# Chapter 6
# Nature-Based Climate Solutions in European Schools: A Pioneering Co-designed Strategy Towards Urban Resilience


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**Abstract** As cities around the world are increasingly facing the impacts of climate change, a growing number of municipalities are leading collaborative projects to adapt schools to rising temperatures. The implementation of nature-based solutions (NBS) is highlighted as an important component to be included in these initiatives given their multifunctional and cost-effective character. However, the challenges and upscaling opportunities of these pioneering projects are still not well understood nor systematically studied on a comparative basis. This study explores and compares three European pilot nature-based projects aiming to make schools more

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resilient to climate change impacts while creating other co-benefits for children and the wider local community. These projects are *Oasis* (Paris), *Climate Shelters* (Barcelona) and *Care in School Environments* (Madrid). Building on a framework for assessing the co-benefits of urban NBS, the comparative analysis explores the selection criteria of schools and their equity implications, the multifunctional role of NBS beyond climate adaptation, the main aspects and challenges related to the co-design process and the subsequent project implementation and the potential for upscaling at the city level. Based on this exploration, we contend that nature-based climate adaptation projects in schools can be a spearhead for a wider community-based strategy towards urban resilience.

**Keywords** Nature-based solutions · Green resilient infrastructure · Children's geographies · Urban equity · Green schoolyards

## 6.1 Introduction

As cities around the world are increasingly facing the impacts of climate change, a growing number of municipal governments are fostering or directly leading the implementation of transformative co-produced projects to adapt schools to rising temperatures, including more intense urban heat islands. A recent report by the C40 Cool Cities Network (Vetter 2020) identified several reasons to make schools more resilient to climate change impacts, including: (1) children are a particularly vulnerable age group to extreme heat; (2) creating schoolyards with enough shaded areas encourages children to play outside and increases physical activity during recess time; (3) using schools as community hubs can bring climate awareness to families; and (4) transformed schools can act as *cool islands* or *climate shelters* that can be also used by neighbours after school hours or on weekends, especially during hot days. According to the report, an important component to be promoted in school climate adaptation projects is the implementation of *nature-based solutions* (NBS), such as tree plantations, green roofs and walls, water elements or educational and rain gardens. NBS are defined by the European Commission as *solutions that are inspired and supported by nature which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience* (Wild et al. 2020 p. 3). Similarly, the International Union for the Conservation of Nature (IUCN) refers to NBS as *actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits* (Cohen-Shacham et al. 2019 p. 21). In general, the concept of NBS is considered as an umbrella term bringing together previously established ecosystem-based notions such as *ecosystem services*, *green and blue infrastructure* or *natural capital* (Nesshöver et al. 2017).

The implementation of NBS in school environments can thus play an important role towards rapid, systemic transitions leading to climate-resilient cities (de Coninck et al. 2018). Further, as reflected in the UN Sustainable Development Goal

(SDG) 11 (Target 11.7), cities should also ensure an equitable access to safe and inclusive green and public spaces, particularly in the case of children. However, previous research has shown a declining and unequal trend regarding children's use of and access to urban green spaces (Gidlow and Ellis 2011). Incorporating NBS in school settings seems a promising path to overcome disparities in residential access to urban nature and to boost multiple co-benefits ranging from climate change adaptation to enhanced health, wellbeing and learning (Chawla et al. 2014; van Dijk-Wesselius et al. 2018, 2020; Baró et al. 2021).

Most children spend a substantial share of their daily life in school settings. While generally most of the school time is spent indoors, children also use outdoor environments (typically school playgrounds) during recess or physical activity time, in some cases up to 10 h per week (Slater et al. 2012; Shape America 2016). Despite school grounds are still usually dominated by sport fields and paved surfaces, nature-based designs are increasingly seen and valued as innovative alternatives thanks to their multiple positive impacts on children. The transformation of school settings into *green environments* builds on a growing body of literature showing a strong positive association between (urban) nature and child overall wellbeing and health (Bell and Dyment 2008; Chawla 2015). Everyday access to school green and blue spaces has been associated with health benefits such as moderation of stress (Chawla et al. 2014; Akpinar 2016) and improvement of attention-deficit hyperactivity disorder's (ADHD) symptoms (Faber Taylor and Kuo 2011; Markevych et al. 2014). There is also evidence on the beneficial associations between higher exposure to urban vegetation and schoolchildren behavioural and cognitive development (Amoly et al. 2014; Dadvand et al. 2015; Pérez-del-Pulgar et al. 2021). Several studies have also assessed the impact of school green space on the academic performance of pupils, yet results are generally non-significant or mixed so far (Browning and Rigolon 2019; Kuo et al. 2021). Further, green schoolyards can overcome the classic design of playgrounds situating sport fields at the centre (generally used by boys) and smaller recreational areas in the surroundings (generally used by girls), which often results in a strong spatial gender hierarchy. In contrast, naturalized playgrounds can help diversifying play options and improve the social interaction between girls and boys (Equal Saree 2019) while establishing more supportive relationships and strengthening their emotional and relational wellbeing (Chawla et al. 2014). Green spaces in school environments are also increasingly seen and used as outdoor learning environments where children can develop environmental knowledge and (lifelong) affinity towards nature (Broom 2017; Rosa et al. 2018; van Dijk-Wesselius et al. 2020). Finally, tree canopy and other vegetated covers can have a substantial positive impact on urban schoolyards' microclimate, by enhancing thermal comfort and reducing heat stress perception of children (Antoniadis et al. 2020).

In Europe, recent nature-based climate initiatives to transform school settings are generally implemented through co-production approaches, that is, engaging factual and potential users of these spaces since the earliest stages of the design process. However, while the benefits of nature-based school transformations within the context of urban climate resilience are increasingly supported by scientific evidence as described above, the implementation challenges and upscaling opportunities of this

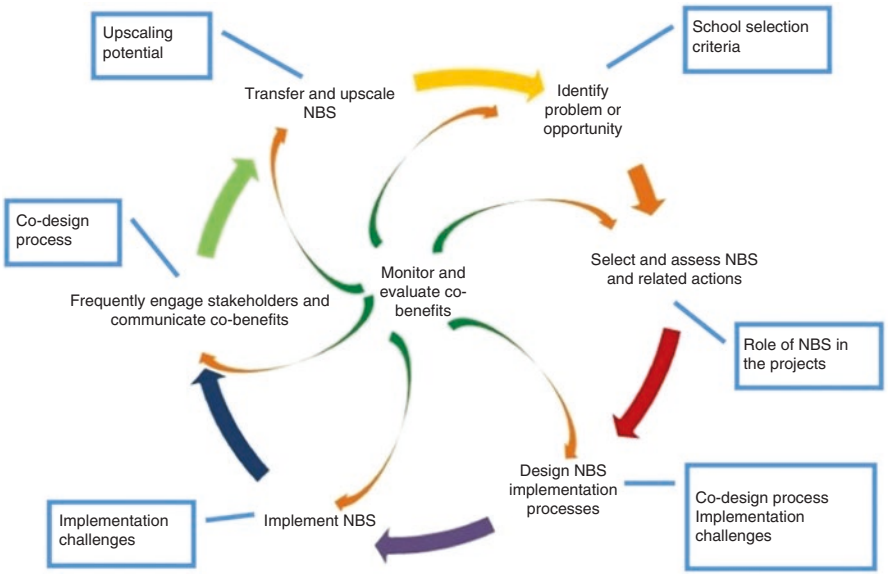


**Fig. 6.1** Aspects assessed in the three nature-based climate resilience school projects. (Modified from Raymond et al. (2017), published under a Creative Commons license (CC BY 4.0))

kind of projects are still not well understood nor systematically studied on a comparative basis. In response to this knowledge gap, the goal of this chapter is to explore and compare three European pioneering pilot projects aiming to make schools more resilient to climate change impacts while creating healthier, more playful and pedagogical environments for children, mostly through nature-based interventions in their schoolyards. These projects are *Oasis* (implemented in Paris, France), *Climate Shelters* (Barcelona, Spain) and *Care in School Environments* (Madrid, Spain). Indeed, these cities represent large-size cities where the nature-based school interventions have been conducted in neighbourhoods with different socioeconomic and environmental conditions. Working in these settings allows for both unravelling the specificities of each particular context and finding common patterns.

The comparative analysis builds on the framework for assessing and implementing the co-benefits of NBS in urban areas developed by Raymond et al. (2017), focusing on the following aspects (see also Fig. 6.1): (1) selection criteria of schools and related equity implications; (2) the role of NBS in the projects; (3) participatory process and level of co-design achieved; (4) main barriers or challenges encountered during project implementation; and (5) potential for upscaling, understood as how successful initiatives testing new practices, services or governance approaches can be mainstreamed or brought to higher policy levels (Fastenrath et al. 2020).

## 6.2 Description of the Three Nature-Based Climate Resilience School Projects

### *6.2.1 Oasis (Paris)*

The Oasis project (standing for Openness, Adaptation, Sensitization, Innovation and Social ties) involves the transformation of ten school playgrounds (including nursery, primary and secondary centres) across the city of Paris into *cool islands* using both grey (engineering) and green (nature-based) solutions. The project aims to address climate challenges such as heat stress mitigation (heatwaves and their exacerbation due to the urban heat island effect are identified as a major risk for the city) and stormwater control (including flooding risk) but also contribute to environmental awareness and social cohesion both across school communities and the wider neighbourhood community. The project was funded under the UIA programme (Urban Innovation Actions, part of the European Regional Development Fund – ERDF) with almost 5 M € and has been implemented during the period 2019–2021.

The initiative involves a cross-disciplinary collaboration between the municipality, local civic organizations, associations and research centres coordinated by the Resilience Office of the City of Paris (see also Fig. 6.2). Other City departments directly involved include the Department of Education and the Department of Architecture and their respective local divisions. The other partners include (1) the Council of Architecture, Urban Planning and the Environment, a local NGO responsible for the co-design and training process with the school communities; (2) the Paris Federation of the Education League, a platform of local associations that is responsible for the broader local community engagement process; (3) the French National meteorological and climatological centre, responsible for environmental monitoring and educational activities; (4) the Interdisciplinary Research Laboratory for Future Energies, responsible for the microclimatic and thermal evaluation; and (5) the Laboratory for Interdisciplinary Evaluation of Public Policies, at Sciences Po, responsible for the overall participatory, social impact and evaluation process. The funded project is part of a wider OASIS framework initiated as an action plan of the City's Resilient Strategy (Paris City Council 2018). The ultimate goal of this plan is to have all 760 Paris' public schoolyards transformed into *oases* by 2050.

### *6.2.2 Climate Shelters (Barcelona)*

Climate Shelters (*Refugis Climàtics*) is a twin project of Oasis since it shares the same funding scheme (UIA initiative) and operational approach based on the transformation of 11 primary schools in Barcelona through climate-resilient green, blue and grey interventions. This pilot project involves creating more shaded spaces through greenery, incorporating water points, improving buildings' ventilation and

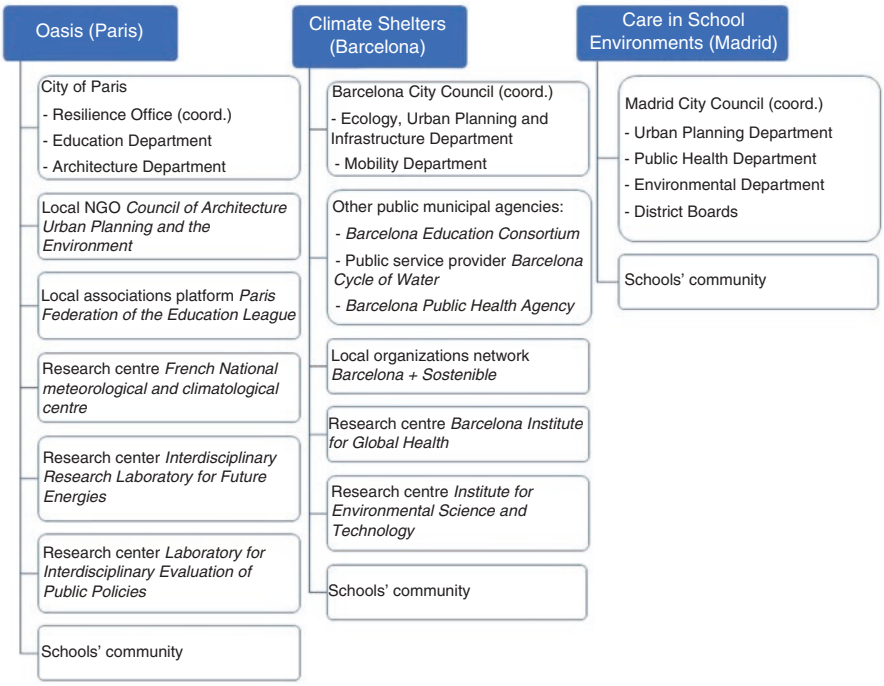


**Fig. 6.2** Main stakeholders involved in the co-design process of nature-based climate resilience solutions at schools in each case study project. School community actors include school board, teachers, schoolchildren and parents

implementing permeable materials, among other interventions. The ultimate goal is that schools (both buildings and grounds) serve as cooling spaces to pupils, school staff and external visitors (through the programme *Patis escolars oberts al barri* – Schoolyards open to the neighbourhood), especially during hot days. It is also planned that participating schools will expand the environmental education approach in their curriculum thanks to the new nature-based interventions. The project started in 2019, and it is expected to finish in 2022, counting with a total budget of almost 5 M € (4 M € from the UIA programme and 1 M € provided by the Barcelona City Council).

Besides the municipality, the initiative involves other public agencies and research centres (see Fig. 6.2). It is led by the Ecology, Urban Planning, Infrastructures and Mobility Department of the Barcelona City Council, and the Barcelona Education Consortium collaborates with the management and implementation of the measures. The project is also embedded in the programme *Escoles + Sostenibles* (More Sustainable Schools), the educational branch of a wider network of public, private and civic organizations fostering environmental, social and economic sustainability in Barcelona (*Barcelona + Sostenible*). Other partners include the Barcelona Cycle of Water (public service provider) which provides expertise on water usage; the Public Health Agency of Barcelona and the

Barcelona Institute for Global Health, both evaluating the health impacts of the interventions; and the Institute for Environmental Science and Technology, assessing environmental quality aspects such as air pollution levels. The project is part of a wider line of action to prevent excessive heat through the identification and creation of climate shelter spaces included in the Barcelona Climate Plan 2018–2030 (Barcelona City Council 2018) and the Climate Emergency Declaration (2020). By the end of the project, it is expected to transform 3000 $m^2$ of schoolyards and to have clear guidelines for replicating the interventions in other schools in the city.

### *6.2.3 Care in School Environments (Madrid)*

Care in School Environments (*Cuidados en Entornos Escolares*, own translation) was a project aiming to create a new school ground model by transforming the schoolyards of nursery and primary public schools in the municipality of Madrid. The project responded to the need to undertake a profound and holistic revision of the – so far dismissed – relevance of schoolyards for children's education, health and development and as spaces of opportunity for climate change adaptation interventions.

Since its inception in 2017, the project was characterized by having evolved without a specifically dedicated municipal budget. This fact led to a strong dependence on the voluntaristic motivation of the municipal officers of the Urban Planning, Public Health and Environmental departments and district boards with a direct influence on the development of the project (see Fig. 6.2). The actual project became possible thanks to the cross-departmental and district pooling of existing budgets and resources previously allocated to other goals (e.g. district level funds for school maintenance, climate change programmes, urban plans etc.). This budget pooling managed to allocate a total of 1 M € to schoolyard transformation without creating a dedicated new municipal budget line.

The project involved the transformation of three schoolyards and was implemented between 2017 and 2019. The selected schools were located in areas of priority intervention in regard to the major working lines of the three involved departments: (1) social vulnerability, identified in the Madrid Urban Regeneration Strategy of the Urban Planning Department (Madrid City Council 2016–2018); (2) climate vulnerability to extreme events, identified in the Air Quality and Climate Change Plan of the Environmental Department (Madrid City Council 2017); and (3) health vulnerability, identified in the broader City Public Health Program *Madrid a City that Cares* (Madrid City Council, 2017–2021). In addition, the selected schools were located in districts whose local board agreed to reorient the budget of the framework contracts for school maintenance towards school ground transformation works. The project also developed a preliminary City Schoolyard Intervention Strategy identifying the available environmental and play resources in and around all schools of Madrid (García-Serrano et al. 2017a).

## 6.3 Data Collection and Comparative Analysis

Information on the three case study projects was collected via semi-structured interviews with the main project coordinators and promoters and also complemented with institutional project documents available online.[1] Therefore, the comparative analysis is limited to the view of these institutional partners, and it does not reflect the perspectives or experiences of *end users* who participated in the co-design processes (e.g. school personnel, parents or children). For Oasis, interviewees included the Deputy Chief Resilience Officer of the City of Paris and an UIA Expert. In the case of Care in School Environments, we interviewed the Co-manager of the project from the General Directorate of Strategic Planning of the City of Madrid. Finally, the International Relations Project Coordinator and Head Architect Manager for the Ecology, Urban Planning and Mobility Area of the Barcelona City Council and the responsible for the *Escoles + Sostenibles* programme were interviewed as coordinators of Climate Shelters. All interviews were conducted between January and June 2021 via video-conference due to the Covid-19 pandemic restrictions. The guiding interview questions built on the five main analysis points mentioned in the introduction section as follows:

1. School selection criteria: What were the main selection criteria of schools (i.e. exposure to environmental harms such as pollution, heatwaves, equality/equity/justice criteria etc.)?
2. The role of NBS: What are the main NBS interventions included in the project (e.g. rain gardens, trees, blue spaces etc.)? For which challenges/goals these NBS elements have been mostly designed (e.g. heatwaves, runoff control, environmental education etc.)?
3. Participatory process: Who has been mainly involved in the participatory process of the project (e.g. school staff, parents etc.)? What was the role of schoolchildren during the process? What is the level of co-production/co-implementation achieved?
4. Implementation barriers/challenges: Which are the main barriers/obstacles faced during the implementation of the project (e.g. restricted timeframe, budget cuts, coordination between partners, Covid-19 crisis etc.)? How have been these barriers addressed (or not)?
5. Upscaling potential: Has the project made any relevant changes after/during its implementation that were not anticipated? Is the project planned to be upscaled at city level? How?

The comparative analysis was based on a manual coding of the five analysis points as reflected in a synthesis of the interview transcripts and the reviewed documents.

[1] Oasis: www.uia-initiative.eu/en/uia-cities/paris-call3; Climate Shelters: https://www.uia-initiative.eu/en/uia-cities/barcelona-call3; Care in School Environments: https://madridsalud.es/cuidado-de-los-espacios-publicos-de-los-colegios/

## 6.4 Results

### *6.4.1 Selection Criteria of Schools and Equity Implications*

Several school selection criteria were considered across the three projects (see an overview in Table 6.1). The shared funding scheme of Oasis in Paris and Climate Shelters in Barcelona is probably the reason that both projects applied similar criteria. For instance, the two cases had a similar budget to transform 10–11 schools, and both decided to apply a balanced geographical distribution across the different city districts (at least one selected school per district). In contrast, Care in School Environments, in Madrid, with a more limited funding scheme and scope, was only implemented in three schools located in priority areas of intervention for its social, environmental and health vulnerabilities with already approved operational budgets.

Criteria related to school type (public vs private or charter), size and accessibility were key in the selection process. In all cases, eligible schools had to be publicly funded and giving nursery and/or primary education (except for Oasis where two secondary schools – *collèges* – were also included). In Barcelona, schools with a higher number of pupils were also prioritized. In Paris, it was mandatory that selected schools had a schoolyard with direct street access to make it accessible to external users. Similarly, in Barcelona, it was required that schools were part of the *Schoolyards open to the neighbourhood* programme, which promotes the public use of schoolyards after school hours by neighbourhood residents. Further, the selection of schools was also based on the support/interest of district authorities (Oasis and

**Table 6.1** Summary of the school selection criteria in each case study project. Note: two checks indicate that the criterium was mandatory or very relevant, and one check indicates that it was supplementary or secondary

| Criteria | Oasis (Paris) | Climate Shelters (Barcelona) | Care in School Environments (Madrid) |
|---|---|---|---|
| Equal geographical distribution (across city districts) | ✓✓ | ✓✓ | |
| Pre-existing intervention plans (with secured budget) | | | ✓✓ |
| District authority and/or school support | ✓ | ✓✓ | ✓ |
| Publicly funded school | ✓✓ | ✓✓ | ✓✓ |
| Schoolyard with direct access to street (to make it accessible to external visitors) | ✓✓ | ✓✓ | ✓ |
| Poor condition of the schools (building rehabilitation needed; low greenery) | ✓ | ✓ | ✓ |
| High exposure to environmental/climate harms (e.g. urban heat island, air pollution etc.) | ✓ | ✓ | ✓ |
| Number of pupils and other potential beneficiaries | | ✓ | |

Care in School Environments) and/or the schools themselves (Spanish cases). In fact, the schools selected in the Climate Shelters project had to follow an open application process where all selection criteria were evaluated based on a comprehensive threshold/points system.[2]

Finally, poor condition of schools in terms of the buildings' state (e.g. low thermal isolation) or lack of greenery in the schoolyards, together with a high exposure to environmental harms such as urban heat island effects or air pollution, were considered also as selection criteria in all cases, but with a more secondary weight.

### *6.4.2 The Role of Nature-Based Solutions in the Projects*

The role of NBS is prominent in all the projects thanks to its multifunctionality in terms of climate adaptation (heat mitigation and stormwater runoff control), biodiversity, environmental education and health benefits. The main NBS intervention implemented in the three cases, with a clear focus on climate adaptation, was the replacement of impervious schoolyard pavements by natural and permeable materials (e.g. wood chip, sand areas, natural soil) and the construction of diverse topologies (e.g. small hills) and play structures. All projects included different types of green infrastructure (see also Fig. 6.3) such as gardens with native species to enhance biodiversity (e.g. Mediterranean gardens in Barcelona and Madrid), green walls, vegetated pergolas and increased tree canopy cover to create shaded spaces (e.g. a total of 74 trees have been planted in Climate Shelters). The creation of rain gardens and other sustainable drainage systems (including stormwater storage tanks) was especially common in Oasis and Care in School Environments. Blue infrastructure was also relevant in the three projects. Traditional and multifunctional (e.g. sprayer showers) fountains were implemented in all cases. Other innovative and singular water elements directly addressing environmental education goals were also built, such as the case of pedagogical rivers and small ponds in Paris, water-based game spaces in Barcelona and drinking fountains in Madrid (see a summary in Table 6.2).

Besides green and blue infrastructure, projects also included *grey* interventions, mostly oriented to increase the energy efficiency of school buildings (including the installation of solar panels), to enhance indoor air circulation and to create shaded areas.

[2] See: https://www.uia-initiative.eu/en/news/adapting-barcelona-climate-change-multicriteria-approach-selection-schools-be-converted

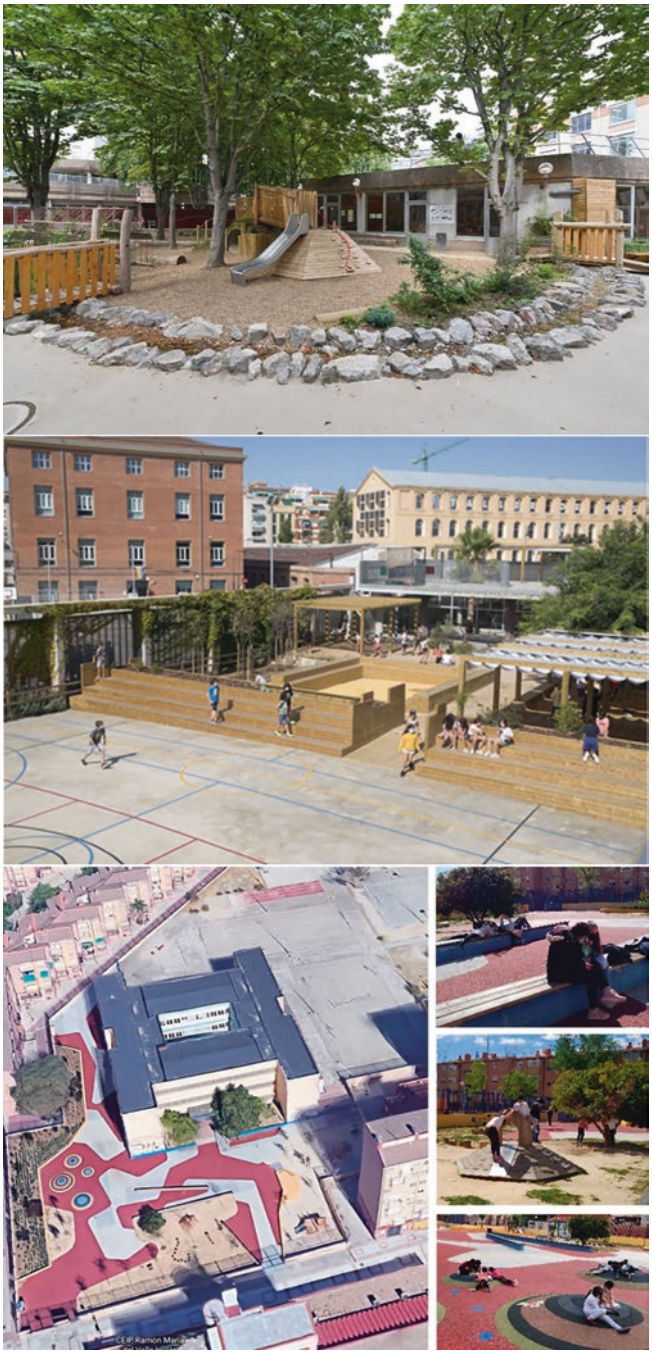

**Fig. 6.3** Pictures of nature-based solutions implemented in the three case study cities. Upper photo: schoolyard of an Oasis project school (Paris) with permeable pavement, trees and pedagogical stream (Source: Laurent Bourgogne, City of Paris). Middle photo: schoolyard of Can Fabra

**Table 6.2** Summary of the main green and blue infrastructure elements included in the case study projects

| Main green and blue infrastructure elements | Oasis (Paris) | Climate Shelters (Barcelona) | Care in School Environments (Madrid) |
|---|---|---|---|
| Natural and permeable pavements (e.g. wood chip, sand areas) with diverse topologies and play structures | ✓ | ✓ | ✓ |
| Gardens with native species | ✓ | ✓ | ✓ |
| Green walls and vegetated pergolas | ✓ | ✓ | ✓ |
| Increased tree canopy cover (shade areas) | ✓ | ✓ | ✓ |
| Rain gardens and other sustainable drainage systems | ✓ | | ✓ |
| Traditional and multifunctional fountains | ✓ | ✓ | ✓ |
| Pedagogical river and other singular water elements | ✓ | ✓ | |

### *6.4.3 Co-design Process*

All projects invested a substantial share of their resources in implementing a comprehensive participatory process or co-design strategy mostly focused on the transformation of the schoolyards (as the interventions in the buildings were more technical). Table 6.3 provides an overview of the main aspects related to these processes. In all cases, these strategies primarily aimed to engage with different stakeholders/groups of the school community, including schoolchildren, school staff (teachers, directors etc.), extracurricular instructors and also parents.

The engagement processes were mostly implemented through a series of workshops facilitated by experienced knowledge brokers. In the case of the project Care in School Environments, the process also included a preliminary phase of Participatory Action Research (PAR, see Pain et al. 2012) – with a core group of participants representing the educational community – and the use of surveys. The workshops were designed based on the target group (pupils, staff or parents) in Oasis, whereas Climate Shelters and Care in School Environments also organized sessions with mixed groups (i.e. all actors together).

**Fig. 6.3** (continued) school (Climate Shelters, Barcelona) with wood structures, pergolas and vegetated walls (*Pati de l'Escola Can Fabra* by Òscar Giralt and Gerència d'Àrea d'Ecologia Urbana licensed under CC-BY-NC-ND). Lower photo: schoolyard of Ramón María del Valle Inclán School (Care in School Environments, Madrid) with impervious pavement removed, natural soil, new permeable pavements, rainwater harvesting and planted trees and bushes. (Source: Google Earth 6.0, (2008) 3D Buildings data layer. Available at: http://www.google.com/earth/index.html [Accessed 20/06/2021] & Ramon Maria del Valle Inclán School Schoolyard Core Group). All images are published with the permission of the owner(s)

**Table 6.3** Summary of the main aspects related to the co-design process in the case study projects

| Main aspects of the co-design process | Oasis (Paris) | Climate Shelters (Barcelona) | Care in School Environments (Madrid) |
|---|---|---|---|
| Participants in the main co-design process | School community (pupils, staff, parents etc.) | School community + wider local community | School community + wider local community + technical council staff |
| Tools used during the co-design process | Workshops | Workshops | PAR methodology, survey, workshops |
| Main stages of the co-design process | Diagnosis, co-design | Diagnosis, co-design, evaluation | Diagnosis, co-design, evaluation |
| Additional sustainability/resilience educational events | Specific raising-awareness workshops | City sustainability programme in schools | City sustainability programme in schools |
| Participation of external stakeholders (beyond school community) | Yes, *citizen assemblies* | Yes, as part of main co-design process | Yes, as part of main co-design process |

All projects followed two main steps during the co-design process: (1) diagnosis (current state, uses of the schoolyard and identification of needs or deficiencies) and (2) co-design (discussing, sharing and co-designing ideas for the transformation of the schoolyard). Building on the outputs of the co-design stage, the technical departments of each City Council developed the final executive plans for each school. It is worthy to mention that in the case of Climate Shelters and Care in School Environments, the plan was not considered definitive until the school had approved it. In Barcelona and Madrid, a last follow-up step was included in the form of evaluation sessions (and a report in the case of Madrid) intended to estimate the level of satisfaction of the school community with the implemented interventions. In addition, a second impact evaluation is being carried out in Madrid as of 2021 (3 years after the interventions) using different qualitative methods (focus groups, interviews, questionnaires etc.). The Oasis project also organized *raising-awareness* workshops for schoolchildren with educational materials about climate change to motivate and boost their engagement in the co-design process. In Madrid and Barcelona, students from some of the transformed schools (all in the case of Barcelona) were already aware and engaged in climate change activities as a result of their previous participation in educational programmes for environmental sustainability coordinated by the City Councils (*Educar hoy por un Madrid más sostenible* and *Escoles + Sostenible* respectively).

Besides the school community, the Climate Shelters and Care in School Environments projects also included the participation of other community stakeholders (e.g. neighbourhood associations, sport organizations that make use of school facilities after school hours etc.) as part of the main co-design process (including the preliminary PAR phase in the case of Madrid). In contrast, the Oasis project included a distinct participatory process oriented to the broader local

community (i.e. beyond the school actors). The goal behind this process was to engage with potential users of the schoolyards after school hours since the aim of the project also was to open them to the neighbourhood as additional public spaces. A series of *citizen assemblies* were organized (mostly online due to Covid-19 pandemic) in order to identify concerns and opportunities of the schoolyards as shared community spaces after school hours (e.g. potential activities allowed). However, this process was not coordinated with the co-design school community phase, so the final schoolyard plans did not reflect the outputs at this broader level.

### 6.4.4 Main Challenges Encountered During Project Implementation

As usual, all projects faced several barriers during their implementation (see a summary in Table 6.4), but one overarching barrier was directly related to the project capacity for entailing transformative processes. All project promoters stated explicitly or implicitly the *reluctance to change* expressed by some actors. For example, the implementation of NBS in the schoolyards was an unusual intervention to be executed by project engineers and perceived as *dirty* or *unsafe* by some adults (parents and school staff) in the Oasis project. In general, the participatory processes and the engagement with the school community (especially teachers) played a key role in order to overcome this reluctance. In Oasis, several *peer learning* sessions were also organized consisting of visiting schools (from other countries) with similar projects already implemented. Both school personnel (e.g. directors, teachers) and technical staff (architects, engineers) could talk to their peers involved in other school transformation projects and share experiences. In Madrid, the inclusive and

**Table 6.4** Summary of the main challenges encountered (first column) and strategies followed to address or mitigate them (other columns)

| | Strategies to address or mitigate the challenges | | |
|---|---|---|---|
| Main challenges | Oasis (Paris) | Climate Shelters (Barcelona) | Care in School Environments (Madrid) |
| Reluctance to change by (some) stakeholders | Co-design process and *peer learning* sessions | Co-design process | Co-design process |
| Malpractice in project implementation | Not reported | Not reported | Close monitoring of construction works |
| Tight implementation timeframe, bureaucratic barriers, silo thinking | High political support | High political support | High degree of voluntaristic work Pooling of existing municipal budgets |
| Covid-19 pandemic | Online participation | Online participation and digital *tours* | NA (pre-pandemic implementation) |

robust participatory process (characterized by the PAR methodology) proved to be decisive in minimizing conflict with the school community and avoiding the rejection of the interventions. However, due to the innovative nature of some interventions, the monitoring of the construction works had to be very thorough in order to avoid *malpractice* by the construction companies, i.e. deviation from what was decided in the co-design process and implementation of *standard* solutions.

In all cases, the alignment of the project timeframe with the schools' rhythms and availability was also challenging. The design of the solutions had to be done in a very short period of time, which didn't allow to tailor them as initially desired. Similarly, its implementation had to be done mostly during the summer and after school hours in order to avoid interference with the school activities. Moreover, in Barcelona, some school buildings were classified as historical heritage which required a longer bureaucratic process before the works could be started. These concerns were expressed as follows: *in terms of works, projects had to be drafted in a month and a half, public tenders had to be issued in a month and executed in barely 2 months… the results could have been better with more time. What we did in 8 or 9 months should have been done in a year and a half, so that the final solutions would have been more adequate, fairer* (Co-manager of Climate Shelters, Barcelona).

High-level political support and/or will was highlighted as a key enabler or barrier for the projects' implementation. In Oasis and Climate Shelters, a strong political support fostered the coordination between the different city departments involved in the project, avoiding silo thinking and pushing for the timely implementation of the interventions. On the other hand, Care in School Environments shows how a bottom-up project can have a greater transformative potential adapted to the communities' needs but face difficulties for upscaling due to the lack of political support (and budgetary limitations).

Finally, the outbreak of the Covid-19 pandemic impacted the projects in several ways. For instance, in Paris the restrictions associated with the pandemic delayed the transformation of one school and the opening of the schoolyards to the broader community. In Barcelona, the pandemic changed the uses and dynamics of the schoolyards. For instance, during winter, the classrooms were forced to keep the windows always open, making it impossible to measure the effectiveness of the new school ventilation systems. All this resulted in the delay or difficulty in evaluating the expected social, health and environmental changes as initially designed. Moreover, the dynamics of the workshops were affected by social distancing. For example, in the Climate Shelters project it was planned to organize schoolyard tours where the architects and project technicians could explain to the community the different infrastructures to be implemented. However, due to the pandemic, these activities had to be done using photographs and plans via video calls, making the communication process more difficult. However, the Covid-19 pandemic was also seen as an opportunity for upscaling this kind of initiatives, as it is explained in the next subsection. In Madrid, the project was implemented before the pandemic, but participant schools have recently reported to have been in a better position to adapt to Covid-related school protocols thanks to the school ground transformations (Co-manager of the Care in School Environments, Madrid).

### 6.4.5 *Potential for Upscaling*

Oasis and Climate Shelters are pilot projects which will be replicated in other schools according to municipal plans. Actually, upscaling is already ongoing in Paris (with municipal funds), and all public schools are expected to be part of the Oasis framework by 2050. The City has also been contacted by many French municipalities interested in replicating the project in their own schools. In Barcelona, the plan is to transform at least ten schoolyards per year considering the processes and solutions implemented in the Climate Shelters projects. This will be operationalized through a stable action programme called *Transformem els patis escolars* (Transforming schoolyards). In both cities, the projects are backed by municipal climate adaptation policies (Barcelona Climate Plan 2030 and Paris Resilience Strategy). In Madrid, there are no current plans to upscale the project due to lack of political support from the current municipal government (which changed from a left-wing coalition towards a right-wing conservative coalition shortly after the implementation of the project). Nevertheless, the pioneering municipal public schoolyard intervention strategy deployed by Care in School Environments remains as an important legacy for school ground transformation, as shown by the widely referenced School Environments Design Guide (García-Serrano et al. 2017b).

Despite the abovementioned negative impacts of the Covid-19 pandemic, the Oasis project coordinator considered that it will also enhance the acceptability of this kind of projects by the (school) communities: *these projects don't seem now like something weird, but as something needed. I anticipate that the transformation of schoolyards into resilient, green, sustainable places will evolve globally* (Oasis project manager, Paris). The results of the research evaluations being carried out as of 2021 (in terms of climate, health or social benefits) will be also crucial to support upscaling efforts in these cities and others. Another point expressed by the Care in School Environments representative is that in order to make these investments cost-effective (also considering the higher maintenance costs), the transformed schoolyards should be publicly accessible beyond school hours: *the large investment required to adapt schools to climate change and update their space to a contemporary pedagogical model makes sense if they represent a leisure infrastructure for the neighbourhood beyond school hours* (Co-manager of the Care in School Environments, Madrid). This is already done in Barcelona and planned in Paris.

## 6.5 Discussion and Conclusion

Growing evidence on the multiple benefits of nature contact for the overall development and wellbeing of schoolchildren have supported the implementation of green school(yard) transformations during the last decades, especially in countries like Canada, the USA or the UK (Bell and Dyment 2008). School greening initiatives are gaining new momentum as a way to make school settings more resilient to

climate change impacts through the increasingly mainstreamed concepts of urban green infrastructure (Demuzere et al. 2014) and NBS (Kabisch et al. 2017). In this chapter, we have examined three recently implemented pilot projects in different European cities to better understand the challenges that these co-produced initiatives have faced but also the potential opportunities for upscaling.

The first aspect analysed was the school selection criteria. Due to limited budgets and complex (co-)funding strategies, the number of transformed schools was restricted to 3 centres in Madrid, 10 in Paris and 11 in Barcelona. Despite climate resilience was highlighted as the main challenge to be addressed by the projects (especially for Climate Shelters and Oasis), a higher exposure to climate harms (e.g. urban heat island) was not considered as a key criterion for school selection. Instead, aspects related to school type, condition, size, accessibility or institutional support (by the schools themselves or by municipal authorities) played a more relevant role. A balanced geographical distribution (at least one selected school per district) was also a mandatory prerequisite in Barcelona and Paris, regardless of the socioeconomic characteristics of each district. Nevertheless, this last criterion and the requirement of accessible (public) schoolyards to local residents address issues intertwined with the incorporation of (in)equality aspects into the climate resilience agenda. Both criteria are based on the idea that cities are not uniform landscapes and communities and therefore resilience practices need to consider disparities and different vulnerabilities (Vale 2014). In any case, our findings suggest that criteria related to climate justice or social equity were not the most prioritized in the school selection process, at least in Paris and Barcelona. Given the existing school green inequalities observed in cities like Barcelona (see Baró et al. 2021), we contend that the upscaling of these initiatives should consider the justice and equity dimensions more prominently. To this end, it is also important to understand why some schools might not be willing to engage in this type of projects (as apparently it was the case in Barcelona). In other countries, it has been observed that schools with lower resources cannot access schoolyard greening programmes because of the co-funding requirements established by the municipalities or the corresponding funding organization, including the extra costs that the maintenance of NBS usually entail (Jansson et al. 2019; Giezen and Pellerey 2021).

The three studied projects implemented a variety of NBS contributing to mitigate heat stress and stormwater runoff. However, it is also evident from the interviews and the project documents that climate nature-based solutions were also designed and implemented to offer multiple co-benefits related to educational, play, health or social cohesion opportunities (through the opening of green schoolyards to local residents). Besides, all projects also implemented hybrid (e.g. vegetated pergolas) and grey solutions (e.g. cool roofs) indicating that NBS and *classic* grey solutions can be synergetic rather than alternative options in this type of infrastructure transformations (see also Kabisch et al. 2017; Lin et al. 2021).

As suggested by different authors (Frantzeskaki and Kabisch 2016; Raymond et al. 2017), the design of NBS implementation processes needs to enable cross-sectoral partnerships and support openness, transparency and legitimacy of knowledge from citizens, practitioners and policy stakeholders. In the three analysed

projects, this approach was addressed through the establishment of multidisciplinary teams (including the involvement of different City Council departments and interdisciplinary coordination profiles such as the Urban Resilience Officer in Paris) and the early engagement with multiple *end users*, including schoolchildren, school staff, parents and also urban residents more widely, throughout the different stages of the implementation process. In fact, the ambitious co-design strategy developed in all projects and applied in most pilot schools (from diagnosis of current state to evaluation of implemented measures) contributed to overcome several implementation challenges such as negative perceptions by some stakeholders, a problem frequently cited in other NBS projects (Collier et al. 2016). The exclusion of potential users, their knowledge and experience from the co-design process could negatively affect the effectiveness of the resulting adaptation measures (Muñoz-Erickson et al. 2017). This limitation is not unique in the case of co-designing NBS in school environments. Van der Ven et al. (2016) note that who should be engaged in the co-design process is an unresolved question for co-production in climate change adaptation in general. Institutional willingness for promoting inclusivity and equality in the co-production process is thus necessary (Wamsler 2017), as well as deep understanding of the stakeholders shaping place dynamics and uses to give voice to those who usually play the role of observers in the co-design processes (Ruiz-Mallén 2020).

The upscaling of the projects to more schools is planned as of 2021 in Paris and Barcelona. From our findings, strong political support at the highest municipal level and external funding (European UIA in this case) are key factors for the successful implementation and subsequent upscaling of these projects. Actually, a change in Madrid's government after 2019 municipal elections was clearly identified as a roadblock for the upscaling of Care in School Environments project. Upscaling efforts are also easier if framed within ambitious city-wide strategies related to urban greening, climate change adaptation or urban resilience (see also Fastenrath et al. 2020). The knowledge, scientific evidence and lessons learnt during the demonstration phase of the projects are also crucial for a successful mainstreaming phase. Besides, some NBS can produce additional or incremental co-benefits when scaled up. For example, despite schoolyards generally cover a small share of the total urban area, their transformation at the city level could generate substantial benefits in terms of habitat for species, pollination or stormwater runoff control similar to green roof upscaling efforts (Langemeyer et al. 2020). Moreover, schoolyards are generally not bound by urban planning regulations; hence, they are opportunity spaces for climate and social innovation/experimentation. The Covid-19 pandemic, despite it caused several additional implementation challenges, is also seen as an opportunity for school re-design and the creation of safe outdoor educational spaces.

This comparative exploration is not exhaustive, and it only includes the institutional perspective of project coordinators and available policy reports. Future research should include the experience and views of other involved stakeholders, especially *end users* such as schoolchildren and schoolteachers. These multiple social perceptions can be assessed through diverse methods, including Q method

(Buchel and Frantzeskaki 2015), narrative analysis (Gerstenberg and Hofmann 2016) or fuzzy cognitive mapping (Gray et al. 2015).

We contend that nature-based school transformations can be the spearhead for climate resilience and adaptation in cities due to the central role that schools play in urban life. Schools act as neighbourhood hubs, and their grounds can be re-purposed as spaces for social cohesion and intergenerational encounter around which to implement urban transformation capacities. Nature-based interventions in schools can also contribute towards climate justice as children will be the most affected by the impacts of climate change, yet those who have contributed the least to it. The exploration of these three pioneering projects suggests that school transformations are an opportunity for a radical urban social-ecological transition through the development of a strong climate and environmental awareness among those who will decide the fate of our cities during the second half of the twenty-first century.

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