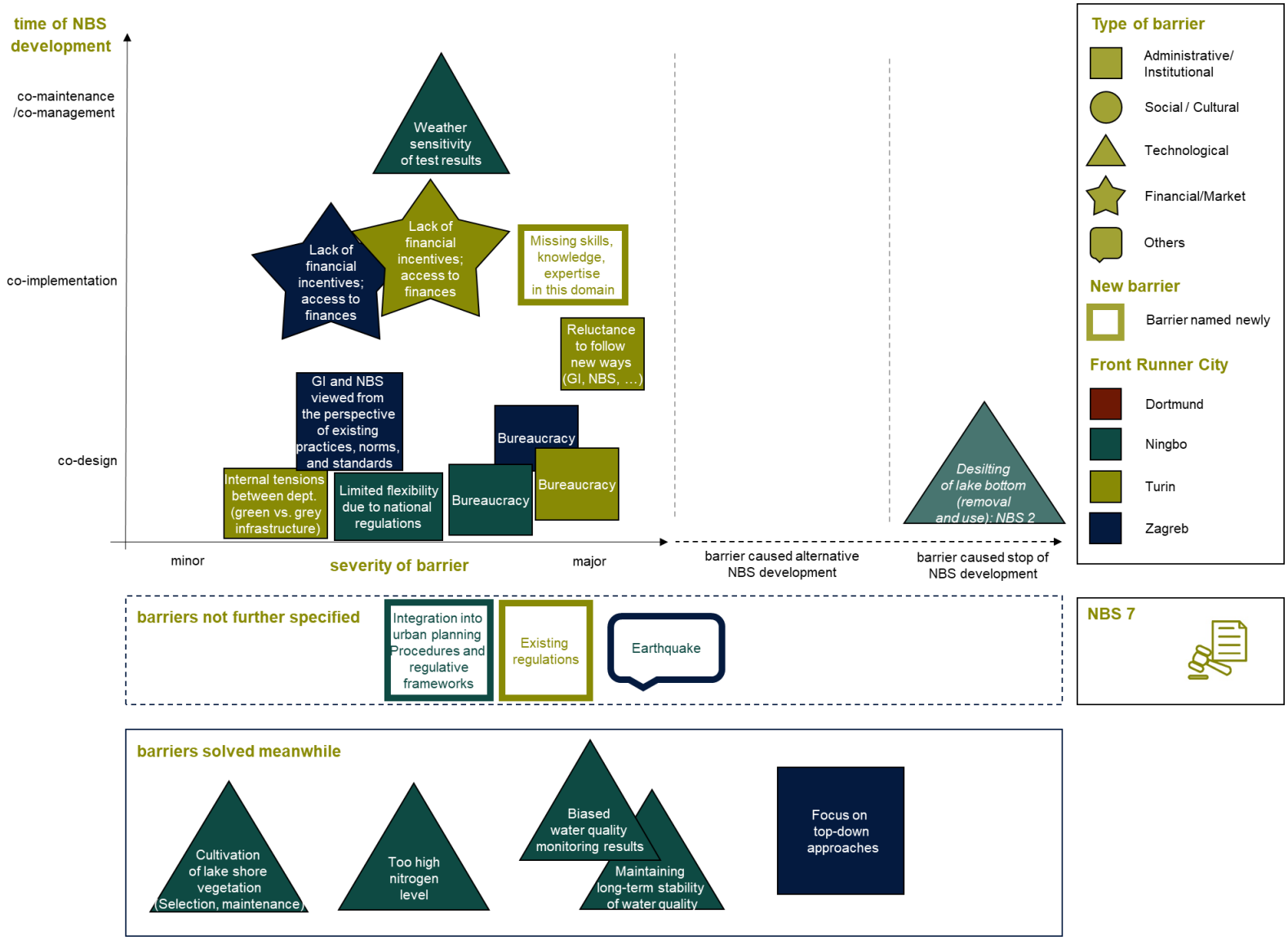

Figure 23. Update on synthesized barriers of NBS 7 including a renewed categorization and addition of newly emerged barriers.

10.2.2. Solutions to encountered barriers

In the time between the interviews 2020 and the workshops 2021 a few, mainly technological, barriers could be solved. For Ningbo, most of them (s. Figure 22 and Figure 23). The too high nitrogen level is combat with environmental remediation actions (planting of aquatic plants, dredging of rivers and lakes, filtration and recycling). A professional company manages the selection and maintenance of lakeshore vegetation. Weekly monitoring of the water quality aims to eliminate instable water quality.

During the workshop, Turin added existing regulations (with further specifications) and a new major barrier (s. Figure 23): missing skills, knowledge, expertise on protocols and procedures for environmental compensation. Similar to Zagreb, Turin is setting up a multidisciplinary team to bring together skills, knowledge, and expertise (s. Figure 24). The existing regulations represent a barrier difficult to change, because an innovative view to see NBS as an asset for the city is lacking. Thus, proGIreg has to demonstrate the benefits to include NBS and green infrastructure in urban planning generally, and in Turin specifically for NBS 7. The reluctance to follow new paths is highlighted as a key challenge. Strategic alliances of key stakeholders (administration, companies, and citizens) are needed to overcome this by working on the economic value of nature and NBS. By doing so, this NBS can be of value for all other NBS of the proGIreg project and beyond.

The lack of financial incentives and missing access to finances demands agreements and engagements from different stakeholder groups towards financial solutions, including sponsoring, and donations.

Zagreb aims to support a new way of planning, promoting green solutions. Besides the multidisciplinary task force, it is highlighted that strategic planning and urban planning have to be brought together and interlinked (s. Figure 24). Given the term NBS is not yet familiar for Zagreb aims at introducing and integrating the concept of NBS into urban planning and regulative frameworks. On a more general level, Croatian planning processes include stakeholders in co-creating too late, thus requiring more inclusive procedures. Formal planning is binding and long-term oriented, for this reason changes towards inclusive, green, and more sustainable and resilient processes are needed. Furthermore, despite the earthquake affecting Zagreb and the LL heavily may be turned into re-thinking earlier planning processes, protocols, and procedures.

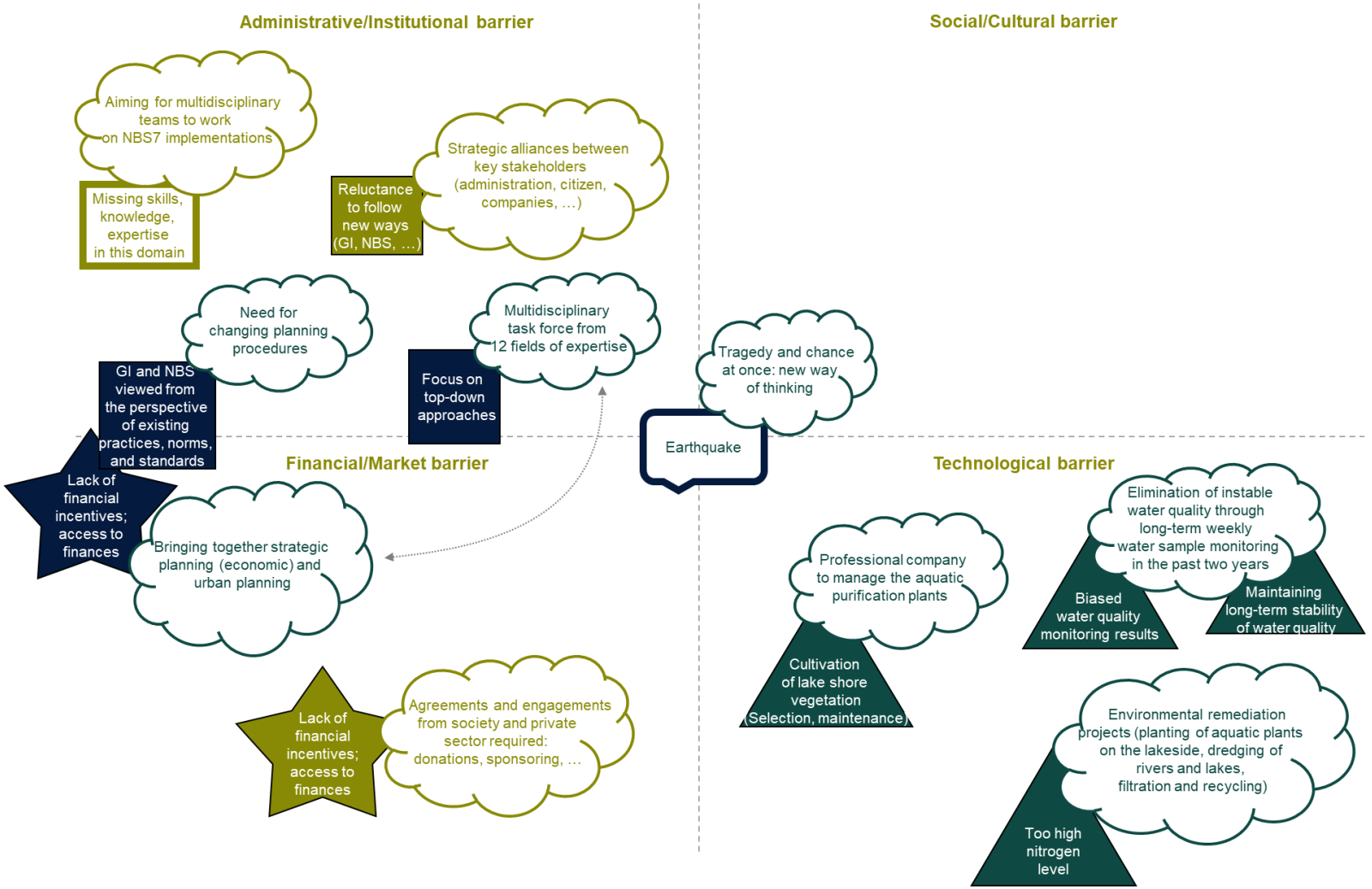

Figure 24. Solutions applied to overcome barriers.

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

11.1. Introduction

Dortmund and Turin are the two FRC promoting pollinator biodiversity within NBS 8. The activities aim to support biodiversity through the planting of pollinator friendly plant species; dedicated specifically hereon or attached to other NBS activities.

In Dortmund, several pollinator-friendly flowering fields could already be implemented; first seeding activities took place in spring 2021 followed by several other sites in early summer 2021. By doing so, formerly intensively mowed public areas were transformed into species-rich meadows offering valuable habitats for pollinators. These activities are partly standing alone, but partly also intertwined with NBS 3 and 4 activities in Dortmund's LL. Additionally, the new association 'Naturfelder Dortmund e. V.' was founded in July 2021 to promote urban biodiversity inside the proGIreg LL, but also beyond in the whole city.

Turin focuses on butterfly gardens in schools and activities involving disadvantaged people. The objective is to promote the presence of butterflies in the city through the creation of a network of green areas consisting of suitable plants (food plants and nectar sources). The scientific aim of the project is accompanied by the social purpose, the involvement of fragile people with mental or physical disabilities, against isolation and social stigma. The NBS achieved the goal to include disabled people in training them to monitor the butterflies. This activity has proven to be healthy for the target group.

11.2. Collective scheme/report on barriers and solutions

11.2.1. Barriers

Activities to improve pollinator biodiversity in Turin and Dortmund resulted initially in a number of technological barriers (s. Figure 25), which could be overcome with further advancements of the NBS actions (s. Figure 26, Figure 27). Yet, new minor barriers occurred. Both cities struggled to find land; the 2020 interviews ranked this in Dortmund as a major, in Turin as a minor barrier (s. Figure 25). Both were able to find areas for NBS 8 activities via networking, awareness raising and dedicated planning (s. Figure 27). Specific preparatory activities (plant selection, interactions, selection of nurserymen, soil preparation) could also be handled with appropriate measures, mainly by involving biodiversity experts. At the time of the interviews 2020, coordination (administrative/institutional barrier) and mowing were indicated as minor barriers in Dortmund. The team dedicated huge efforts into solving these issues for long-term maintenance and advancement. By doing so, the team found solutions to maintain biodiversity-rich areas for more than a year: proper soil preparation, suitable techniques and timing concerning the mowing of the flower meadows, seed mixtures including annual, biennial, and

perennial plants. Yet, it remains open to some extent, how long a certain area can be maintained without losing biodiversity significantly. This is still on the action list internally in proGIreg, but even more on the one of the newly founded association “Naturfelder Dortmund e. V.” The Dortmund group has already taken over the NBS 8 activities – accompanied by proGIreg staff – to look for additional sites where to seed flower meadows, site-specifically they are testing different seed mixtures, techniques, and soil preparation activities to select the most promising ones for future use. The association’s foundation ensures long-term advancement of pollinator biodiversity in Dortmund – also beyond the proGIreg LL. Apart from the association, which is working in the whole city of Dortmund, it is also planned to integrate day care centers, kindergartens, schools into NBS 8 maintenance in the project’s LL area. This multi-stakeholder approach to maintain the areas rich in pollinator biodiversity is also followed in Turin.

11.2.2. Solutions to encountered barriers

Turin and Dortmund both raised the issue of allergies, which remains an open question to be tackled and put awareness on (s. Figure 25, Figure 26, Figure 27). So far, the only response is to provide information. Participants of the NBS 8 workshop mentioned and discussed some new barriers: apart from the technical hurdle of stony soils difficult to be cultivated (Dortmund), many social/cultural-related issues were put on the table (s. Figure 26). Covid19 pandemic hampered face-to-face meetings in the preparatory phase of the foundation of the association “Naturfelder Dortmund e. V.”. Fluctuations in the core team funding the association complicated this challenge. proGIreg stuff supported the process through well prepared online meetings. Turin also complained about Covid19 implications restricting citizen involvement in the implementation and maintenance phase of NBS 8 activities. Dortmund also named complains about ‘messy green areas’ expressed by citizens associated to the spreading of flower meadows – instead of short grass lawns poor of biodiversity.

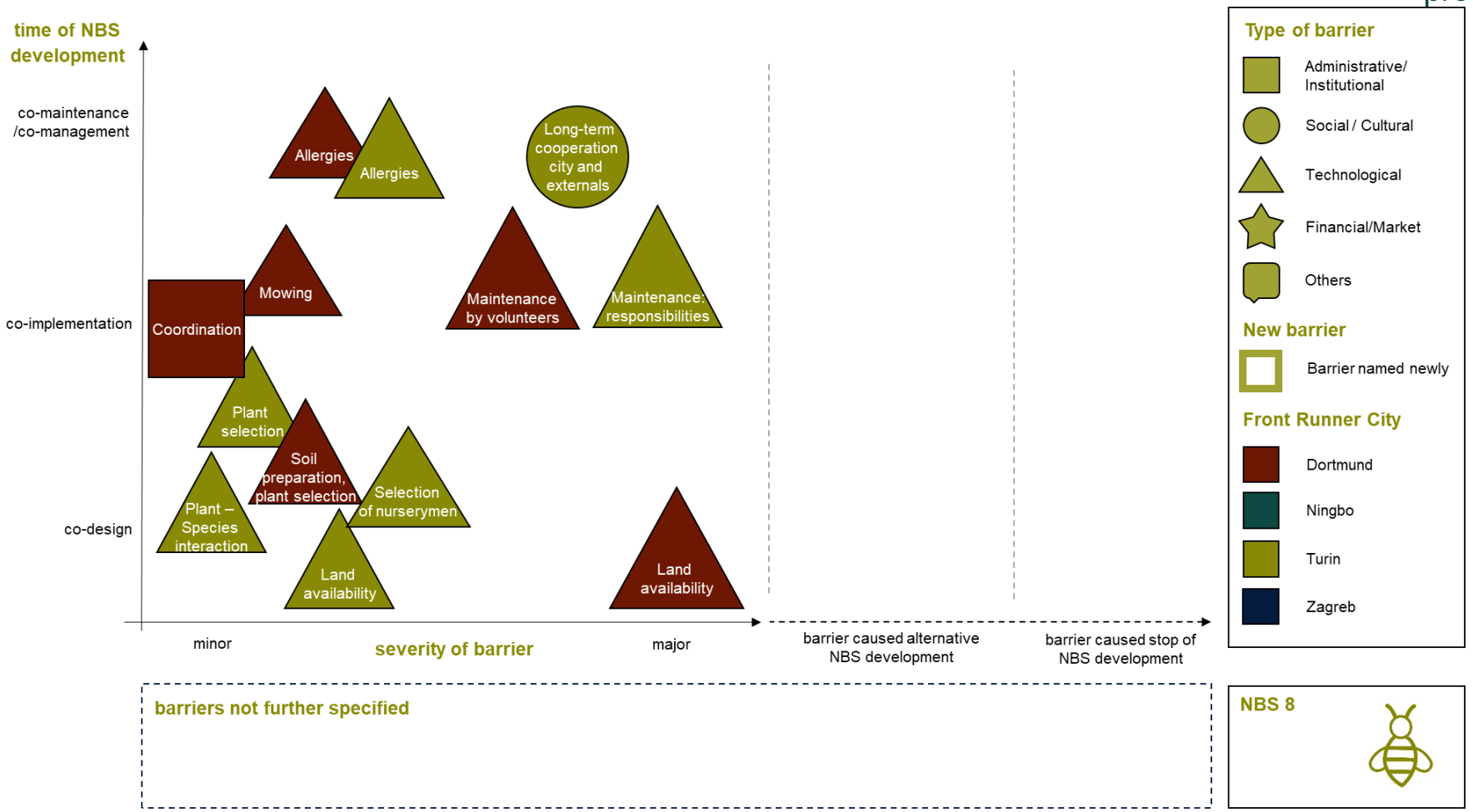

Figure 25. Synthesized barriers of NBS 8 based on the interviews in 2020

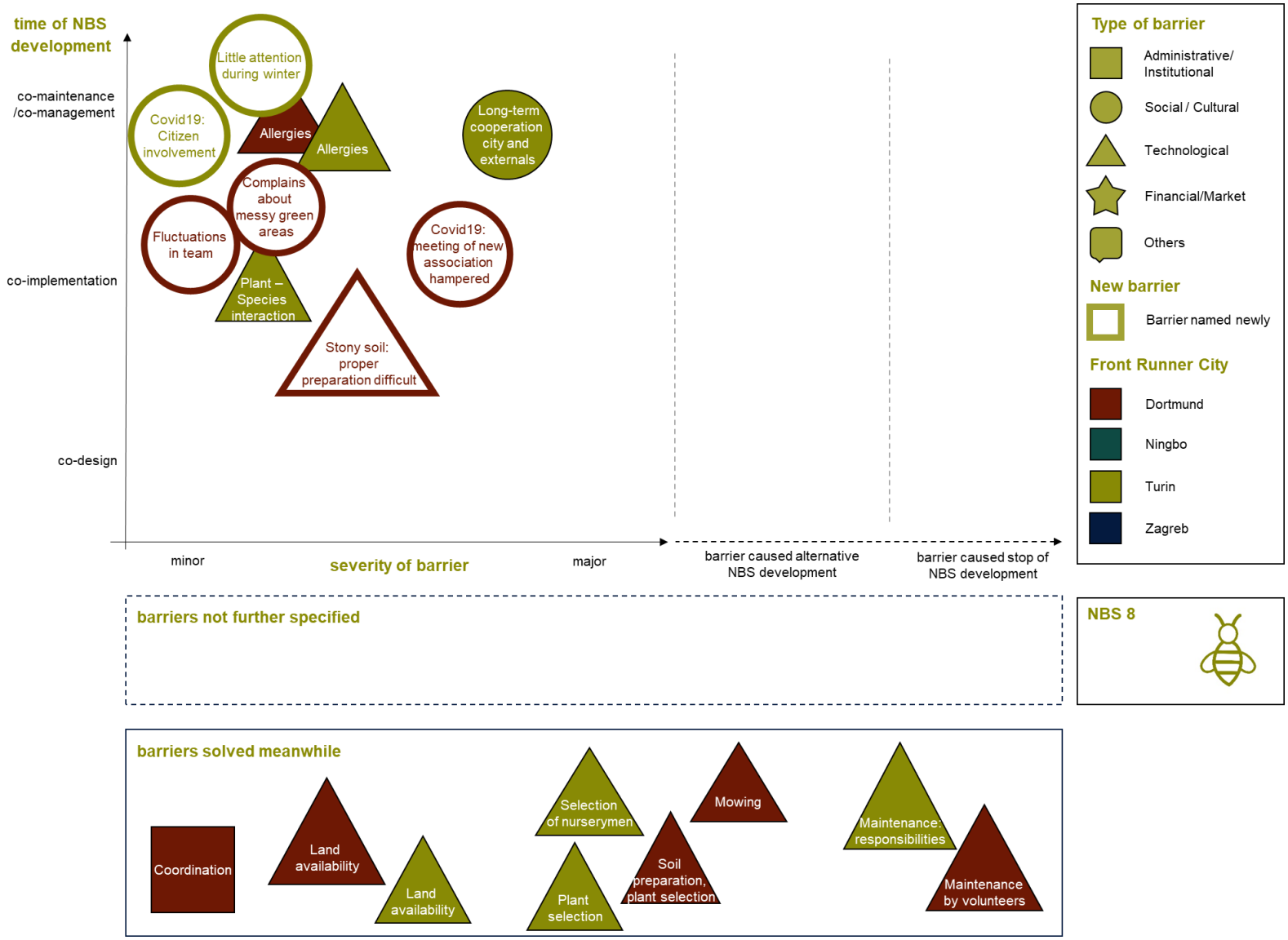

Figure 26. Update on synthesized barriers of NBS 8 including a renewed categorization and addition of newly emerged barriers.

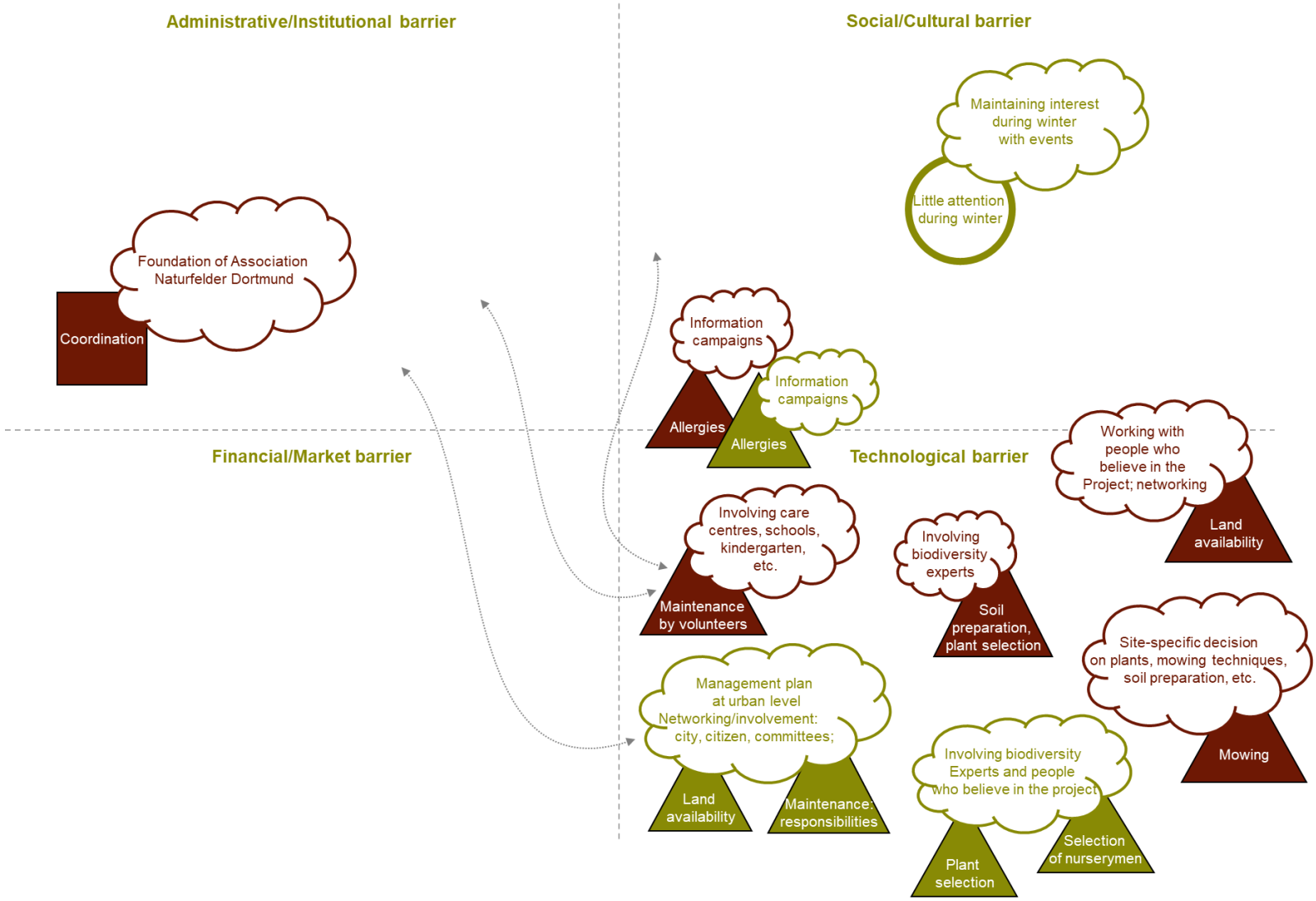

Figure 27. Solutions applied to overcome barriers.

12. Considerations and discussion

The presented results of the two rounds of data collection (individual online interviews in 2020 and NBS-specific workshops in 2021) have to be seen in light of varying stages in the NBS developments. While a continuously increasing number of NBS are being implemented and maintained, other NBS are still in the planning/co-design phase, notably for the construction of NBS (NBS 1, 4, 5, 6) as well as for on-going conceptual activities to develop protocols and procedures for environmental compensation measures (NBS 7).

The interviews in 2020 were influenced by the by that time new Covid19 pandemic and were therefore held online (s. Del. 5.2 and 5.3). Following these individual online interviews, the workshops of 2021 offered not only the opportunity to receive an update on the barriers and applied solutions to overcome them, but also to share experiences and knowledge among the responsible partners for each NBS in the FRC.

Considerations have been elaborated concerning the following topics:

- → Synthesised results: similarities and differences between NBS
- → Common barriers and applied solutions to overcome them
- → FRC workshops with Follower Cities' findings (Del. 5.2, 5.3)
- → Contribution of external knowledge (Del 5.4, other NBS projects)

12.1. Synthesised results

The outcomes of the interviews as well as the workshops show similarities, but also differences between NBS. Different stages of NBS development need to be considered. Generally, certain types of barriers occur in specific phase of NBS development (s. Figure 28). Administrative/institutional barriers are mainly challenging the planning/co-design phase, in which they dominate – especially for the NBS 1, 3, 6, and 7. No severe administrative/institutional barriers influenced the pollinator biodiversity development of NBS 8. Here, technological barriers dominated in the beginning. For the NBS 2 (new soil), 4 (Aquaponics), and 5 (capillary GI) technological and administrative/institutional barriers prevail the planning/co-design phase. This domination of administrative/institutional barriers is no longer true for the implementation and maintenance phase of NBS developments. During implementation, the participants in the interviews and workshop emphasize strongly on technological, often NBS-specific, barriers and financial barriers. Financial barriers are named as major barriers for NBS 3, 4, 5, 6, and 7. For all these NBS, technological barriers complement to the financial barriers; additionally, technological barriers dominate for NBS 2 and 8 when reaching the implementation phase. For the maintenance/running phase of the NBS, it is still being difficult to detect certain patterns due to the delays of some NBS developments. So far, most barriers concern social and technological ones, but also financial challenges risk longer-term advancements of NBS. Apart from the time of NBS development, barriers occur partly very specifically for one or few certain NBS, while other barriers are named

more often allowing the conclusion that these barriers tend to be of overarching nature. Barriers, which are frequently named by several NBS and cities, are:

- → bureaucracy/lengthy municipal processes (administrative/institutional barrier),
- → soil contamination, pollution (technological barrier),
- → lack of expertise, knowledge, and skills (technological barrier),
- → limited budget (financial barrier),
- → long-term maintenance (technological and financial barrier), and
- → Covid19-related restrictions.

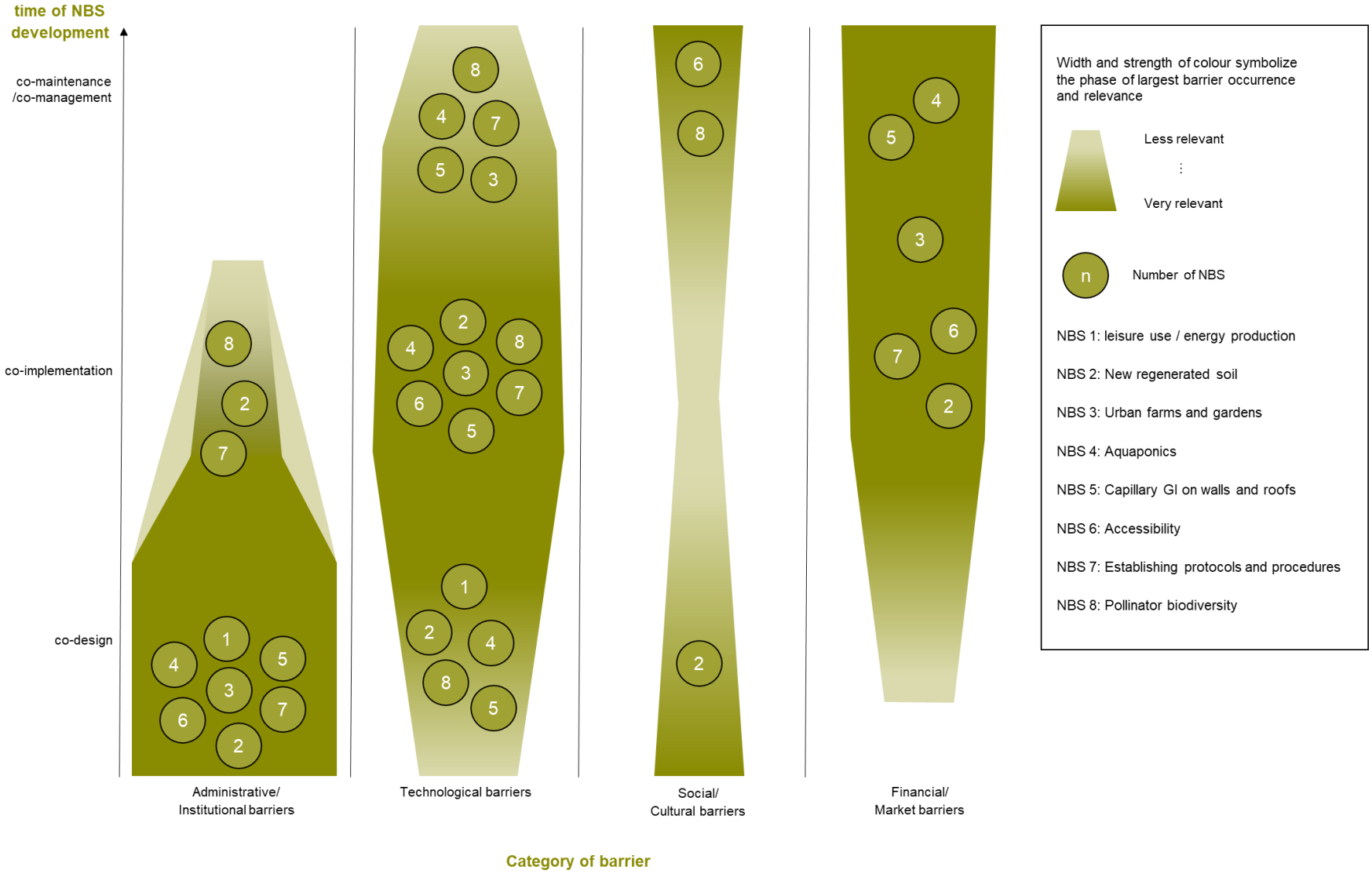

Figure 28. Simplified visualization of occurrence and relevance of main barrier categories for the eight NBS and phases of NBS development: co-design, co-implementation, co-maintenance/co-management.

12.2. Common barriers

Administrative/institutional barriers

Except for NBS 8, representatives of all other seven NBS name bureaucracy/lengthy municipal processes as administrative/institutional barrier. Applications and permission procedures for NBS developments follow protocols, standards, and norms established for traditional, well-known grey infrastructure constructions mainly, not differentiating between grey and green infrastructure when they include physical constructions, as sport equipment (NBS 1), greenhouses (NBS 4), green walls/roofs (NBS 5), and paths/roads (NBS 6). Overall, administrative protocols and procedures (NBS 7) have to be adjusted to NBS and green infrastructure solutions. Thus, this NBS can be advantageous for all other NBS when being successfully tested and implemented. This requires political will and support on local level providing appropriate legal frameworks and planning structures.

Technological barriers

In many cases, soil and/or water contaminations pose a major challenge for re-using post-industrial sites. The FRC highlighted contamination as a key barrier when implementing NBS – especially concerning food production (NBS 3, 4) and its preparatory activities like new soil (NBS 2) and leisure activities (NBS 1, 6). In Ningbo, the level of lake sediment pollution even caused the stop of NBS 2 implementation. Apart from Ningbo, the three European FRC ranked contamination as major (NBS 1, 3, 6), while in Dortmund the soil contamination on Hansa coking plant caused the development of an adjusted Aquaponics development without interacting with the soil to avoid any harmful effects (NBS 4). Appropriate measures (removal of contaminated soil, planning constructions without touching the contaminated soil, protection layers, etc.) were able to overcome the issue of soil contamination for some cases with, while other NBS developments still face problems.

Three NBS are not limited by soil contamination: pollinator biodiversity (NBS 8), green walls and roofs as these NBS implementations, which do not interact with possible harmful soil and/or water directly (NBS 5), and the conceptual NBS 7 on protocols and procedures for environmental compensation.

Lack of expertise, knowledge, and skills is also named several times, especially for the NBS 1, 3, 4, and 7. For example, NBS 4 implementation requires dedicated knowledge on Aquaponics, which is either largely existing in the project team (Dortmund) or bought in from outside the project team (Zagreb, Turin).

Financial barriers

Especially representatives of the construction NBS (NBS 1, 3, 4, 5, 6) name limited budgets as a (potentially) major barrier. While the costs for NBS implementations were calculated a couple of years back, the recent rapid cost increase, mainly of materials, but also staff costs of craftsmen, challenges NBS implementations. Partly it was already possible to overcome this barrier by allocating additional budget, e.g. using the overhead budget or by adding additional

municipal budget. For example, Zagreb contributes additional municipal budget to the NBS 6 development. Additionally, Zagreb signed a contract with a company to maintain and advance the NBS 4 and 5 urban mini farm. NBS 7 highlights a lack of financial incentives and access to finances beyond proGIreg for establishing protocols and procedures for environmental compensation.

While some NBS require extensive mid- and long-term maintenance activities, others do only need minor maintenance. The NBS, which require comprehensive maintenance, are community-based urban gardening and farming (NBS 3), Aquaponics (NBS 4), capillary GI (NBS 5), and pollinator biodiversity (NBS 8). Workshop participants representing these NBS highlight long-term maintenance and advancement as barriers demanding proper planning.

Covid19

A number of NBS representatives (NBS 1, 3, 5, 6, and 8) named Covid19 implications as severe barriers. Although restrictions are loosening (early autumn 2021), Covid19 still has effects on the NBS developments causing delays, cancelling of physical meetings or full order books of construction companies delaying implementations.

12.3. Applied solutions to overcome barriers

Project partners were already able to overcome a wide number of barriers by applying solutions. However, several barriers still existed at the time of the workshops in 2021. When it comes to the solutions, it is important to highlight that the findings rely on a limited number of NBS developments. Especially, NBS 1 is only carried out in Dortmund with regard to sport exercise equipment in a public park and the new soil (NBS 2) only in Turin after cancellation of this activity in Ningbo due to too heavily polluted lake sediment. This limits the findings to living lab case studies highlighting the explorative character of the work on barriers and solutions. However, it can contribute to the growing collection of knowledge and experience in this domain. So far, the applied solutions are mainly addressing barriers individually, but not allowing recommendations on how to tackle barriers conceptually. Yet, different types of barriers demand different types of solutions:

- → Technological barriers require expertise, skills, and knowledge – either gained internally in the responsible team, or bought in from outside.
- → Administrative/institutional barriers can be overcome by convincing politicians and other local decision-makers, but also by highlighting the NBS benefits compared to other measures, like traditional grey infrastructures. Lengthy municipal processes follow pre-defined standards, norms, and rules, which are in many cases not suitable for green infrastructure/NBS implementations. Therefore, multidisciplinary task forces can help overcoming municipal silo thinking, as done especially in Turin and Zagreb for NBS 7, but also the establishment of an association in Dortmund for NBS 8 circumvented bureaucracy.
- → Financial/Market barriers can only be overcome by convincing decision-makers on the advantageous effects of NBS – looked upon holistically as well as from different angles: environment, society, and economy.

The main solutions applied per barrier category and NBS are as follows. Administrative and institutional barriers are:

- → addressed by internal (municipal) networking, information campaigns on NBS benefits, and cooperation/alliances (NBS 1, 3, 6, 7);
- → flexibility, also in terms of planning procedures (NBS 1, 7, 8);
- → NBS-specific public tenders (NBS 2);
- → establishing multidisciplinary teams (NBS 7);
- → foundation of an association (NBS 8); and
- → hiring of an external expert (here architect for building application) (NBS 4).

Technological barriers were able to be tackled by following measures:

- → consultation of experts and hiring/ordering companies (NBS 3, 4, 5, 6, 7, 8);
- → peer education, training, capacity building (NBS 3, 5);
- → suitable machinery, equipment, and NBS-related actions/measures (NBS 3, 5, 7)
- → monitoring (NBS 4, 5);
- → site-specific adaptations (NBS 4); and
- → law modification (NBS 2).

Financial/market barriers emerged mainly due to increasing costs. This threat could partly be solved by successfully recruiting additional money, often internally in municipalities (NBS 1, 6), but also externally (society, private sector → donations, sponsoring…) (NBS 7).

One of the main obstacles to plan NBS developments in a co-designed way together with the local communities is Covid19. This could partly be tackled by both small workshops in presence and online formats. Further social/cultural barriers required negotiation processes to result in satisfactory plans for the NBS to be implemented and maintained/management with several stakeholder groups.

Administrative/institutional barriers have to be solved mainly internally in municipalities or other public authorities. This can be done via networking and cooperation, but it is also needed to inform other departments on the advantages and benefits of NBS developments. The key to overcome technological barriers is for many NBS the consultation of experts and hiring/ordering of external companies. Furthermore, in some cases peer education, training, and capacity building could also achieve the knowledge required to continue with the NBS development successfully. Increasing costs for NBS implementations could for some NBS be solved by recruiting additional budgets. Suitable negotiation processes are needed to bring together different interests and stand points for joint decision-making processes.

The project's "replication toolkit" – developed under Deliverable 2.6 takes advantage of the knowledge gained on barriers and solutions. It presents recommendations on how to deal with potential challenges and barriers throughout the proGIreg process, collected from discussions with FRC and previous deliverables, including WP 5 on barriers and solutions. The replication toolkit's operational level is more NBS-focused, providing recommendations and examples on how FRC dealt with most common challenges and obstacles for each NBS, such as the lack of a shared identity of places, difficulties encountered in engaging different stakeholders and public actors, and more technical issues related to the implementation of specific NBS.

The findings on barriers and solutions are based on a (partly very) limited number of activities per NBS. Thus, it is important to compare them with state-of-the-art for what reason the next sub-chapter a) bridges FRC with FC (12.4.) and b) goes beyond the proGIreg activities (12.5.).

12.4. Bridging FRC and Follower Cities

During the workshops of 2021, WP 5 key partners focused on the four FRC and the proGIreg funded NBS developments. However, the interviews of 2020 were also carried out with NBS representatives of the Follower Cities (s. Del. 5.2 on technological and Del. 5.3 on non-technological barriers). The findings of the FRC workshops on barriers and (successfully) applied solutions are not only described in Del. 5.5, but will also be presented and discussed with the Follower Cities during replication events taking place under WP 6 auspices. Furthermore, the Follower Cities are in the process on knowledge transfer from the experiences of the FRC, now implementing the Roadmap to Urban Planning developed in proGIreg's Deliverable 2.6. This deliverable's "replication toolkit" allows FC to get insights into barriers and solutions applied in FRC as well as to draw recommendations how to deal with barriers. This toolkit, which is strongly taking advantage of the results of the earlier WP 5 outputs, especially Del. 5.2 and 5.3, includes a strategic and an operational level.

The four Follower Cities focus on different NBS. While three NBS (2, 4, and 7) are not considered at all, five NBS are followed by one or several Follower Cities. NBS 1 (leisure activities and clean energy on landfill sites) is planned in Zenica: a landfill of industrial waste is under transformation into a recreational space for the local communities. Tree plantings are to prevent potential landslides, and additionally provide shade (s. Del. 5.2). Similar to Dortmund's NBS 1 – but also other NBS developments in the four FRC – Zenica raised the cost issue and lack of expertise and knowledge in the field concerned (s. Del. 5.2 and 5.3). Cascais holds a long tradition on community-based urban gardening and farming activities (NBS 3). Barriers/Challenges coming from Cascais are the lack of finances for required resources (compost, materials and equipment), dependency on (partly uncertain availability of) volunteers, and transfer of skills (easy-to-transfer hands-on knowledge). The barriers on finances and expertise/knowledge overlap largely with FRC descriptions (s. before and Del. 5.3). In Zenica, the 2020 interviews revealed a lack of holistic thinking and planning, lack of continuity, but also limited sharing of information and weak transparency. The FRC Turin and Zagreb emphasise the barriers lack of bureaucracy/lengthy municipal processes, limited budget, Covid19, and long-term maintenance concerning the NBS 5 implementation of capillary GI (green walls, roofs). The FC of Zenica mentioned a lack of mechanisation (suitable roof drainage system beneath the GI) as a barrier, while Cluj-Napoca highlights limited citizen engagement and awareness due to a general underestimation of the benefits by the public. These two Follower Cities are – like the FRC – concerned about the high costs of implementation and maintenance issues as well (s. Del. 5.2, 5.3). NBS 6, which concerns not only the three European FRC, but also all four Follower Cities (Cascais, Cluj-Napoca, Piraeus, and Zenica), is associated with a number of barriers: bureaucracy/lengthy municipal processes, limited budgets, soil contamination, and Covid19 implications are highlighted by the FRC and partly repeated by Follower Cities. Among others, the following barriers overlap and complement to the FRC findings on barriers: missing legal frameworks on how to approach

NBS 6 activities in the city (Cascais), fragmented responsibilities in municipal planning (Cascais, Piraeus), conflicts between different interests (Cluj-Napoca, Piraeus), soil issues (Zenica), lack of social acceptance (Piraeus, Zenica), costs (Cascais, Cluj-Napoca, Piraeus), and Covid19 including possible budget cuts. With regard to pollinator biodiversity (NBS 8), Piraeus struggles with an internal lack of communication between departments (silo thinking) as well as a low awareness in administration and among citizens. Yet, even more Piraeus is facing missing financial incentives and resources to promote NBS 8 as well as other NBS developments. Thus, FRC can play a crucial role in providing good arguments, sound assessments, and suitable pathways (including co-design, citizen engagement, overcoming municipal silo thinking, and holistic assessments of social, environmental, economic benefits) for Piraeus, but also the other Follower Cities and beyond to promote NBS developments – even with scarce public budgets available. Generally, the lack of clear objectives and an overall vision on biodiversity and pollinators is missing in most cities, which would be needed in order to create a targeted plan for associated actions. While the FRC are naming rather few or no severe barriers for the NBS 8 implementation, findings from the Follower Cities show the importance for demonstrating successful implementation also for these comparable easy-to-implement and “low-threshold” NBS (little budgets needed, possible with only little land, easy-to-acquire knowledge, etc.).

The upcoming replication events will play a key role in transferring the FRC experiences to the Follower Cities.

12.5. Going beyond proGIreg

ICLEI's global network of cities was approached to add knowledge on non-technological barriers beyond proGIreg (s. Del. 5.4). The reason for focusing on non-technological barriers is the individuality of technological barriers when planning, implementing, and maintaining NBS. The survey aims to deepen the analysis on non-technological barriers, considering it an important step for the replicability of NBS within and beyond the project. By including cities from different geographical areas in Europe and in the rest of the world, this research gives a broader understanding of the barriers encountered at the local level when implementing green infrastructure solutions. The online survey is based on proGIreg outputs, but also a desktop research collecting information and data from existing projects, networks, studies, and institutions. External projects/networks include Clever Cities, Connecting Nature, EdiCitNet, GrowGreen, Klimatek, ThinkNature,UnaLab, UrbanGreenUp, and UrbiNat. ICLEI Europe identified 32 external cities from the organisation's network, which are working on NBS and which received a personal invitation to the survey. In addition, the survey was sent to all NBS projects in which ICLEI is involved (CLEVER Cities, REGREEN, Connecting Nature, CONEXUS, GoGreenRoutes) and disseminated through NetworkNature. Different ICLEI Secretariats around the world were also asked to disseminate the survey within their regional reach. The majority of the total of 14 participating cities are coming from Europe (ca. 75%), the remaining from East Asia and Pacific (19%) and Latin America and the Caribbean (6%). Quite a number could also be linked to the eight proGIreg NBS, especially community-based urban farming/gardening (NBS 3), accessible green corridors (NBS 6), and partly also green walls and roofs (NBS 5).

Bureaucracy and lengthy municipal processes are highlighted by proGIreg's FRC, but also other administrative/institutional barriers, such as the lack of institutional understanding of NBS benefits, silo thinking/internal competitions, missing knowledge in public authorities on green infrastructure/NBS, and missing protocols and procedures, are named a few times during interviews (2020) and workshops (2021). The survey beyond proGIreg confirms these findings (s. Figure 29):

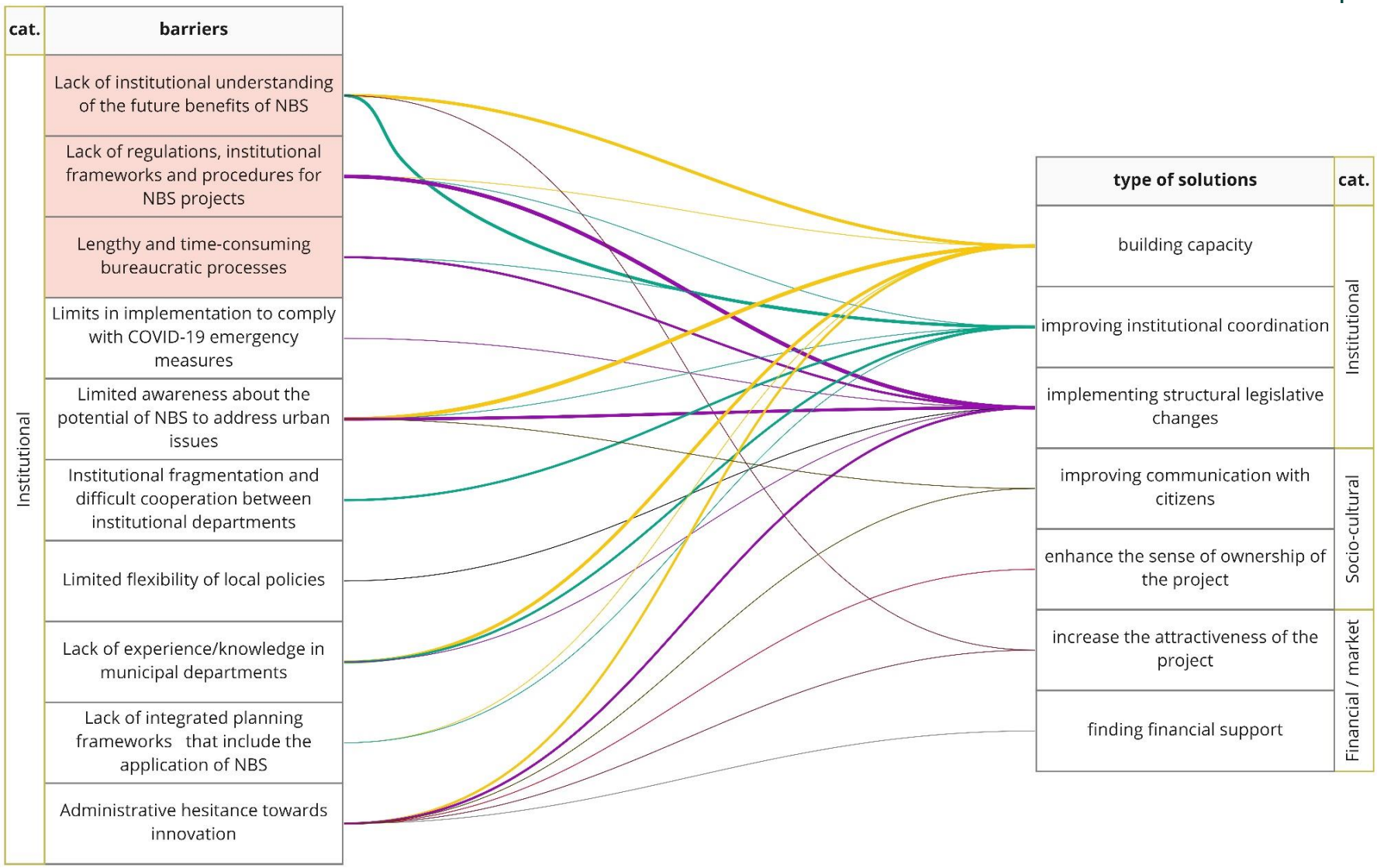

Figure 29. Institutional barriers and solutions (Source: Del 5.4)

Lack of institutional understanding of NBS benefits, lack of regulations, institutional frameworks and procedures, and lengthy bureaucratic processes are named most often here. The 14 city representatives on NBS recommend solutions such as building capacity, improving coordination, and implementing structural changes of the legislative body and are in line with solutions found and applied by proGIreg partners. However, the general level of information does not allow NBS-specific statements and recommendations. The survey's leading social/cultural barriers are lack of communication between administration and local communities, low confidence/awareness in NBS benefits, and concerns about costs for NBS implementations and maintenance activities.

ProGIreg's interviews and workshops highlight technological, administrative/institutional, and financial/market barriers, but only to a limited extent social/cultural barriers; when raised, they are mainly ranked as minor – compared to other barrier categories. The limited number of survey participants as well as weak links to specific NBS do not allow comparing the survey's findings beyond proGIreg (Del. 5.4) with the internal findings. Hence, the information may only provide general insights. Interestingly, vandalism is named only very little in the online survey, while this is – together with Covid19 – the most often named social/cultural barrier in proGIreg's FRC (interviews and workshops).

Financial/market barriers named most often in the survey do partly support proGIreg's interview and workshop findings: high costs of maintenance is named by half of the survey participants, and slightly more lack of private investment and lack of local/regional funding. The proGIreg interviews and workshops show a prevalence of the financial barrier 'limited budget' boosted by recently (partly rapidly) increasing costs. The statements from the survey are also – but with slightly different wordings – named in the workshops. This includes lack of financial incentives/access to finances (NBS 7), internal capacities and resources: financial and staff (NBS 1), extra funding/lack of funding (NBS 3), long-term finances (NBS 4), and long-term maintenance costs (NBS 5). The main solutions to overcome barriers are building institutional knowledge (capacity building, integrated coordination, …), communication with local communities allowing co-design processes and citizen involvement, looking for financial and institutional solutions including public-private partnership models and financial savings/economic feasibility of NBS compared to other (grey) solutions.

13. Conclusions

During the development of NBS on post-industrial sites a number of barriers and challenges occur. They occur at different times (planning/co-design, implementation, maintenance phase) as well as with varying severity. The severity ranges from minor barriers, which can be overcome with a little extra of resources or efforts to major barriers, which may cause the cancellation of NBS development and continuity. In proGIreg, this happened with the Ningbo NBS 2 development due to an unsurmountable pollution of the lake sediment. Some barriers require alterations from initial plans and ideas such as soil contaminations given proGIreg's focus on post-industrial urban regeneration areas. Some NBS developments remain in the planning/co-design phase; therefore, the findings presented in this report have to be seen in light of this level of advancement in the project.

Administrative/institutional barriers are mainly challenging during planning/co-design phase of NBS developments. Technological barriers can occur during planning/co-design phase, but increase in severity later on when reaching the implementation phase. Apart from technological barriers, which are often very NBS-specific, financial barriers emerge progressively with NBS advancement. For the maintenance/running phase, it is premature to detect certain patterns due to the delays of some NBS developments. So far, most barriers concern social, technological, but also financial challenges risking longer-term maintenance and advancement of NBS. Some barriers are specific for one or few NBS, while other barriers tend to be of overarching nature and occur in several NBS:

- → bureaucracy/lengthy municipal processes (administrative/institutional barrier),
- → soil contamination, pollution (technological barrier),
- → lack of expertise, knowledge, and skills (technological barrier),
- → limited budget (financial barrier),
- → long-term maintenance (technological and financial barrier), and
- → Covid19-related restrictions.

Only when decision-making bodies (policy, legislation, and administration) are becoming aware of the different types and categories of barriers, it will be possible to support implementation of productive Green Infrastructure and NBS. The barriers and applied solutions encountered in the proGIreg project provide important lessons learnt. These can be advantageous in leveraging NBS from single case studies and pilot projects, like proGIreg, to more widespread or even mainstream activities on post-industrial sites – and beyond. ProGIreg's findings on barriers are limited to case studies highlighting the explorative character of the work carried out in proGIreg. Nonetheless, it contributes to knowledge and experience generation, also with regard to applied solutions that are mainly addressing barriers individually, but not allow recommendations on how to tackle barriers conceptually. Yet, it has to be stated, that the different types of barriers demand different types of solutions:

- → Gaining expertise, skills, and knowledge from inside or outside the responsible NBS development team (technological barriers),

- → convincing politicians and decision-makers; demonstrating benefits of NBS developments; multidisciplinary task forces to overcome municipal silo thinking and lengthy processes (administrative/institutional barriers),
- → transparent and robust co-design processes with different stakeholder groups on an equal footing bringing administration and citizens closer together in decision-making processes (social/cultural barriers), and
- → demonstrating the benefits of environmental, social, and economic sustainability; NBS integration into business models (financial/market barriers).

Administrative/institutional barriers have to be solved mainly internally in municipalities or other public authorities. This can be done via networking and cooperation, but it is also needed to inform other departments on the advantages and benefits of NBS developments. The key to overcome technological barriers is for many NBS the consultation of experts and hiring/ordering of external companies. Furthermore, in some cases peer education, training, and capacity building could also achieve the knowledge required to continue with the NBS development successfully. Increasing costs for NBS implementations could for some NBS be solved by recruiting additional budgets. Suitable negotiation processes are needed to bring together different interests and stand points for joint decision-making processes.

Overall, it appears of utmost importance to integrate (productive) Green Infrastructure and NBS into administrative and institutional frameworks. It is fundamental not only to add these new green interventions into existing standards, norms, and regulations, but also to provide appropriate protocols and procedures to allow widespread upscaling and replication of NBS on post-industrial sites, more generally in densely populated areas. This is building one of the core activities in the project's Follower Cities with the aim to set up strategies to help the integration of NBS into the local urban planning framework (Task 2.3; Deliverable 2.7). Replication activities (WP 6), including replication events, are key formats for that. Political will, successful and convincing case study examples from proGIreg and other NBS EU HORIZON 2020 sister projects, and a shift on how to perform administrative processes, like building permissions or other types of required permissions to approve NBS developments and advancements, are important milestones on this path. While the majority of proGIreg's NBS deal with specific local site conditions allowing physical green implementations, NBS 7 aims to establish protocols and procedures, which demonstrate how to integrate NBS into legal frameworks, regulatory and planning domains. This allows replication by other cities as long as local contexts are considered appropriately. Being successful with NBS 7 may represent a key achievement of proGIreg alongside other key components, mainly the TRL increase for the eight NBS, detailed benefit assessments (WP 4), and integration of NBS into (party) self-sustained business models (WP 5).