LIFE my building is green

LIFE17 ENV/EN/000088

Application of Nature-Based Solutions for local adaptation of educational and social buildings to Climate Change

Action: Integration and transferability at local, national and European level

Deliverable: Financial plan for the replication of the LIFEmyBUILDINGisGREEN experience.

Date: 02/08/2023

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Date: **02/08/2023**

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1. SUMMARY EN ESPAÑOL

The climate change is one of the greatest challenges our planet is facing, and as such, it is necessary to act swiftly to minimize its negative effects. In this context, European schools in general, and those in the Mediterranean basin in particular, have an important challenge in need of renovation. We recommend nature-based solutions to ensure the health and well-being of the people using them. These solutions include, for example, the installation of green roofs, vertical gardens, or vegetal structures for shading to reduce temperature and improve air quality, as well as rainwater harvesting for use in irrigation systems.

However, the implementation of these types of renovations that many schools and other buildings require to adapt to new scenarios involves a series of investments and procedures that are preventing their execution, despite social demand. Whether due to lack of budget availability or unwillingness to undertake the necessary studies and work, these actions are being postponed, resulting in these buildings experiencing the effects of climate change and unsuitable conditions for educational activities.

The LIFE myBUILDINGisGREEN project aims to carry out a series of prototype actions in three pilot schools to demonstrate their impact on the building and indoor environmental conditions in classrooms. Through the various deliverables and materials generated by the project, the impact of these solutions can be appreciated. Furthermore, they can be used to facilitate future projects that consider these types of actions.

This deliverable provides information on nature-based solutions proposed by the project and information to prepare estimates of the necessary investments and key considerations for financial planning to implement them. However, specific financial plans are not presented since each case requires specific information regarding each building.

As an example, four brief examples of schools in different locations and their plans for adapting to climate change using nature-based solutions are presented. The intervention areas and the most suitable nature-based solutions were selected according to the project's criteria, an approximate budget was calculated, and the overall impact of these actions was estimated.

Regarding the costs/budgets presented for nature-based solutions, it should be noted that the data presented was extracted from actual budgets used in the execution projects of the demonstrative pilots carried out in the three selected schools. However, in the current circumstances, with significant price variations in many raw materials, costs will need to be updated for each scenario. Additionally, the prices were obtained from the markets in Spain and Portugal. When considering similar interventions in other countries, it should be acknowledged that these references will have limited validity.

Regarding the impacts, the project proposes a series of reference indicators, but it is recommended to adapt them based on the most important challenges faced by each institution. The definition of these indicators and the challenges of each school should guide the establishment of priorities in the actions.

2. ENGLISH SUMMARY

Climate change is one of the biggest challenges facing our planet and, as such, it is necessary to act quickly to minimize its negative effects. In this context, European schools in general, and in the Mediterranean basin in particular, have a major challenge to be renovated, we recommend with nature-based solutions, to ensure the health and well-being of the people who use them. These solutions include, for example, the installation of green roofs, vertical gardens or plant structures for shading to reduce temperature and improve air quality or rainwater harvesting for use in irrigation systems.

However, the approach of this type of renovations that many schools and other types of buildings need to adapt to new scenarios, involves a series of investments and implementation of procedures that are preventing them from being carried out, despite the social demand. Either by the lack of budget availability or by the lack of willingness to face the necessary studies and works, this type of actions are being postponed and thus causing these buildings to suffer the effects of climate change and to have unsuitable conditions for teaching activities.

The LIFE myBUILDINGisGREEN project aims to carry out a series of prototype actions in three pilot schools and show the impact they have on the building and the environmental conditions inside the classrooms.

Through the different deliverables and materials generated by the project, the impact of these solutions can be appreciated. In addition, they can be used to facilitate future projects in which this type of actions are considered.

This deliverable contains information on the SbN proposed by the project and information to prepare estimates on the required investments and certain keys on how to prepare the financial plans to carry them out. However, financial plans are not presented as such, since in each case the specific information related to each building is required.

As an example, 4 examples of schools in different locations and the plans for their adaptation to climate change using BNS are briefly presented. The most appropriate areas for action and BNS have been selected according to the criteria of the project, an approximate budget has been calculated and the overall impact that these actions would have has been estimated.

Regarding the costs/budgets presented for the SbN, it should be noted that the data presented are taken from the actual budgets used in the implementation projects of the demonstration pilots carried out in the three selected schools. However, in the current circumstances, with the large variations in the budgets of the three selected schools, it should be noted that the data presented are taken from the actual budgets used in the implementation projects of the demonstration pilots.

prices of many raw materials, costs will have to be updated for each scenario. In addition, prices have been obtained in the Spanish and Portuguese markets. When considering similar interventions in other countries, it should be taken into account that these references will have a limited validity.

In relation to impacts, the Project proposes a series of reference indicators, but it is recommended to adapt them according to the most important challenges faced by each particular institution. The definition of these indicators and the challenges of each school should guide the prioritization of actions.

3. RESUMO EM PORTUGUÊS

Climate change is one of the greatest challenges facing our planet and, as such, it is necessary to act quickly to minimize its negative effects. In this context, European schools in general, and the Mediterranean basin in particular, have an important challenge to be renewed, we recommend nature-based solutions to ensure the health and well-being of the people who use them. These solutions include, for example, the installation of green roofs, vertical gardens or vegetative structures for shading, in order to reduce the temperature and improve air quality, or the collection of rainwater for use in irrigation systems.

However, the implementation of this type of renovation, which many schools and other types of buildings need to adapt to new environments, involves a series of investments and procedures that are preventing its realization, despite the social demand. Whether due to the lack of budgetary availability or to the lack of will to face the necessary studies and works, these actions are being delayed, which causes these buildings to suffer the effects of climate change and not to have adequate conditions for educational activity.

The LIFE myBUILDINGisGREEN project aims to carry out a series of prototype actions in three pilot schools and demonstrate the impacts that these actions have on the building and the environmental conditions inside the classrooms. Through the various results and materials generated by the project, it will be possible to appreciate the impact of these solutions. Moreover, they can be used to facilitate future projects that consider this type of action.

This document contains information on the nature-based solutions proposed by the project and information to prepare estimates on the necessary investments and some guidelines to prepare financial plans for its implementation. However, specific financial plans are not presented, since each case requires specific information related to each building.

As an example, four examples of schools in different locations and the plans for their adaptation to climate change using nature-based solutions are briefly presented. The areas of intervention and the most appropriate nature-based solutions were selected according to the project criteria, an approximate budget was calculated and the overall impact of these actions was estimated.

Regarding the costs/prices presented for the nature-based solutions, it is important to keep in mind that the data presented were extracted from the actual budgets used in the implementation projects of the demonstration pilots carried out in the three selected schools. However, under current circumstances, with the large variations in the prices of many raw materials, the costs will have to be updated for each site. In addition, the prices were obtained in the Spanish and Portuguese markets. When considering similar interventions in other countries, it is necessary to take into account that these references will have limited validity.

Regarding impacts, the project proposes a series of reference indicators, but it is recommended that they be adapted according to the most important challenges faced by each particular institution. The definition of these indicators and the challenges of each school should guide the prioritization of actions.

4. INTRODUCTION

Climate change is one of the greatest challenges facing our planet and, as such, it is necessary to act quickly to minimize its negative effects. In this context, European schools in general, and in the Mediterranean basin in particular, have a major challenge to be renovated, we recommend with nature-based solutions, to ensure the health and well-being of the people who use them. These solutions include, for example, the installation of green roofs, vertical gardens or plant structures for shading to reduce temperature and improve air quality or rainwater harvesting for use in irrigation systems.

However, the approach of this type of renovations that many schools and other types of buildings need to adapt to new scenarios, involves a series of investments and implementation of procedures that are preventing them from being carried out, despite the social demand. Either by the lack of budget availability or by the lack of willingness to face the necessary studies and works, this type of actions are being postponed and thus causing these buildings to suffer the effects of climate change and to have unsuitable conditions for teaching activities.

The LIFE myBUILDINGisGREEN project aims to carry out a series of prototype actions in three pilot schools and show the impact they have on the building and the environmental conditions inside the classrooms.

Through the different deliverables and materials generated by the project, the impact of these solutions can be appreciated. In addition, they can be used to facilitate future projects in which this type of actions are considered.

The valuation only of the necessary investments when considering this type of initiative means that the operations rarely seem profitable for society. Aspects such as people's physical and mental health, resource management, respect for the environment or the protection of biodiversity are issues that are not usually valued economically and do not enter into the equation.

The LIFE myBUILDINGisGREEN did not aim to provide a compendium of indicators covering all the issues that could be assessed when considering this type of investment. The study has focused on assessing what conditions could be achieved by applying this type of solutions and whether they are suitable for school activity.

5. FINANCIAL PLAN

A financial plan for the integral or partial renovation of schools in the Mediterranean basin with solutions based on nature has as its main objective to adapt educational spaces to school activity in the new scenarios caused by climate change. In addition, it will serve to promote sustainability and climate resilience in the education sector. Through a combination of cost-benefit analysis, evaluation of financing options, establishment of an action plan, implementation and monitoring and evaluation, it aims to achieve effective and sustainable renovation. A financial plan focused on implementing nature-based solutions to combat the effects of climate change will serve to bring about a positive transformation in the school environment, to the benefit of students, educational staff and the community at large.

The following are the stages of a financial plan for a comprehensive renovation of schools in the Mediterranean basin with nature-based solutions to combat the effects of climate change:

1. **Cost-benefit analysis**: The first thing to do is to analyze the costs and benefits of the renovation. Both the costs of the intervention itself should be taken into account, as well as the long-term benefits, the improvement in the health and well-being of the educational community, the energy savings and the reduction of greenhouse gas emissions. It is also important to consider the material costs of nature-based solutions, such as the installation of vertical gardens and rainwater harvesting systems.
2. **Evaluation of financing options**: Different financing options for the renovation, such as loans, grants and sponsorships, should be evaluated. Grants and sponsorships can be especially useful for projects that have a positive impact on the environment. Consideration may also be given to creating a special fund to finance the renovation.
3. **Establishing an action plan**: Once costs and financing options have been evaluated, a detailed action plan should be established. This will include defining areas in need of renovation, designing nature-based solutions, and developing a timeline for renovation.
4. **Plan implementation**: With the action plan in place, implementation of the renovation can begin. Clear timelines and goals must be established, and it must be ensured that quality and sustainability standards are being met.
5. **Monitoring and evaluation**: Once the renovation has been completed, it is important to monitor and evaluate its effectiveness. This will include tracking energy savings and reduced emissions, as well as monitoring air and water quality in the renovated area.

In general, a financial plan for a comprehensive renovation in schools in the Mediterranean basin with nature-based solutions will require a significant initial investment, but can also generate significant long-term savings and environmental benefits. With careful planning and execution, effective and sustainable renovation can be achieved.

In this deliverable we present 4 cases of schools in different locations for which we have calculated the budget and estimated the impact that the proposed solutions would have, always considering the objective of achieving comfort for children and also for teachers and other school staff. The schools have been extracted from those previously studied to design 15 implementation projects (see deliverable C5.7).

This deliverable presents a brief summary of the proposed interventions and a plan to estimate the investment to be made. No further information is available from the schools to go further and propose a particular financial plan. Such a study will have to be addressed on a case-by-case basis and assess the funding opportunities that apply to the competent authority or private entity managing the school. In the current context, there may be funds at the European level such as cohesion funds or at the national or regional level that promote the renovation of buildings for their adaptation. As it cannot be otherwise, the project recommends the inclusion of SbN in these renovation projects for the multiple benefits they provide.

6. CASE STUDIES

6.1 OPENBARE BASISSCHOOL HET VOGELNEST (PUBLIC ELEMENTARY SCHOOL HET VOGELNEST)

Climate risk zone 3: Coastal zones, deltas and floodplains

Some of the features to highlight of this building are:

- One of the facades (NO) is exposed to the sun without any type of protection.
- The roof is sloped and tiled.
- Part with a green area of 610m^2

The values obtained from the psychrometric diagram are:
2- Summer hole shading (1.3%)
3- Use of thermal inertia (0.5%)
4- Thermal discharge of the building mass (not applicable) 5,6- Evaporative cooling systems (not applicable) 7- Night ventilation (not applicable)
9- Management of internal loads: lighting, equipment, people, etc. (29.7%)
10.11- Solar collection (9.1%)
12- protection against external winds (9.9%)

According to this study, the building initially has a percentage of comfort hours in the climate of **3.4%.** After the implementation of the SbN, this percentage could increase to **39%**.

The SbNs selected for this case have been chosen mainly for:

- Increase green spaces, for various reasons such as the need for shading and increased biodiversity.
- For water management, as it is a key element in this location (Amsterdam).

The following BMS are proposed to improve the thermal comfort of the *Openbare Basisschool Het Vogelnest* (*Public Elementary School Het Vogelnest*): mBiGCUVE green roof, two mBiGFAC green facades, a mBiGPond pond and a mBiG-SUVE permeable pavement arranged around the east courtyard to create shaded spaces. Figure 8 shows the distribution of the solutions in the school.

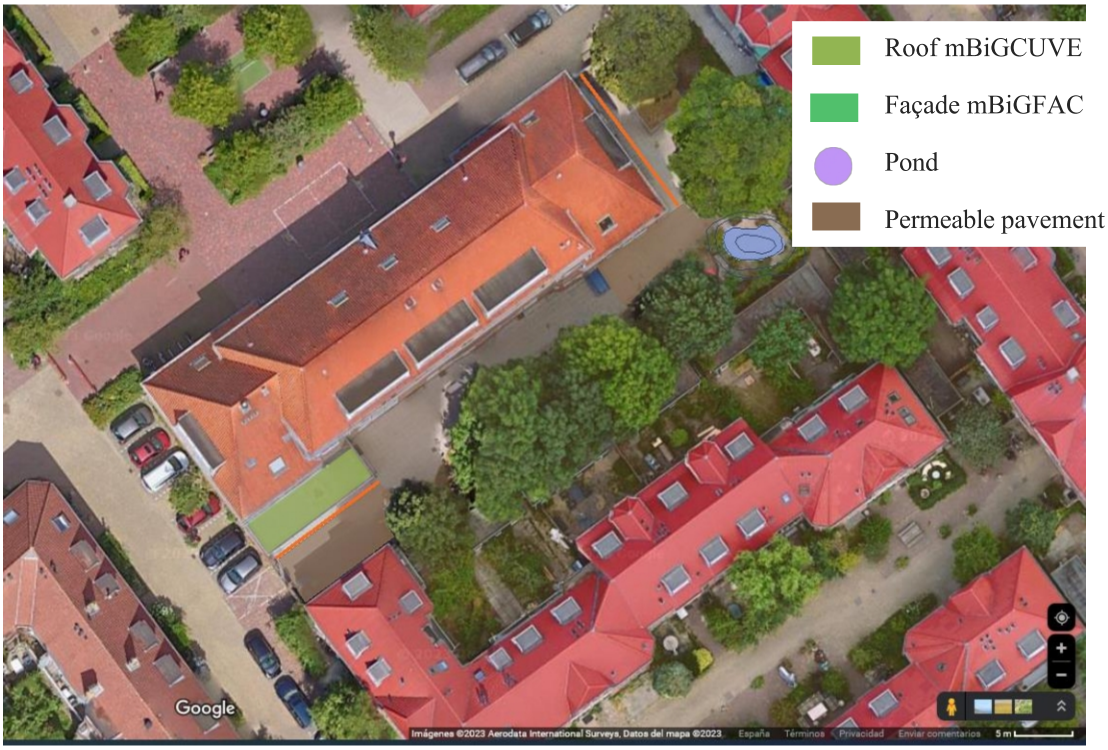


Illustration 1. General plan of SBN implementation at Public Elementary School Het Vogelnest

Green cover - type mBiGCUVE
Installation of an mBiGCUVE green roof on the main building, covering an **area of 37 m².**
Type of vegetation: *Sedum* genus, within which we highlight the following species: *Sedum acre, Sedum álbum, Sedum floriferum, Sedum reflexum, Sedum sexangulare, Sedum spurium.*
Impact: this type of solution mainly improves the thermal discharge of the building (9.1%).

Green facade - type mBiGFAC
Installation of two mBiGFAC green facades on the main building, covering a total **area of 77 m².**
Vegetation type: *Parthenocissus tricuspidata "Veitchii".*
Impact: this type of solution mainly favors protection against external winds (9.9%).

Permeable pavement - type mBiG_SUVE

Installation of a permeable pavement, covering an **area of 102 ^{m2}**.

Vegetation type: *Lolium perenne, 10% Poa pratensis, 10% Agrostis spp, 70% Festuca spp.*

Impact: this type of solution mainly favors solar gain (9.1%).

Pond - type mBiGPond

Installation of a permeable pavement, covering an **area of 20 ^{m2}**.

Vegetation type: *Iris pseudacorus*, *Nymphaea alba*, *Alisma lanceolatum*, *Potamogeton nodosus*, *Parthenocissus tricuspidata*.

Impact: this type of solution mainly favors solar gain (9.1%).

Budget estimate

With the proposed interventions and using as a reference the costs associated with each SbN listed in Annex 1, this approximate budget for the interventions has been prepared. It should be borne in mind that this is an estimate and that the budget should be adjusted once the complete project has been sized.

Table 1. Budget estimate for proposed interventions

Intervention	***Cost ($^{€/m2}$)***	***Surface area (^{m2})***	***Estimated budget***
mBiGCUVE	175,79 €	37	6.504,35 €
mBiGFAC	88,59 €	77	6.821,59 €
mBiG_SUVE	54,29 €	102	5.537,91 €
mBiGPond	367,55 €	20	7.351,09 €
Total			**26.214,94 €**

Impact

Through the implementation of the proposed BMS, a series of environmental, social and user welfare benefits are provided. The following indicators are positively impacted: building interior temperature, building envelope temperature, building exterior environmental conditions, energy savings, water consumption, building management, and building management.

rainwater harvesting, plant and animal biodiversity, noise reduction levels from outside, energy efficiency measures, increase in green space, citizens' perception of urban nature.

Specifically, the following table shows the impact related to the green area indicator. The green area increases by 7% and the permeable area by 9%.

Table 2. Green and permeable surface before and after SBN installation

	Surface area (m)^2	Percentage	Increase (%)
Total surface area	1621	-	-
Initial green area	610	38%	-
Final green area	723,3	45%	**7%**
Initial permeable surface	610	38%	-
Final permeable surface	748,4	46%	**9%**

6.2 <u>CEIP CERVANTES (ALBACETE, SPAIN)</u>

Climate risk zone 1: Southern Europe and Mediterranean basin Location:

C. Sta. Quiteria, 39 (municipality and province: Albacete, Autonomous Community of

Castilla-La Mancha) Some of the characteristics of this building are as follows:

- One of the facades (S) is exposed to the sun without any type of protection and faces the school playgrounds.
- The roofs are flat
- Part with a green area of 70m^2

The values obtained from the psychrometric diagram are:

2- Summer hole shading (8.9%)
3- Use of thermal inertia (not applicable)
4- Thermal discharge of the building mass (7.2%)
5,6- Evaporative cooling systems (not applicable) 7-
Night ventilation (not applicable)
9- Management of internal loads: lighting, equipment, people, etc. (29.5%)
10,11- Solar collection (23.4%)
12- protection against external winds (not applicable)

According to this study, the building initially has a percentage of comfort hours in the climate of **13.9%.** After the implementation of the SbN, this percentage could increase to **38%**.

The SbNs selected for this case have been chosen mainly for:

- Increase green spaces, for various reasons such as the need for shading and solar gain, since temperatures in the hot months are very high.

The following SBN are proposed to improve the thermal comfort of the CEIP Cervantes school: mBiGCUVE green roof, mBiGCUVE-SUS green roof, mBiGFAC green façade. Figure 2 shows the distribution of the solutions in the school.

General plan of SBN implementation at CEIP Cervantes school (Albacete, Spain).

Green cover - type mBiGCUVE

Installation of an mBiGCUVE green roof on the main building, covering an **area of 359 ^{m2}**.

Type of vegetation: *Sedum* genus, within which we highlight the following species: *Sedum acre, Sedum album, Sedum floriferum, Sedum reflexum, Sedum sexangulare, Sedum spurium.*

Impact: this type of solution mainly improves the thermal discharge of the building (7.2%).

Green cover - type mBiGCUVE-SUS

Installation of an mBiGCUVE-SUS green roof on the main building, **covering an area of 235 m2**.

The type of vegetation recommended is of the *Sedum* genus*, with the* following species: *Sedum album, Sedum acre, Sedum lydium, Sedum sexangulare, Sedum hispanicum, Sedum spurium, Sedum floriferum, Sedum kamschaticum, Sedum hybridum and Sedum reflexu.*

Impact: this type of solution mainly improves the thermal discharge of the building (7.2%).

Green facade - mBiGFAC

Installation of the mBiGFAC system on the south façade, protecting the openings of one of the main and most unprotected façades. It covers a length of 20 m and 7 m and a total **plant shading** area **of 201** ^{m2}.

Vegetation type: *Parthenocissus tricuspidata "Veitchii".*

Impact: this type of solution mainly favors solar gain (23.4%).

Ventilation protocol

It is proposed to install two windows on opposite facades, preferably north/south or in the direction of the prevailing winds at night during the summer season. Standard windows with motorized tilt-and-turn sashes and two additional sliding sashes are included.

Installation of motorized casement windows: **7 windows on the SW façade** and **4 windows on the NE façade** to create cross ventilation.

The implementation of a night ventilation protocol in the school's classrooms favors cooling in an efficient way to improve the thermal environment in the buildings and reduce indoor temperatures. During the night, the accumulated heat is conducted to the outside through the open windows.

Budget estimate

With the proposed interventions and using as a reference the costs associated with each SbN listed in Annex 1, this approximate budget for the interventions has been prepared.

Keep in mind that this is an estimate and that the budget should be adjusted once the complete project has been sized.

Table 3. Budget estimate for proposed interventions

Intervention	***Cost*** ***(€/m2)***	***Surface area*** ***(m2)***	***Estimated budget***
mBiGCUVE / mBiGCUVE-SUS	175,79	594	104.421,16 €
mBiGFAC	88,59	201	17.807,01 €
Windows	2.862,04	11	31.482,39 €
Total			**153.710,56 €**

Impact

Through the implementation of the proposed BMS, a series of environmental, social and user welfare benefits are provided. The following indicators are positively impacted: building interior temperature, building envelope temperature, building exterior environmental conditions, energy savings, water consumption, rainwater management, plant and animal biodiversity, noise reduction levels from the exterior, energy efficiency measures, increased green space, citizens' perception of urban nature.

Specifically, the following table shows the impact related to the green area indicator. The green area increases by 67% and the permeable area by 60%.

Table 4. Green and permeable surface before and after SBN installation

	Surface area (m)^2	Percentage	Increase (%)
Total surface area	996	-	-
Initial green area	594	60 %	-
Final green area	865	87%	**80%**
Permeable surface initial	70	7%	**-**
Final permeable surface	664	67 %	**60 %**

6.3 ESCOLA BÁSICA DE 1º CEB DE RIO DE MOINHOS (ABRANTES, PORTUGAL)

Climate risk zone 1: Southern Europe and Mediterranean basin

Location: R. of Estremoz (municipality: Abrantes, Intermunicipal Community: Médio Tejo, District: Santarém).

Some of the features to highlight of this building are:

- All facades are exposed to the sun without any type of protection.
- The roofs are pitched and tiled.
- Part with a green area of 666m^2

The values obtained from the psychrometric diagram are:

2- Shading of hollows in summer (7.0%)
3- Use of thermal inertia (not applicable)
4- Thermal discharge of the building mass (2.2%)
5,6- Evaporative cooling systems (not applicable) 7-
Night ventilation (not applicable)
9- Management of internal loads: lighting, equipment, people, etc. (45.3%)
10,11- Solar collection (21.4%)
12- protection against external winds (not applicable)

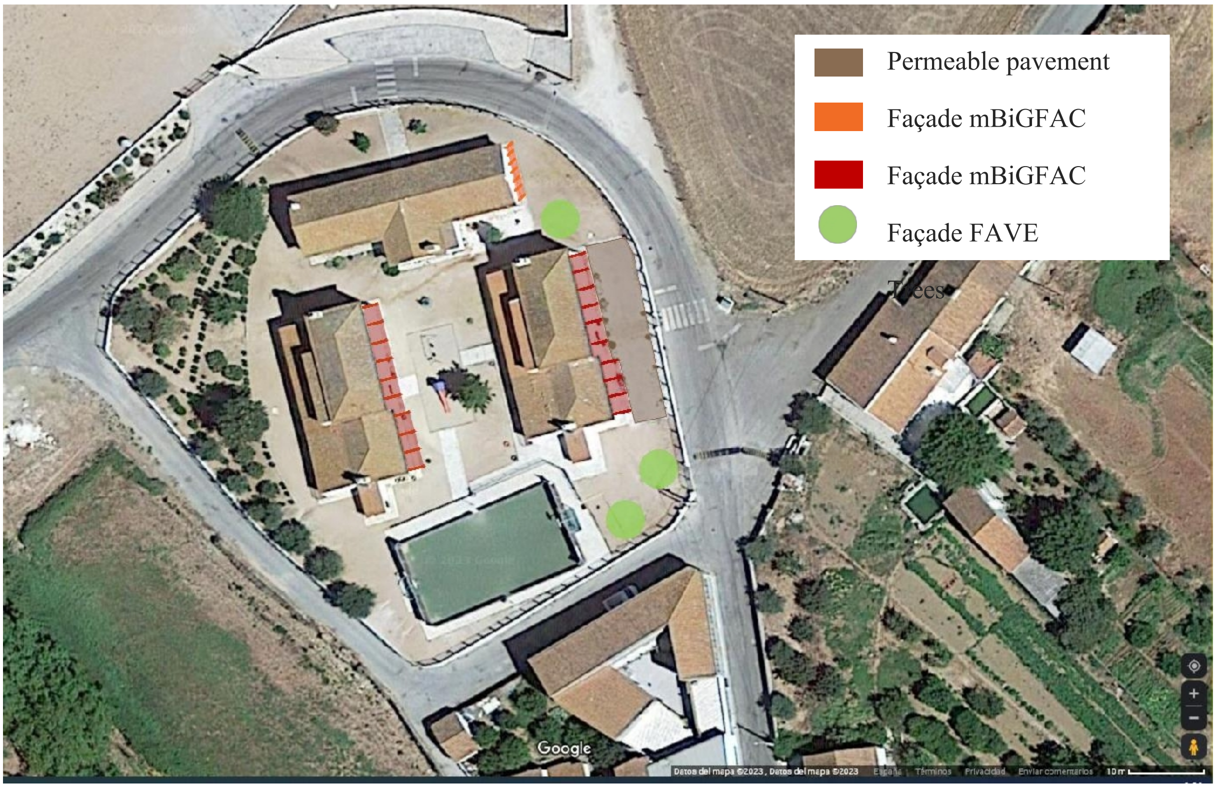
According to this study, the building initially has a percentage of comfort hours in the climate of **13.5%**. After the implementation of the SbN, this percentage could increase to **72%**.

The SbNs selected for this case have been chosen mainly for:

- Increase green spaces, for various reasons such as the need for shading and solar gain.

- Manage rainwater.

The following BNS are proposed to improve the thermal comfort of the Escola Básica de 1º CEB De Rio de Moinhos school: a tree-lined façade, a mBiGFAC type façade, FAVE system and a permeable paving system. Figure 8 shows the distribution of the solutions in the school.



General plan of SBN implementation in Escola Básica de 1º CEB de Rio de Moinhos (Abrantes, PORTUGAL).

Green façade - type mBiGFAC

Installation of an mBiGFAC green façade on one of the buildings, covering an **area of 24 m²**.

Vegetation type: *Parthenocissus tricuspidata "Veitchii".*

Impact: this type of solution mainly favors the thermal discharge of the building mass (2.2%).

Green façade - FAVE type

Installation of FAVE system in both buildings, covering an **area of 351 m²**.

Type of vegetation: *Virgin Vine Parthenocissus Quinquefolia, Parthenocissus Tricuspidata, Lonicera, Clematis or Clematis, Aquebia or Akebia, Trachelospermun Jasminoides.*

Impact: this type of solution favors the thermal discharge of the building mass (2.2%).

Permeable pavement - type mBiG_SUVE

Installation of a permeable mBiG_SUVE pavement on the east side of the school, covering an **area of 144 ^{m2}**.

Vegetation type: *Lolium perenne*, 10% *Poa pratensis*, 10% *Agrostis* spp, 70% *Festuca* spp.

Impact: this type of solution mainly favors solar gain (21.4%).

Trees

Three trees will be planted in the east courtyard, with more sunlight, to create a shaded area, with a surface area of 39 m².

Type of vegetation: *Quercus suber*.

Impact: this type of solution mainly favors solar gain (21.4%).

Budget estimate

With the proposed interventions and using as a reference the costs associated with each SbN listed in Annex 1, this approximate budget for the interventions has been prepared. It should be borne in mind that this is an estimate and that the budget should be adjusted once the complete project has been sized.

Table 5. Budget estimate for proposed interventions

Intervention	***Cost (€/m2)***	***Surface area (m2)***	***Estimated budget***
mBiGFAC	88,59 €	24	2.126,21 €
FAVE	105,51 €	351	37.033,89 €
mBiG_SUVE	54,29 €	144	7.818,22 €
Trees	400,00 €	3	1.200,00
Total			**48.178,32 €**

Impact

Through the implementation of the proposed BMS, a series of environmental, social and user welfare benefits are provided. The following indicators are positively impacted: building interior temperature, building envelope temperature, building exterior environmental conditions, energy savings, water consumption, rainwater management, plant and animal biodiversity, noise reduction levels from the exterior, energy efficiency measures, increased green space, citizens' perception of urban nature.

Specifically, the following table shows the impact related to the green area indicator. The green area increases by 9% and the permeable area by 4%.

Green and permeable surface before and after SbN installation.

	Surface area (m)^2	Percentage	Increase (%)
Total surface area	4526	-	-
Initial green area	832	18 %	-
Final green area	1080	24%	**9%**
Initial permeable surface	666	15 %	**-**
Final permeable surface	849	19 %	**4%**

6.4 SCUOLA MEDIA STATALE MASSARI GALILEI (BARI, ITALY)

Climate risk zone 1: Southern Europe and Mediterranean basin

Location: Via Daniele Petrera, 80 (municipality: Bari, region: Apulia) Some

of the features to highlight of this building are:

- One of the facades (E) is exposed to the sun without any type of protection, unlike the rest of the building, which is shaded by trees.
- The roofs are flat and one of the buildings has solar panels already installed.
- Part with a green area of 515m^2

The values obtained from the psychrometric diagram are:

2- Shading of hollows in summer (8.1%)
3- Use of thermal inertia (not applicable)
4- Thermal discharge of the building mass (2.2%)
5.6- Evaporative cooling systems (2.4%) 7- Night ventilation (not applicable)
9- Management of internal loads: lighting, equipment, people, etc. (32.8%)
10,11- Solar collection (12.7%)
12- protection against external winds (1.1%)

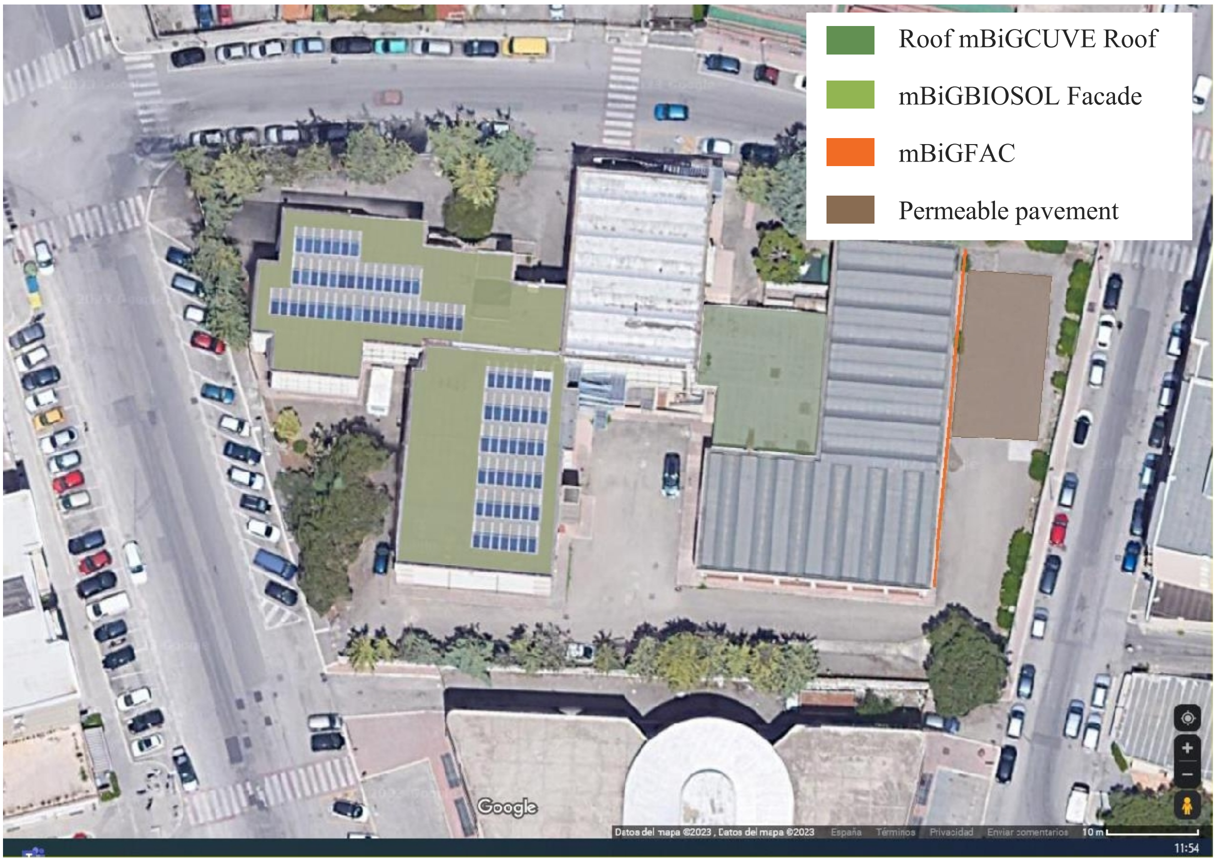
According to this study, the building initially has a percentage of comfort hours in the climate of **16.9%**. After the implementation of the SbN, this percentage could increase to **63%**.

The SbNs selected for this case have been chosen mainly for:

- Increase green spaces, for various reasons such as the need for shading and increased biodiversity.

- For water management.

The following SbN are proposed to improve the thermal comfort of the Scuola Media Statale Massari Galile school: mBiGCUVE green roof, mBiGBIOSOL green roof, mBiGFAC green façade and mBIG-SUVE pavement, arranged around the main buildings and in the eastern part of the school to create shaded spaces. The following illustration shows the distribution of the solutions in the school.



General plan of SbN implementation at Scuola Media Statale Massari Galilei (Bari, ITALY).

Green cover - type mBiGCUVE

Installation of an mBiGCUVE green roof on the main building, covering an **area of 70 ^{m2}**.

Type of vegetation: *Sedum* genus, within which we highlight the following species: *Sedum acre, Sedum álbum, Sedum floriferum, Sedum reflexum, Sedum sexangulare, Sedum spurium.*

Impact: this type of solution mainly favors the thermal discharge of the building mass (2.2%).

Green cover - type mBiGBIOSOL

Installation of an mBiGCUVE green roof on the main building, covering an **area of 832 ^{m2}**.

Type of vegetation: *Sedum* genus, within which we highlight the following species: *Sedum acre, Sedum álbum, Sedum floriferum, Sedum reflexum, Sedum sexangulare, Sedum spurium.*

Impact: this type of solution mainly favors the thermal discharge of the building mass (2.2%).

Green façade - type mBiGFAC

Installation of an mBiGCUVE green roof on the main building, covering an **area of 208 ^{m2}**.

Vegetation type: *Parthenocissus tricuspidata "Veitchii".*

Impact: this type of solution mainly favors the thermal discharge of the building mass (2.2%).

Permeable pavement - type mBiG-SUVE

Installation of an mBiGCUVE green roof on the main building, covering an **area of 167 ^{m2}**.

Vegetation type: *Lolium perenne, 10% Poa pratensis, 10% Agrostis spp, 70% Festuca spp.*

Impact: this type of solution mainly favors solar gain Ç (12.7%).

Budget estimate

With the proposed interventions and using as a reference the costs associated with each SbN listed in Annex 1, this approximate budget for the interventions has been prepared. It should be borne in mind that this is an estimate and that the budget should be adjusted once the complete project has been sized.

Table 7. Budget estimate for proposed interventions

Intervention	***Cost** (€/m2)*	***Surface area** (m2)*	***Estimated budget***
mBiGCUVE	175,79 €	70	12.305,52 €
mBiGBIOSOL	301,83 €	832	251.124,33 €
mBiGFAC	88,59 €	208	18.427,16 €
mBiGSUVE	54,29 €	167	9.066,96 €
Total			**290.923,97 €**

Impact

Through the implementation of the proposed BMS, a series of environmental, social and user welfare benefits are provided. The following indicators are positively impacted: building interior temperature, building envelope temperature, building exterior environmental conditions, energy savings, water consumption, rainwater management, plant and animal biodiversity, noise reduction levels from the exterior, energy efficiency measures, increased green space, citizens' perception of urban nature.

Specifically, the following table shows the impact related to the green area indicator. The green area increases by 21% and the permeable area by 21%.

Table 8. Green and permeable surface before and after SbN installation.

	Surface area (m)^2	Percentage	Increase (%)
Total surface area	5192	-	-
Initial green area	515	10 %	-
Final green area	1625	31%	**21%**
Initial permeable surface	515	10 %	**-**
Final permeable surface	1584	31 %	**21 %**

7. SUMMARY AND CONCLUSIONS

Climate change is one of the greatest challenges facing our planet and, as such, it is necessary to act quickly to minimize its negative effects. In this context, European schools in general, and in the Mediterranean basin in particular, have a major challenge to be renovated, we recommend with nature-based solutions, to ensure the health and well-being of the people who use them. These solutions include, for example, the installation of green roofs, vertical gardens or plant structures for shading to reduce temperature and improve air quality or rainwater harvesting for use in irrigation systems.

However, the approach of this type of renovations that many schools and other types of buildings need to adapt to new scenarios, involves a series of investments and implementation of procedures that are preventing them from being carried out, despite the social demand. Either by the lack of budget availability or by the lack of willingness to face the necessary studies and works, this type of actions are being postponed and thus causing these buildings to suffer the effects of climate change and to have unsuitable conditions for teaching activities.

The LIFE myBUILDINGisGREEN project aims to carry out a series of prototype actions in three pilot schools and show the impact they have on the building and the environmental conditions inside the classrooms.

This deliverable presents 4 studies carried out in four schools in very different areas using SbN for their adaptation to climate change. The schools are the Public elementary school Het Vogelnest (Amsterdam, The Netherlands), the CEIP Cervantes (Albacete, Spain), the escola básica de 1º CEB de Rio de Moinhos (Abrantes, Portugal) and the scuola media statale Massari Galilei (Bari, Italy). For these schools, the proposed interventions have been summarized, a budget has been estimated and their impact has been estimated in order to facilitate the drafting of financial plans in case the competent authorities consider the necessary renovations.

As a general conclusion of this deliverable, it can be extracted in the first place, although already seen in previous studies of the Project, that the actions that can generate more impact on buildings are those aimed at protecting them from solar irradiation. Actions on roofs or facades, especially in climate risk zone 1: Southern Europe and the Mediterranean basin, reduce the maximum temperatures reached inside buildings. For this purpose, green roof solutions of different types depending on the type of roof and the functionalities they may have and the shading of the facade are the most appropriate.

In addition, creating shading solutions for patios with a greater presence of plants also has important benefits. On the other hand, the implementation of

Automated building ventilation through controlled window openings can significantly improve indoor conditions without requiring direct human intervention.

In relation to the necessary investments, the costs presented have been estimated based on the pilot projects carried out in the project. These costs may be subject to regional or national variations or due to the effect of external factors such as raw material markets, but they should serve to show the level of investment required and that they are not exorbitant amounts that cannot be afforded by the authorities that own or are responsible for the educational centers in relation to the impact they may produce.

Alternative measures such as the installation of air conditioning solutions in buildings using air conditioning equipment should be assessed using a broad evaluation framework and not only the value of the initial investment required.

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9. ANNEXES

Annex 1. Calculation bases for infrastructure cost estimates

This annex presents the approximate implementation costs for each of the Nature-Based Solutions that have been proposed in the different schools. Some of these solutions have not been used in the schools selected for this basic financial study. They are also presented as documentation that is thought to be useful when considering studies for retrofitting buildings, especially educational centers, with SbN for their adaptation to climate change.

These costs have been established based on the actual costs incurred in the implementations carried out in the project in the three demonstration schools: CEIP Gabriela Mistral in Solana de los Barros (Badajoz, SPAIN), EB1 Horta das Figueiras in Évora (Central Alentejo, PORTUGAL) and EB1 do Falcão in Porto (PORTUGAL).

To see the details of each of the solutions, please refer to the deliverables corresponding to the design of the SbNs proposed by the project and the implementation projects of the three pilot schools.

Facade solutions

mBiG FAVE Solution

Information gathered in the implementation project of the pilot construction project of the CEIP Gabriela Mistral school.

The cost presented includes the previous works for the adaptation of the façade and the realization of the foundations and supports for fixing the structure. Although in each case these previous works will have to be adjusted to the state of the facade and the circumstances of the building environment, it is assumed that the amounts required in the case of CEIP Gabriela Mistral (€ 50,876.78 base budget for 694 m^2 of implemented solution) will be similar to those of most of the buildings that consider similar solutions.

In this particular case a small piece was also added on the façade of a different prototype, mBiGToldo, which for this study has not been considered because this solution would only be recommended in very specific cases.

The cost of this solution used in this document is **€73.$^{28/m2}$** base and **$^{€105}$.51/m2** once the cost of general costs, industrial profit and VAT (21% in the case of Spain) are included.

mBiGFAC Solution

Information collected in the execution project of the construction project of the pilot of the EB1 do Falcão school. It is a façade covering with tensors and climbers.

The cost presented includes the previous works for the adaptation of the façade and the ground for the anchorages. It is assumed that the amounts required in the case of the EB1 do Falcão school (€8,859.21 base budget for 100m^2 of covered facade with this solution) will be similar to those of most of the buildings where similar solutions are proposed.

The cost of this solution used in this document is **€88.$^{59/m2}$** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.

Roofing solutions

mBiG CUVE solution

Information gathered in the implementation project of the pilot construction project of the CEIP Gabriela Mistral school.

The cost presented includes the previous works for the adaptation of the roof and access and protection systems on the roofs for their use. Although in each case these previous works will have to be adjusted to the state of the roofs and the circumstances of the building, whether the roofs can be walkable or not, it is assumed that the amounts required in the case of CEIP Gabriela Mistral (€ 52,497.45 base budget for 430 m^2 of roofs made) will be similar to those of most of the buildings that consider similar solutions. In this case, the roofs were flat and walkable. Half of the surface area was also adapted for use for educational purposes so that children could have access to them.

The cost of this solution used in this document is **€122.$^{09/m2}$** base and **$^{€175}$.79/m2** once the cost of general costs, industrial profit and VAT (21% in the case of Spain) are included.

mBiG Tray Solution

Information collected in the implementation project of the pilot construction project o f the EB1 Horta das Figueiras school.

The cost presented includes the work of fixing the trays to the roof. Although in each case these previous works will have to be adjusted to the state of the roofs and the circumstances of the building, whether the roofs can be walkable or not, it is assumed that the quantities required in the case of EB1 Horta das Figueiras will be similar to those of most of the buildings where similar solutions are proposed in similar roofs. In this case the roofs were flat, but not walkable.

The cost of this solution used in this document is **€132.$^{47/m2}$** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.

mBiGUL Solution

Information gathered in the implementation project of the pilot construction project of the EB1 do Falcão school.

The cost presented includes the previous works for the adaptation of the roof and access and protection systems on the roofs for their use. Although in each case these previous works will have to be adjusted to the state of the roofs and the circumstances of the building, whether the roofs can be walkable or not, it is assumed that the amounts required in the case of the EB1 do Falcão school (€53,464.92 base budget for 410 m^2 of roofs completed) will be similar to those of most buildings where similar solutions are considered. In this case the roofs were flat and walkable.

The cost of this solution used in this document is **€130.$^{40/m2}$** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.

mBiGSECAR Solution

Information gathered in the implementation project of the pilot construction project of the EB1 do Falcão school.

The presented cost includes the previous works of adaptation of the roof and access and protection systems on the roofs for its use. However, these amounts are important because it is a solution adapted to be placed on sloping roofs without major interventions. It is assumed that the quantities required in the case of school EB1 do

Falcão (€10,008.57 base budget for 50m^2 of roofs completed) will be similar to those of most buildings where similar solutions are proposed.

The cost of this solution used in this document is **€200.$^{17/m2}$** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.

mBiGBioSol Solution

Information gathered in the project for the implementation of the pilot construction project of the EB1 do Falcão school.

The presented cost includes the previous works of adaptation of the roof, the access and protection systems on the roofs for its use and the installation of the photovoltaic panels. However, these amounts are important because it is a solution adapted to be placed on sloping roofs without major interventions. It is assumed that the amounts required in the case of the school EB1 do Falcão (€ 69,421.39 base budget for 230m^2 of roofs made) will be similar to those of most buildings that consider similar solutions.

The cost of this solution used in this document is **€301.$^{83/m2}$** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.

Other solutions

mBiG PEVE solution

Information gathered in the execution project of the construction project of the pilot project of the CEIP Gabriela Mistral school. It is a pergola with vegetation for outdoor seasonal shading.

The cost presented includes the previous works for the realization of the foundations and supports for fixing the structure. Although in each case these previous works will have to be adjusted to the state of the corresponding location, it is assumed that the quantities required in the case of CEIP Gabriela Mistral will be similar to those of most of the buildings where similar solutions are proposed.

The cost of this solution used in this document is **€175.51/m2** base and **€252.71/m2** once the cost of general costs, industrial profit and VAT (21% in the case of Spain) are included.

mBiG SUVE Solution

Information collected in the execution project of the construction project of the pilot project of the CEIP Gabriela Mistral school. It is an exterior paving slab built with draining mortar and with space for the introduction of substrate and seeds.

The cost presented includes the preliminary works for the preparation of the land and the realization of the corresponding water drainage structures. Although in each case these previous works will have to be adjusted to the state of the corresponding location, it is assumed that the amounts required in the case of CEIP Gabriela Mistral will be similar to those of most of the buildings where similar solutions are proposed.

The cost of this solution used in this document is **€37.71/m2** base and **€54.29/m2** once the cost of general costs, industrial profit and VAT (21% in the case of Spain) are included.

mBiGPond solution

Information collected in the implementation project of the pilot construction project of the EB1 do Falcão school. This is an artificial pond to collect excess rainwater managed by the school's SBNs. It allows the creation of an aquatic space with great plant biodiversity that attracts a great diversity of plants.

The cost presented includes the previous land adaptation works. It is assumed that the amounts required in the case of the EB1 do Falcão school (€3,307.99 base budget for a pond of 9m^2 surface area) will be proportional to those of most of the interventions that propose similar solutions.

The cost of this solution used in this document is **€365.55/m2** final solution price. The cost has had to be updated slightly from the initial budget estimate because it was calculated prior to the pandemic. The cost would be increased for other general operations of this type of project, but would be included in the project total.