

December 2020

Keywords: Urban Innovation Action,
school, climate refuges, sustainable
urban development

We are transforming Barcelona's schools to adapt them to the effects of climate change

Marta Vilar and Jaume Barnada

Directorate of Sustainability Strategy and Culture – Area of Urban Ecology (Barcelona City Council)

Barcelona City Council has received funding from Urban Innovation Actions (UIA), a European Commission programme for the 'Adapting schools to climate change through green, blue and grey' project, which plans interventions in eleven schools with a set of measures involving nature, water and architecture. Both school pupils and local residents will be able to enjoy these improvements, as school playgrounds will remain open throughout the summer, while during emergency heat-wave situations they will act as climate refuges. The project will also have an educational side to it, as children will take part in designing climate solutions and evaluating the measures taken. Meanwhile, various research centres will scientifically assess the results of the implemented measures, in terms of health and climate comfort. Participants in this project include Barcelona City Council – through the Area of Urban Ecology, the Barcelona Education Council, the Barcelona Water Cycle, the Barcelona Public Health Agency, the UB's Barcelona Institute of Global Health, and the UAB's Institute of Environmental Science and Technology, along with the eleven selected schools.

Climate change is a reality and it affects people's health and quality of life. In order to tackle this problem, Barcelona City Council declared a climate emergency in January 2020¹. Barcelona is facing the challenge of preparing for the high temperatures which will affect the city, according to climate forecasts. A sizeable part of the solution lies with cities themselves, and they must also show leadership in formulating the main demands. Barcelona City Council wants to be at the forefront of speeding up the necessary cross-cutting changes to the way we live. We need everyone to get involved and join forces with all the stakeholders involved.

Since April 2018, Barcelona has had its own Climate Plan², which is a road map for establishing the necessary mitigation, adaptation, resilience and climate justice measures, as well as the promotion of citizen action. The main aims of the Climate Plan are to reduce Barcelona's contribution to climate change, anticipate climate risks in order to ensure and improve the city's ability to respond to the inevitable effects that are now inevitable, and reduce people's vulnerability to climate change, in order to guarantee their health and well-being. The Climate Plan is an opportunity to join forces and make Barcelona a pioneering city that accepts responsibility for its contribution to climate change and makes preparations to reduce the city's vulnerability to its

1. <https://www.barcelona.cat/emergenciaclimatica/ca>

2. <https://www.barcelona.cat/barcelona-pel-clima/ca/>

effects while becoming a fairer and more participatory place. The Climate Plan's Line of Action 3 refers to mitigating heat. More specifically, it proposes the improvement of thermal comfort in city buildings and public areas, and creating a network of climate refuges to deal with high temperatures, in order to ensure people's health and provide special care for the population's most vulnerable groups.

The Barcelona Climate Plan is a cross-cutting strategy that includes the execution of 242 measures before the end of 2030. A strategic plan containing proposals to mitigate the effects of climate change, including projects to adapt the city, promote climate justice and foster citizen participation. Among other things, it includes measures to increase the city's adaptation and resilience to the climate-change effects that we are already experiencing. These measures, which must be implemented from 2021 to 2030, establish the following steps:

- Identifying existing and potential climate refuges: public and private facilities and public areas which could provide suitable thermal-comfort conditions during extreme episodes and establishing the services linked to heat-wave action protocols that these spaces need to offer, aside from quantifying the extra resources required (parks open 24 hours a day, use of 'greened' school playgrounds, city block interiors, etc.). Mapping the degree of cover to ensure territorial fairness and taking into account the areas identified as the most vulnerable to heat.
- Creating water gardens with children's games that combine permanent actions with ephemeral or seasonal ones. With regard to these gardens, they should have acceptable levels of water consumption, comply with all necessary sanitary requirements and be equitably distributed around the territory.
- Improving the thermal comfort of climate-refuge facilities, giving priority to those that serve the most vulnerable population (nurseries, schools, residences, etc.), wherever possible, without any increase in energy consumption (by using passive measures such as cross ventilation, better insulation, darkening with dissipated natural light or geothermal cooling, among others).
- Creating new climate refuge areas (green spaces or facilities) to ensure territorial cover.

The 'Transforming Barcelona's schools to adapt them to the effects of climate change, through green, blue and grey' project fits in especially well with these proposals and, as a pilot scheme, implements the planned actions in some of the city's state schools.

Barcelona City Council applied for funding from the ERDF, through its Urban Innovation Actions (UIA)³ projects. This is a European Commission programme that proposes interventions concerned with adapting to climate change, air quality, employment and housing. In 2018, this programme was allocated €372 million, for the 2014-2020 period, in order to fund innovative projects in cities that fell within the proposed thematic frameworks. The campaign's budget for 2017 was €50 million. Through the Municipal Institute of Urban Planning, Barcelona City Council asked for the maximum possible amount, which was €5 million, with 80% funding through the UIA and 20% through municipal budgets. The municipal proposal was accepted and subsequently validated. The planned execution period is three years, from October 2018 to October 2021. The UIA promotes initiatives that aim to find and test new solutions to sustainable urban development challenges which prove to be relevant to all members of the European Union.

The 'Adapting schools to climate change through green, blue and grey' project proposes interventions in eleven state schools, with a set of measures that may be enjoyed by school pupils and the general public, as the school playgrounds will remain open during the summer. The project will also have an educational side to it, as children will take part in designing climate solutions and in their evaluation. Meanwhile, various research centres will scientifically assess the results of the implemented measures in terms of health and climate comfort.

3. <https://www.uia-initiative.eu/en/news/barcelonas-pilot-project-beat-heat-0>

The first question that must be considered is how to define the term 'climate refuge' and how it may be adapted to a state school facility, as well as the subsequent form of management. Through the cross-cutting participation of various municipal areas, Barcelona City Council has created a committee which is drafting a management protocol for climate refuges in the city. One of the first measures was to define what climate refuges should be like and who they should be for. In this regard, the following points were established:

- They will be places that provide climate comfort to the population, through the implementation of passive measures.
- They will be places for common use in public facilities.
- They may be indoor places, not necessarily air-conditioned, or outdoor places, such as parks and gardens, with ample vegetation and water features.
- They must be safe, easily accessible, provide rest and relaxation areas and have water.
- They will be used in emergency heat-wave situations, but they will also have additional uses. They will therefore be places characterised by diversity and multi-functionality.
- They will be aimed especially at people who are vulnerable to heat (babies, young children, people over the age of 75, people who are chronically ill and people who lack resources, etc.).
- They will not be sensitive facilities that shelter vulnerable people, nor places for medical care, because these places can be overwhelmed during heat waves.
- Climate refuges will form a city-wide network and they may be established in public facilities (libraries, universities, sports centres, multi-sport courts, civic centres, neighbourhood centres, environmental classrooms, museums, state schools), in private facilities (cinemas, theatres, shopping centres, gyms, churches, subsidised and private schools), and in open areas (urban parks that have ample vegetation and water).

As part of the climate-refuge network, and to comply with the proposal presented to the UIA, it was decided to take action on state primary schools, for various reasons:

- The distribution of schools around the city is as widespread as possible and public facilities are more closely tied to the dynamics of their communities, which means that any action taken to transform them has a domino effect because they are visible, well-known and included in the educational project.
- The proposed solution is to turn the schools into climate refuges that are open to local residents. Nowadays, many city schools are already part of the Open Playground project.
- The city has a very active network of schools that include sustainability as just one more factor in their educational project. The More Sustainable Schools Programme⁴ was launched in 2001 as part of Barcelona's Citizen Commitment to Sustainability, with the aim of contributing to sustainability through education and recognising schools as agents of change in the city. A total of 472 educational centres have taken part in the programme during its 19 years of existence. Throughout this time, the participating centres have developed a range of initiatives for improving the schools and their surrounding areas, so this current initiative will have no problem in adapting to a project that has been running for years.
- The schools habitually accept vulnerable people among their pupils and they have a considerable capacity for taking in more, because they are local, neighbourhood places.

4. <https://www.barcelona.cat/barcelonasostenible/ca/escoles-sostenibles>

- The proposal is a project created for each school with the potential for being used as a model that can be applied in other situations; this is a pilot scheme that will have an ensured, intense use.

The project aims to turn eleven school areas into shelters for people who are vulnerable to heat. In other words, climate refuges that are open to all city residents, employing traditional solutions to combat high temperatures in buildings and transforming playgrounds by introducing vegetation, shaded areas and water features. It is therefore an architectural project that affects school infrastructure. However, this project is cross-cutting and cannot function optimally if it is only considered from this reductive perspective. If one thing characterises climate emergency actions, it is their capacity for co-creating projects and acting in various areas at the same time. We could therefore define this action as a process of processes that is adapted to schools, but which becomes a pilot scheme for new actions and involves multiple areas of work.

Participation is one of the key factors in the design of the new spaces and the specific needs of each centre. It is through participation that the education community (children, families, education management and team, and non-teaching staff), the project's partners and technical and scientific experts can reach an agreement on the actions that need to be taken in each school, while working on the idea of climate adaptation.

The educational project ensures the proposal's inclusion in the school environment and the raising of awareness about climate change, as well as offering an educational opportunity for working on the climate emergency with a significant number of city school children.

Opening up these places to city residents maximises resources and gives local residents access to climate refuges outside of school hours, as an intangible parallel process that will complement the infrastructure.

The impact on health and the evaluation will be monitored from the perspective of well-being, to make an assessment based on environmental, learning achievement, well-being, social inclusion and gender parameters.

As this is a pilot project, communication is a basic factor in order to scale the project to the city, so that all schools can eventually be transformed and adapted.

Through these measures, the aim of replicability is to ensure that city residents and the school community understand the need to promote initiatives that adapt the city to climate change and that these measures are replicable in other buildings, particularly in city schools and in other cities.

The 'Adapting schools to climate change through green, blue and grey' project is complex: it is also highly cross-cutting and collaborative in nature, because of the wide variety of actions and processes that have to be carried out in parallel. It is being coordinated by Barcelona City Council's Area of Urban Ecology and it brings together a series of partners who develop specific actions defined by a joint strategy. These partners are:

- Barcelona City Council and municipal organisations: The Area of Urban Ecology, the Area of Social Rights, the Barcelona Public Health Agency (ASPB), Barcelona Water Cycle (BCASA), the Energy Agency
- Barcelona Education Consortium (CEB)

- Research organisations: The University of Barcelona's Institute of Global Health (ISGLOBAL)⁵ and the Autonomous University of Barcelona's Institute of Environmental Science and Technology (ICTA)
- School community

Once the project's strategy and schedule had been defined, in agreement with all the partners, the Barcelona Education Consortium initiated a campaign to encourage all city state primary schools to apply for the project, by means of registering as partners in the joint work on the defined processes and by offering the use of their facilities for carrying out the projects. 45 schools applied. The schools were selected using criteria that awarded them specific scores, assessing the suitability of each school facility. These criteria form an evaluation table, by analysing environmental and other specific aspects:

- Data that is specific to each school, their location in the city and district, the year they were built, shared uses with other facilities and adjacent playgrounds.
- The climatic assessment took into account the school's urban environment, its vulnerability to heat waves and the presence of green cover in the area.
- With regard to the buildings, their energy behaviour was identified by assessing the classrooms and façades exposed to the sun, the roofed spaces, the building's energy certification and any protection from the sun.
- The playgrounds of each school were also analysed and evaluated. More specifically, their surface area, the ratio of paved to green areas, the amount of direct sunlight falling on them and the water features, in terms of their number and position.
- Lastly, some aspects that were specific to each school were considered, such as the index of complexity, their membership of the More Sustainable Schools network or if their playgrounds were open to the general public.

As a result of this evaluation, the following ten schools were selected: Cervantes, Els Llorers, Ramon Casas, Ítaca, Poeta Foix, Rius i Taulet, Font d'en Fargas, Antaviana, Can Fabra and Poblenou, with the addition of the Vila Olímpica school, as an initial partner of the project.

The selection process also chose ten control schools. Although no actions would be carried out in their facilities, they would be monitored through the use of sensors that evaluate the climate response of their buildings and playgrounds, in order to compare this information with the schools undergoing interventions.

Once the schools had been selected, they were included in the project as full partners and a participatory process was initiated to evaluate the needs of each one. At the same time, the technical partners initiated a detailed analysis of the buildings and playgrounds in question. This parallel operation was to verify the type of priorities for the interventions and the suitability of those interventions. In order to fine-tune the project's participatory process, a catalogue was drawn up listing the features and solutions that could be implemented according to the technical analysis, which would improve the environmental conditions of the schools while also being in line with the project's objectives.

Participatory process

A participatory process is proposed that involves the education community in the project, i.e. the pupils, the education team, the parents association (AFA), the non-teaching staff and ultimately, all

5. <https://www.isglobal.org/ca/healthisglobal/-/custom-blog-portlet/les-escoles-com-a-refugis-climatics/7305043/0>

the stakeholders involved in the life of the school. This participatory process aims to help define the measures that need to be applied in each school, by means of detecting needs and assessing the impact of the measures on the people using the facility, once they have been implemented. This line of action is developed through participatory sessions held at each school, organised through the More Sustainable Schools programme.

The proposal is based on four sessions with the education community: the first, to validate the challenges facing each centre in terms of climate adaptation and to prioritise the measures that need to be implemented (in accordance with the catalogue of available solutions). The second, to help the technical team assigned to each school to specify the chosen measures and draft the executive project for the work. The third, for carrying out a preliminary evaluation of the implemented measures, and the fourth, scheduled for the hottest part of the year, for assessing whether the implemented solutions improved thermal comfort.

As overall results, it can be seen that throughout the participatory sessions, the education community of every school was well represented and that this project has aroused everyone's interest, something that has led to a generalised demand for continuing with more participation. The improvements that schools prioritise most are to facilitate natural cross-ventilation, add new vegetation, treat surfaces, introduce drinking fountains and install mixed solutions featuring shade, vegetation and water.

Educational process

The participatory process was accompanied by an educational proposal for the entire school community and more specifically for the 5th year primary-school pupils, which is the school year that runs the project in the centre. Three training seminars were held for the teaching staff, offering educational resources for dealing with the subject of climate-change adaptation, as well as specific experiences for monitoring the scientific measures in conjunction with the technical teams. They also went into greater detail about communication strategies for informing local residents about the school being used as a climate refugee, and activities were suggested for making the best teaching use of the implemented measures. Lastly, the schools were also offered the chance to establish an exchange between their pupils and one of the schools taking part in the Oasis Project in Paris.

The project's objective once the three year period has finished is for the centre to continue with the subject of climate change as a major part of its curriculum, with the support habitually offered by the More Sustainable Schools programme. For this reason, they will be provided with a guide and an education kit on the subject, while the sensors will be kept in place so that the pupils can continue to monitor the indicators.

The technical analysis

In order to define what kind of actions can be carried out in each school, a technical analysis was carried out to identify the conditions of the building and the playground, while also looking for weak points and opportunities. This was done by means of in-person inspections, cartography and specific data, with the aim of evaluating the school and the immediate surroundings that affect it. Meanwhile, each school was modelled using simulation programmes, for the incidence of direct sunlight and the possibilities for natural ventilation. This analysis was carried out by the project's municipal technical partners: the Area of Urban Ecology, the Barcelona Public Health Agency (ASPB), Barcelona Water Cycle (BCASA) and the Energy Agency, along with the collaboration of the Barcelona Education Consortium.

The analysis focused on three areas:

- Architectural limitations: with an analysis of the urban situation, general information about the building (dates and conditions), volumetrics, the type of layout, the type of playground, the relationship between the building and the playground, the relationship between the building and the surrounding area, the surface area of playgrounds, the ratio of open space (m²) per

person, the zoning and uses of the playgrounds, the type and conditions of roofing and the active ventilation and air-conditioning systems.

- The limitations of the site: with an assessment of the type of solar protection, the ratio of hard surfaces that could be covered to the total surface area of playground, the presence of intermediate spaces (porches), shade in the summer, the position of vegetation, the ratio of vegetation to playground surface area, vegetation supports, the surface area suitable for new vegetation, the species of trees and plants, the prevailing wind, the water features, the materials used for surfaces and façades, the colour and nature of the materials, the percentage occupied by sandpits and the surface area that could be transformed.
- Urban limitations: with the measurement of the urban environment, air quality and exposure to PM10 and NOx pollution, exposure to noise and the potential for accumulating high temperatures from sunlight.

Indicators were also obtained for an objective comparison of the schools.

The analysis resulted in a series of improvement proposals for each school, which were sent to the Barcelona Education Consortium (CEB) and compared with every other school during the participatory process. It should be said that this scientific analysis was very well received by the schools and that it almost exactly coincided with their needs and proposals.

The catalogue of elements and solutions

Once the analysis by the project's technical partners (the Energy Agency, BCASA, Directorate of Urban Greenery and Biodiversity and the IMSPB) had been carried out together with the CEB, a catalogue consisting of fourteen elements and six mixed solutions was drawn up. This included examples for creating projects in the three planned intervention areas: green (nature), blue (water) and grey (architecture). The catalogue was put together using technical files that will be developed in the definitive executive projects.

The catalogue defines common ways of working on the building, the playground and the fences of each school, while also ensuring solutions for the three types of intervention indicated in the project objectives (green, blue and grey). In other words, it specifies how to act during a pilot project in a replicable way, with a series of shared strategies for school infrastructures that will turn them into climate refuges.

With regard to the green part, nature, it defines the places suitable for new plantings: playgrounds, roofs, façades and dividing walls, while also indicating the type of vegetation: trees, plants and vegetable gardens. It specifies that all the species, including both trees and other plants, should be native or well-acclimatised species, while rejecting invasive species, and that they should meet the functional requirements for improving the school's climatic conditions. The catalogue has an appendix listing the species of trees and other plants to be used in the projects.

In regard to the blue part, water, the catalogue proposes solutions involving water intake points, drinking fountains, leisure features such as fountains and sprinklers, symbolic play features, naturalised ponds and pools for vegetable gardens, and tanks and reservoirs for collecting rainwater. There is a benchmarking appendix for water features.

Lastly, with regard to the grey part, architecture, the following types of action are indicated: power generation using photovoltaic panels, thermal solar panels and low-voltage wind energy, the insulation of roofing and façades, insulation and thermal bridging for doors and windows, solar protection: curtains, blinds, *brise-soleils*, porches, awnings, arbours and cold roofs.

International references

The project aims to transform Barcelona's schools in order to adapt them to the effects of climate change, through green, blue and grey, and it is being promoted at a time of generalised climate

emergency. There are various international programmes that share similar experiences, either in the type of operations or the project concept.

The city of Paris has the Oasis project⁶ aimed at gradually transforming school playgrounds in order to create places that are cooler and more pleasant for enjoying everyday life, which can be shared to a greater extent. This initiative is the result of the resilience strategy adopted by Paris City Council in September 2017. It is aimed at reinforcing the territory's capacity for dealing with the big climate and social challenges of the 21st century. The renovated playgrounds are more natural, have more vegetation, employ better management of rainwater and water features, have installations that are more fun and more suitable for children, and are relaxed places with a better spatial distribution. One of the project's main objectives is to improve the well-being of children during the hottest periods of the year. These playgrounds, designed as cool oases, can also have a wider range of public uses outside of school hours and, in particular, they can be turned into 'refuges' for vulnerable people during heat waves. The Oasis Project is also part of a European UIA campaign. Paris has also paid special attention to Barcelona's Open Playgrounds programme and there have been a number of knowledge exchanges with the Municipal Institute of Education (IMEB), which manages the Open Playgrounds programme.

In 2018 and 2019, Madrid carried out a pilot project for turning school playgrounds into places that were healthier, more socially inclusive and diverse, with a greater ability to adapt to the effects of climate change. First, the city carried out an analysis to evaluate the state of 241 state schools using quantitative criteria (e.g. playground surface area, school/playground ratio, equipment) and qualitative criteria (e.g. shade, vegetation, construction materials, accessibility). The three pilot schools were selected based on the results of the analysis and their vulnerability to extreme heat (sensitive population + high exposure). Madrid collaborated with its partners in order to carry out a thorough, three-month consultative process with the various interested stakeholders from the schools (pupils, families, teaching staff, local residents, etc.) to co-create solutions for cooling systems suited to each context, as well as producing more design guidelines for school playgrounds.

The C40 city network promotes daring climate initiatives, for a healthier and more sustainable future. The C40 has evaluated Barcelona's Schools as Climate Refuges project as a good practice at an international level and has included it in the 'Cooling schools. Experiences from C40's cool cities network. On how to adapt schools to rising urban temperatures' programme, together with the cities of Madrid, Paris, Philadelphia, Accra and London.

Monitoring the project

The project includes various monitoring and data collection systems before, during the work and as an evaluation of the final results. This part of the project is coordinated by the Barcelona Public Health Agency (ASPB), the University of Barcelona's Institute of Global Health (ISGLOBAL) and the Autonomous University of Barcelona's Institute of Environmental Sciences and Technology (ICTA).

It is planned to draw up studies and conclusions on the environmental conditions of the schools, the air quality in the surrounding area and the cognitive capacity of the pupils with regard to temperature variation.

The ISGlobal technical and research team, in coordination with the Barcelona Public Health Agency, is responsible for assessing whether these adaptations have effects such as changes in temperature, humidity and air quality, as well as what impact this has on the health and well-being of the pupils. For example, they analyse thermal comfort, the children's levels of physical activity and attention before and after the intervention, as well as the use of the spaces and the social interactions between the pupils and other people using the space.

6. <https://www.paris.fr/pages/les-cours-oasis-7389>

The **ICTA-UAB** will scientifically evaluate the results of the interventions, in terms of health and learning achievement. These actions coincide with those of the 'Escola respira' [School breathing] programme⁷, which focuses on children and promotes new actions in school environments, as well as reinforcing existing ones aimed at lowering pollution in schools and increasing awareness about the negative effects of pollution on the school population.

As this is an innovation project, it is possible to try out various measures for creating changes, with the aim of seeking solutions that are replicable in the local environment and in Europe as a whole. The evaluation results help to identify which adaptations have generated improved results, so that they can be used as examples in the future.

The projects

The process ends with the cross-referencing of all the data and observations from the previous stages and with clear prioritisation of school-by-school solutions, detailing main and complementary actions. Therefore, the projects are defined using the priorities determined by the participatory process involving the management teams, the school's parents association (AFA) and the technical analyses carried out by project partners. An evaluation table was drawn up and scored, which included technical criteria, the suitability of the solutions, management and maintenance, and the needs of the schools. This table resulted in some actions. Lastly, the works budget caused the type of actions to be adjusted and concentrated, in order to make them as effective as possible in terms of climate impact. The results arising from the evaluation and the priorities were communicated to the project partners.

The technical teams that drafted the projects received a number of inputs, such as the catalogue of elements and solutions, the technical analysis of the schools, the proposal for priority and secondary actions, and the maximum budget for each school, which could not exceed €240,000 and had to be similar for each facility.

The final projects showed a good balance between their initial objectives, the wishes of the schools, the diagnostics and the more technical questions that were proposed to all of the partners by the monitoring committee. The technical observations on the preliminary projects were included in the executive projects, provided that this was possible in technical and budgetary terms. All the projects also include a catalogue of features and solutions, which they develop.

The innovation represented by these actions on the schools is assured, as a new concept of climatic spaces is being designed which is new to Barcelona and adapts perfectly to the city's Climate Emergency Declaration. Enquiries for information about the projects and the possibility of replicating them have been received from other cities, including Paris and Milan. Furthermore, the C40 cities network has asked us for information and considers the project to be a major good practice. The use of passive elements to achieve the project objectives and the production of the catalogue have been a success.

All the projects use nature, the green element, as an essential part of the project, with the aim of achieving greater biodiversity in school playgrounds while also obtaining new cool and shady areas. A considerable number of new trees have been planted and, as a consequence, we are reducing the amount of paved surface area and obtaining more natural, porous ground. Some of these actions include:

- Green walls in the Cervantes, Poeta Foix and Antaviana schools
- Mediterranean gardens in the Els Llorers, Rius i Taulet, Font d'en Fargas and Can Fabra schools

7. <https://ajuntament.barcelona.cat/qualitataire/ca/qualitat-de-laire/com-es-lluïta-contra-la-contaminacio/escola-respira>

- Shady areas with trees in the Ramon Casas, Ítaca, Font d'en Fargas, Antaviana, Can Fabra, Poblenou and Vila Olímpica schools
- Green fences and arbours in the Cervantes, Els Llorers, Ramon Casas, Poeta Foix, Rius i Taulet, Antaviana, Can Fabra and Poblenou schools.

The blue element was the most difficult to work on. The proposed benchmarking features were questioned by all the schools. They received negative feedback for sanitary reasons and their high cost meant the number of actions had to be reduced and it became impossible to implement them as part of the agreed priority actions. However, the projects include some solutions that approach their initial objectives and are also adapted to the wishes of the schools. Furthermore, they meet the technical and health requirements indicated by BCASA and the IMSPB. Some examples include:

- Multi-function fountains that are introduced in all the intervention areas, and in addition to supplying drinking water, they can be fitted with adaptors for water games and hose pipes.
- Singular areas for playing with and manipulating water in the Els Llorers, Ramon Casas, Ítaca, Rius i Taulet i Font d'en Fargas schools.
- An arbour with water in the Antaviana school.

The third element of the project, grey, was also implemented in a positive way. In this case, the use of passive architecture has been a key feature. The high cost of this kind of action meant working only on key and priority elements, as well as specially selecting the types of intervention from a wide range of possibilities. Some of these actions include:

- New roofs for three schools. At Escola Cervantes, the skylight was modified in order to create a central ventilation shaft at the school; at Escola Poeta Foix, a new cold roof was built (ventilated and reflective), and at the Institut Escola Antaviana, a green roof was proposed (trees in planters and a green arbour) on the nursery school's concrete roof, which is also the primary school playground.
- Shade for the roofs of the Rius i Taulet, Can Fabra and Poblenou schools, using awnings and arbours in order to obtain shady spaces on the roofs used as children`s play areas.
- Façades. Solar protection are being installed on various façades, including those of the Cervantes, Ítaca, Antaviana, Can Fabra, Poblenou and Vila Olímpica schools.
- Arbours to create shady areas in the Cervantes, Ramon Casas, Els Llorers, Ramon Casas, Poeta Foix, Rius i Taulet, Antaviana, Can Fabra, Poblenou and Vila Olímpica schools.
- New cross-ventilation for the Cervantes, Font d'en Fargas, Can Fabra and Poblenou schools.

In conclusion, the projects establish a wide range of proposals in the three areas of action, and they comply with the project's objectives, which are to improve climate conditions in schools and construct pilot-scheme, replicable climate refuges. The eleven schools concerned regard them as a great opportunity. The main adaptation work on the schools is scheduled for the summer of 2020.

Schools play a vital role in urban life, and they are not only places where children socialise and receive education; they also act as local centres. Cities are facing greater and greater impacts from climate change and urban heat islands are becoming increasingly intense. Therefore, cities all over the world are starting 'Cool Schools' projects in order to adapt schools and protect children from extreme heat.

There are seven reasons for initiating a 'Schools as Climate Refuges' project in Barcelona:

1. Children are especially sensitive to extreme heat; any action designed for them benefits the population of vulnerable people as a whole.
2. Improving the condition of school buildings and playgrounds using passive architecture, shade and natural ventilation increases thermal comfort and creates a better learning environment.
3. The creation of school playgrounds that have shade, water and children's areas encourages them to play and increases the physical activity of pupils, thereby improving their health.
4. The use of schools as community centres creates social and climatic awareness in the community.
5. Through this project, state schools are acting as a pilot scheme that demonstrates the characteristics which an urban climate refuge should have, as well as being an example of how to reuse existing facilities.
6. The schools will act as comfort areas during periods of high temperatures and they will be open to local residents during heat waves.
7. The formation of a climate-refuge network in public facilities reinforces the idea of a city that uses local facilities to make everyday life easier.

Image 1. At the Escola Els Llorers, in the Eixample, the hard surface used as a sports court is downsized to include more green areas, shade and a proposal for a multi-functional games area



© Jaume Barnada

Image 2. The pupils of Escola Can Fabra take part in the decision-making process for solutions to be implemented in their school



© Laia Ventayol

Image 3. Shady area, climate-refuge project at Escola Poblenu



© BT arquitectes