# 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: 4 reports of recommendations for expert meetings in Brussels

Date: 10/31/2023

**LIFE my building is green - LIFE17 CCA/ES/000088**

**Deliverable: 4 reports of recommendations for expert meetings in Brussels**

Date: **05/31/2023**

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# Index

# 1. SUMMARY EN ESPAÑOL

This document is part of action C5. "Mainstreaming and transferability at local, national and European level". It presents four reports of recommendations for implementing selected Nature- Based Solutions (NBS) in schools based on the climate and building context. These reports are based on the projects to implement NBS listed in deliverable C5.7. Design of 15 Nature-Based Solutions projects. Four schools from four different countries have been selected: Spain, Portugal, Italy and the Netherlands; to represent different contexts in terms of climate risk areas, type of challenges, solutions and budget.

Each report includes the general situation of the school and provides information on the climate and building situation of the school, taking into account the characteristics of the environment and site-specific conditions. The main challenges and related measures are also included. The main challenges faced by the school are identified and measures that can be implemented to effectively address them are described. The existing levels of green and permeable surfaces are also analyzed, considering their current state and their importance as a determining factor in the choice of the most appropriate NBS. This is followed by an evaluation and justification of the selection of each type of NBS, green roofs, green facades, permeable paving, ponds, trees and ventilation protocols. The needs and characteristics of the school are taken into account, such as the situation of the school's façades and roofs with respect to their orientation and the ease of implementing NBS.

# 1. ENGLISH SUMMARY

This document is part of action C5. "Integration and transferability at local, national and European level". It presents four reports of recommendations to implement selected Nature Based Solutions (NBS) in educational centers according to the climatic and constructive context. These reports are based on the projects to implement SbN collected in deliverable C5.7. *Design of 15 Nature-based Solutions projects.* Four schools from four different countries have been selected: Spain, Portugal, Italy and the Netherlands; to represent different contexts in terms of climate risk zones, type of challenges, solutions and budget.

Each report includes the general situation of the school and provides information on the climatic and constructive situation of the school, taking into account the characteristics of the environment and site-specific conditions. The main challenges and related measures are also included. The main challenges faced by the school are identified and measures that can be implemented to effectively address them are described. The existing levels of green and permeable surfaces are also analyzed, considering their current state and their importance as a determining factor in the choice of the most appropriate BSS. This is followed by an evaluation and justification of the selection of each type of SbN, green roofs, green facades, permeable pavements, ponds, trees and ventilation protocols. The needs and characteristics of the school are taken into account, as well as the situation of the school's facades and roofs with respect to their orientation and ease of implementing BSS.

## 2. RESUMO EM PORTUGUÊS

This document is part of action C5. "Integration and transferability at local, national and European level". It presents four reports of recommendations for the implementation of selected Nature-Based Solutions (NBS) in schools, based on climate and building context. These reports were based on the NBS implementation projects listed in deliverable C5.7. Conception of 15 Nature-Based Solutions projects. Four schools from four different countries were selected: Spain, Portugal, Italy and the Netherlands; to represent different contexts in terms of climate risk areas, type of challenges, solutions and budget.

Each report includes the general situation of the school and provides information on the climate and the situation of the school building, taking into account the characteristics of the environment and the specific conditions of the premises. The main challenges and related measures are also included. The main challenges faced by the school are identified and the measures that can be implemented to face them effectively are described. The existing levels of green and permeable surfaces are also analyzed, considering their current status and their importance as a determining factor in the choice of the most appropriate BNS. An evaluation and justification of the selection of each type of SbN, green coverings, green facades, permeable pavements, lakes, arbors and ventilation protocols follows. The needs and characteristics of the school are taken into account, as well as the location of the school's facades and roofs in relation to its orientation and the ease of implementation of the BNS.

# 3. INTRODUCTION

The objective of this deliverable is to encourage and support the implementation and replication of Nature-Based Solutions (NBS) projects in educational centers. To this end, a series of recommendations are elaborated to facilitate the process for stakeholders and support decision making. Four representative project examples are taken as a basis for deliverable C5.1. *Design of 15 Nature-Based Solutions projects*, covering different geographical, technical and economic characteristics. This document supports the selection of BDS in schools that want to adapt to the effects of climate change, reducing indoor temperatures and improving thermal comfort.

This document is organized in four reports, one for each school. The selection of schools covers different typologies of solutions, climate risk zones, challenges and budget to cover the diversity of situations and different contexts that may occur and to facilitate replication in other areas. Each report justifies the selection of SbNs for each school and provides information on the criteria used for the selection of solutions. These criteria are based on the analysis, the specific characteristics of each school, the opportunities and challenges. In this case, the strategies to be implemented are aimed at reducing indoor temperatures and consequently the cooling energy demand during the warm period.

The proposed solutions are based on the main categories of SbN: green roofs and facades, ventilation protocols and outdoor spaces such as green pavements, trees and ponds. For each typology, the elements that determine the suitability of one solution over another are taken into account.

- When it comes to the implementation of green roofs, it is important to consider the type and material of the existing roof, whether flat or pitched. For example, in this case, pitched roofs with tiles have not been considered as viable for the implementation of green roofs due to the technical difficulties and cost overruns involved. In turn, flat roofs are considered viable for the implementation of these solutions, promoting their accessibility by students. Their extension will depend largely on the available budget.
- Regarding the implementation of green facades, the most unfavorable facades have been taken into account due to their orientation, being the East and South the most unfavorable ones during the school period. It is also taken into account whether there are shading elements such as overhangs, buildings and vegetation nearby that provide solar protection to the facades.

- As for permeable pavements, the type of pavement and existing permeable surfaces are taken into account, as well as the need to improve water management, either due to flood risk or to reuse rainwater.
- When implementing trees, the absence of shading elements and the need to provide solar protection to the building or outdoor areas is taken into account.
- For the implementation of ponds/ponds, mainly high rainfall and the need to manage rainwater, avoiding flood risks, are taken into account.
- For the implementation of ventilation protocols to promote night cooling, it is necessary to take into account the orientation of the building, ensuring that ventilation openings are located in areas where they can capture cool air currents at night.

For each solution chosen, it is recommended to determine its characteristics and technical and economic specifications (see deliverable C2.4. *Technical Manuals for the implementation of NBS prototypes* and Annex 1. *mBiG NBS prototypes*), the type of suitable vegetation (see deliverable C2.1. *Guide for the choice of plant species adapted to climate change*).

Three schools in climate risk zone 1 - Southern Europe and Mediterranean basin: Spain, Portugal and Italy; and one school in climate risk zone 3 - Coastal areas, deltas and floodplains: The Netherlands. Furthermore, it has been taken into account that these four projects present a variability in terms of type of solutions and budget, ranging from low cost projects (26,214.94 € and 48,178.32 €), medium cost (153,710.56 €) to those of high cost (290,923.97 €).

# 4. REPORT 1 - OPENBARE BASISSCHOOL HET VOGELNEST (PUBLIC ELEMENTARY SCHOOL HET VOGELNEST)

## 4.1 General information

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|---|
| Location: **Amsterdam**, The Netherlands; Climate risk zone **3**; Budget: **26,214.94 €.** |
| Implemented green surface: **113.3 m²** ; Implemented permeable surface: **138.4 m²** |

Based on the bioclimatic analysis of the building in deliverable *C5.1 - Design of 15 NBS projects*, it is determined that the following passive strategies must be applied to increase thermal comfort: shading of openings in summer, use of thermal inertia, management of internal loads, solar gain and protection against external winds. According to this study, the building initially has a percentage of comfort hours in the climate of **3.4%.** After the implementation of the NbS, this percentage could increase to **39%**. Rainwater management in this area represents an additional challenge, since rainfall in this area is very abundant. Therefore, it is necessary to implement adequate measures to control excess rainwater and avoid problems such as flooding or soil erosion.

Next, the main building characteristics to be taken into account for implementing the NbS prototypes are evaluated:

The main facade of the building is the NW, which does not receive direct sunlight during school hours, so it is not subject to the implementation of green facades. The other main façade has a SE orientation and is protected by leafy vegetation. There are two blind walls on the SE and NE facades. The roofs of the building are pitched and tiled, which makes the implementation and cost of green roofs difficult, so they are not considered for installation on this type of roof. There is a small flat roof that can be the object of implementing green roofs and can also be accessible. On the other hand, the school has an average percentage of green surfaces and permeable surfaces (both 38%).

Therefore, the NBSs that are selected seek to meet the following objectives:
- Increase green spaces and permeable surfaces.
- Gap shading
- Protection against external winds
- Improving water management

## 4.2 Justification

For the public elementary school Het Vogelnest, Amsterdam (The Netherlands), the following BMS have been proposed: mBiGCUVE green roof, mBiGFAC green façade, permeable pavement and pond.

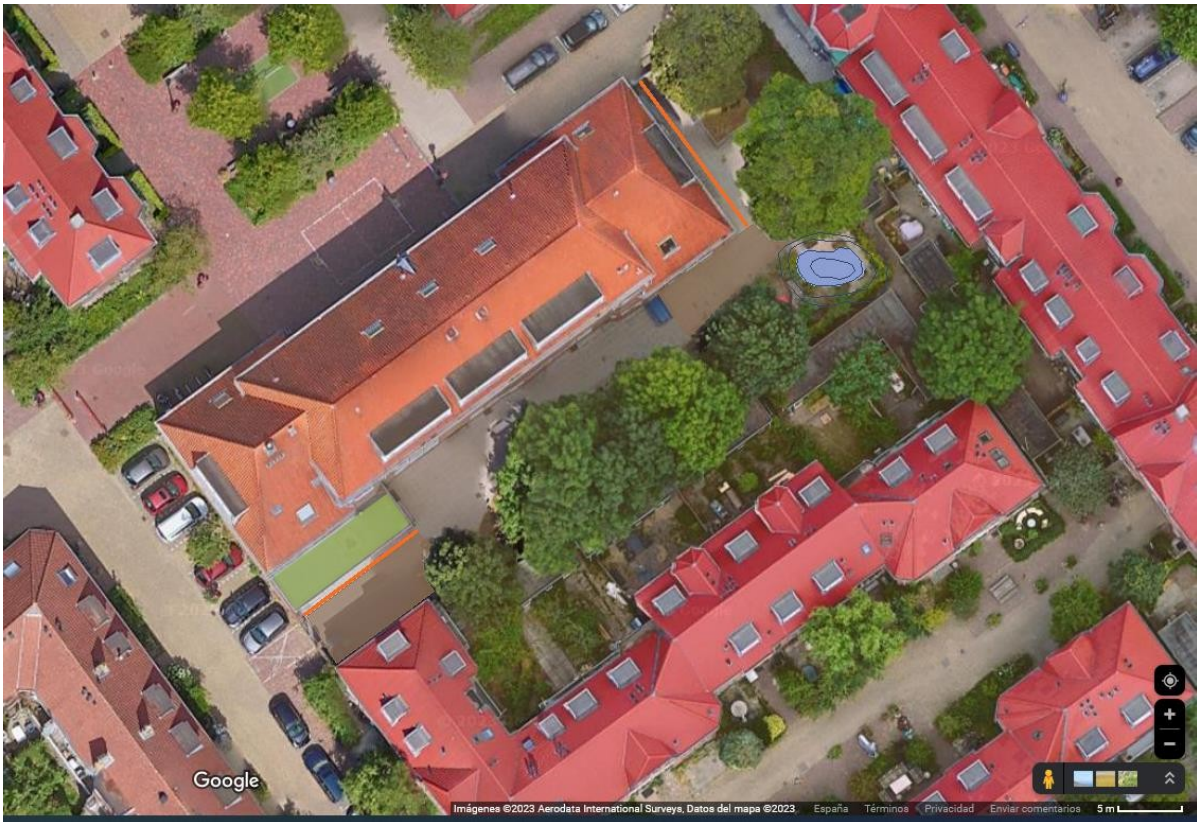


*Illustration 1. General plan of NBS implementation at Public Elementary School Het Vogelnest*

**Green roofs**

The main building has an inclined tile roof with skylights; these characteristics make it difficult to implement green roofs and increase the budget and maintenance costs. For this reason, the installation of green roofs in this part of the building is not proposed in this case.

In the case of the flat roof, an mBIGCUVE type roof is proposed, since in addition to increasing the green and permeable areas, it favors biodiversity and generates a new accessible green space. This prototype is easy to implement, modular and adaptable to the characteristics of the building. In roofs of this type, it is recommended to use vegetation of the *Sedum* genus.

However, it will be essential to carefully evaluate the most suitable species for each site based on their adaptation to the environment, water requirements and whether they are native species. In this way, it can be ensured that the green cover has a healthy and sustainable growth, and that its aesthetic and environmental benefits can be enjoyed in the long term.

**Green facades**

The main façade of the building (NW) does not require the implementation of a green façade for shading of openings, since it does not receive direct sunlight during the school period. The NE and SE facades are blind walls, so it is proposed to install the mBIGFAC system to provide a shading system to the facades that receive more solar radiation and protect against external winds.

This prototype, by means of a system of cables, supports the development of climbing plant species parallel to the facade and with the emergence of vegetation at ground level. In this type of facade the use of climbing vegetation is proposed, being essential to evaluate the most appropriate species depending on their adaptation to the environment, water requirements and if they are native species.

**Permeable pavement**

Part of the existing impermeable pavement was replaced with a permeable pavement to improve water management. The school is located in an area with high rainfall, so this system reduces some of the associated risks, such as surface runoff and the risk of flooding. It also reduces the need for stormwater drainage, reducing infrastructure and maintenance costs.
There are different types of permeable pavements. The use of one type or another will be recommended depending on the specific site conditions. In this case, a pavement with vegetated joints is recommended, since it is a pedestrian area and the pavement does not have to support heavy weight loads, allowing water to seep through the joints and contributing to biodiversity.

**Pond**

As in the case of permeable pavements, the implementation of a pond is proposed to improve water management in a context of high rainfall. It is implemented in one of the green areas of the school. It is recommended that it be at a low point in the ground in order to be able to channel rainwater into the pond. This prototype not only improves water management, it also favors biodiversity, as it plays an important role in the formation of small aquatic ecosystems. As for the type of vegetation, it is recommended to use riparian and wetland plants for a better adaptation to the environment, such as *Iris pseudacorus, Nymphaea alba, Alisma lanceolatum, Potamogeton nodosus, Parthenocissus tricuspidata.*

## 4.3 Conclusion

Thanks to the implementation of these solutions, green areas have increased by 7%, while permeable areas have increased by 9%. These advances make it possible to achieve adequate levels of permeable and green areas, almost half of the total (46%), with a low budget (€26,214.94).

# 5. REPORT 2 - CEIP CERVANTES (ALBACETE, SPAIN)

## 5.1 General information

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| Location: **Albacete**, Spain; Climate risk zone **1**; Budget: **153,710.56 €.** |
| Implemented green area: **795 m$^2$** ; Implemented permeable area: **594 m$^2$** |

Based on the bioclimatic analysis of the building in deliverable *C5.1 - Design of 15 NBS projects*, it is determined that the following passive strategies must be applied to increase thermal comfort: shading of openings in summer, thermal discharge of the building mass, management of internal loads and solar gain. According to this study, the building initially has a percentage of comfort hours in the climate of **13.9%.** After the implementation of the NbS, this percentage could increase to **38%**. The high temperatures in the spring and summer months in this area represent an additional challenge. Therefore, it is necessary to implement appropriate measures to control the temperature increase.

Next, the main building characteristics to be taken into account for implementing the NBS prototypes are evaluated:

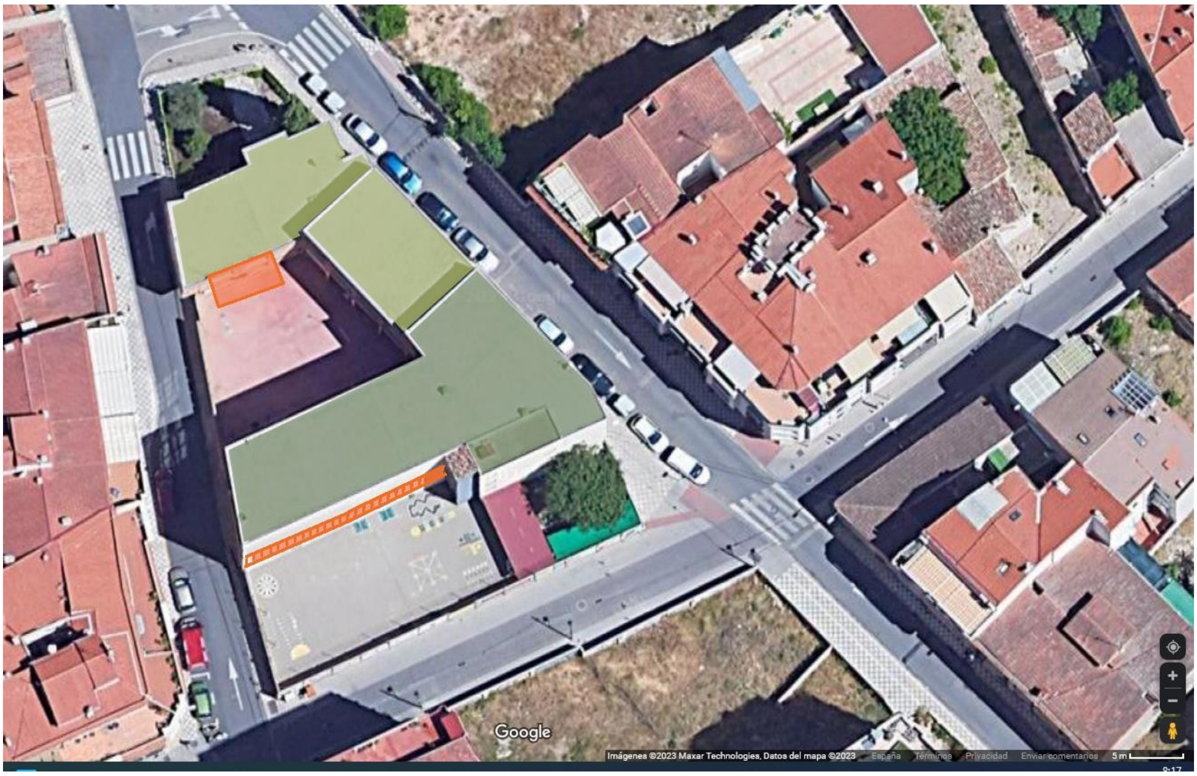
The N facade of the building includes the main entrance of the school, which has a landscaped area with large shrubs and trees. The other main façade has an E orientation, and is partially protected by another building located in front of it. The S façade, which houses the school playgrounds, is not protected at all, and therefore receives a high level of solar radiation. The O façade is well protected by another building located directly opposite with a height similar to that of the school. The roofs of the building are flat and at different heights, which facilitates the implementation of green roofs that are accessible from inside the building. On the other hand, the school has a very low percentage of green surfaces and permeable surfaces (both 7%).

Therefore, the NBSs that are selected seek to meet the following objectives:

- Increase green spaces and permeable surfaces.
- Improve indoor air quality
- Take advantage of night cooling
- Gap shading
- Thermal discharge of the building mass
- Solar collection

## 5.2 Justification

For the CEIP Cervantes school in Albacete (Spain), the following NBS have been proposed: mBiGCUVE and mBIGCUVE-SUS green roofs and mBiGFAC façade.




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

**Green roofs**

All the roofs of the building are flat, which facilitates the installation of different types of green roofs and the cost is lower. The different heights of the roofs make them accessible in case they are not, and they can be accessed from inside the center, increasing the accessibility of the students to green areas. Two types of roofs have been selected: the mBIGCUVE roof and the mBIGCUVE-SUS roof due to their easy adaptation to different types of roofs. In this case, the mBIGBIOSOL type roof, consisting of a green roof and solar panels, has not been selected due to the increased cost and the lack of a high energy cost.

In this case the roofs are proposed to increase the green and permeable areas, promote biodiversity and generate a new accessible green space. This prototype is easy to modular and adaptable to the characteristics of the building. In roofs of this type, it is recommended to use vegetation of the genus *Sedum* and varieties of perennials and herbaceous ground cover and small size. However, it will be essential to carefully evaluate the most suitable species for each site based on their adaptation to the environment, water requirements and whether they are native species. In this way, it can be guaranteed that the green cover will have a healthy and sustainable growth, and that its aesthetic and environmental benefits can be enjoyed in the long term.

**Green facades**

The main facade of the building (N, W and E) do not require the implementation of a green facade for shading of openings, since they do not receive direct radiation during the school period or are largely protected by the adjacent buildings. The two south-facing facades are the ones that receive direct insolation and do not have any type of solar protection, so they are chosen to implement the mBiGFAC green façade prototype to provide protection from solar radiation.

This prototype, by means of a system of cables, supports the development of climbing plant species parallel to the facade and with the emergence of vegetation at ground level. In this type of facade the use of climbing vegetation is proposed, being essential to evaluate the most appropriate species depending on their adaptation to the environment, water requirements and if they are native species.

**Ventilation protocol**

The application of a ventilation protocol through the implementation of monitored windows is recommended, both to improve indoor air quality and to take advantage of night cooling and reduce indoor temperatures during the night. For this purpose, two main and opposite facades are chosen to create cross ventilation. In this case, north and south facing facades are chosen.

## 5.3 Conclusion

Thanks to the implementation of these solutions, green areas experienced a high increase of 80%, while permeable areas increased by 60%. These advances make it possible to reach very high levels of green and permeable areas, exceeding half of the total (87% and 67% respectively). Despite starting from very low levels of green and permeable areas, with an average budget (153,710.56 €) a large increase in these surfaces is achieved with the implementation of SbN, which also has a significant impact on the reduction of temperatures.

# 6. REPORT 3- ESCOLA BÁSICA DE 1º CEB DE RIO DE MOINHOS (ABRANTES, PORTUGAL)

## 6.1 General information

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| Location: **Abrantes**, Portugal; Climate risk zone **1**; Budget: **48,178.32 €.** |
| Implemented green area: **414 m²** ; Implemented permeable area: **183 m²** |

Based on the bioclimatic analysis of the building in deliverable *C5.1 - Design of 15 NBS projects*, it is determined that the following passive strategies must be applied to increase thermal comfort: shading of openings in summer, thermal discharge of the building mass, management of internal loads and solar gain. According to this study, the building initially has a percentage of comfort hours in the climate of **13.5%.** After the implementation of the NbS, this percentage could increase to **72%**. The high temperatures in the spring and summer months in this area represent an additional challenge. Therefore, it is necessary to implement appropriate measures to control the temperature rise in the building.

Next, the main building characteristics to be taken into account for implementing the NBS prototypes are evaluated:

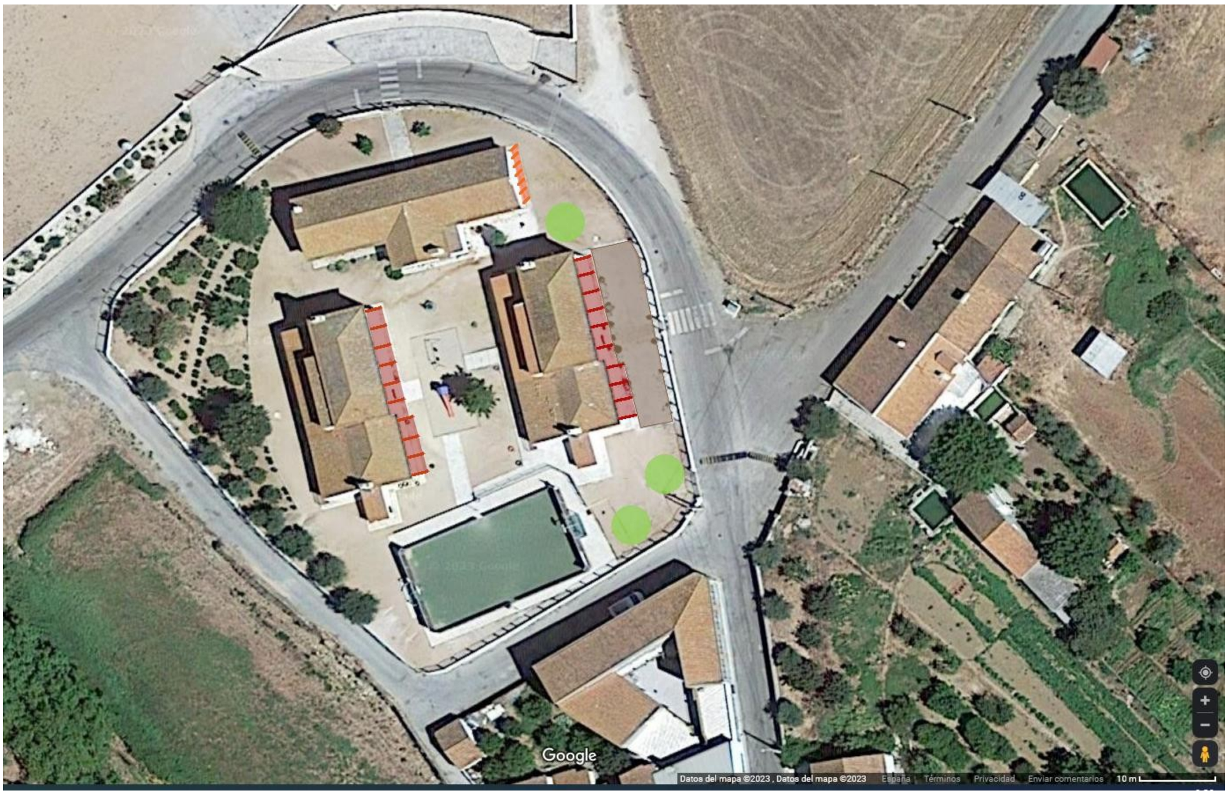
The educational center has 3 buildings. The first building, located further north, has the main façade facing north and without any type of solar protection, as well as the south façade. The west and west facades are blind walls. The second and third buildings, located further east and west, have similar characteristics, with the main façade facing east and without solar protection, while the north and south walls are blind. The third building has a wooded area with shrubs and an orchard on the west façade. The roofs of the building are pitched and tiled, which makes it difficult to implement green roofs. On the other hand, the school has an average percentage of green surfaces and permeable surfaces (both **33%**).

Therefore, the NBSs that are selected seek to meet the following objectives:

- Increase green spaces and permeable surfaces.
- Gap shading
- Thermal discharge of the building mass
- Solar collection
- Water management

## 6.2 Justification

For the school Escola básica de 1º ceb de rio de moinhos de abrantes (Portugal), the following NBS have been proposed: mBiGFAC and mBIGFAVE green facades, mBiGSUVE permeable pavement and trees.




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

**Green facades**

The main facades of the second and third building, facing east, are the most suitable for implementing a green facade that provides shading of openings, since they receive direct sunlight during the school period and have a high percentage of glazed openings. It is proposed to implement the FAVE system, adapted to the heights of the building. This prototype is recommended because it is modular, dismountable and adaptable to any building. It is a light and modular substructure that supports different vegetation solutions, separated from the façade and anchored to the façade at the floor slab level to facilitate its adaptation to any building. The vegetation is climbing and deciduous, to facilitate the passage of solar radiation in winter and prevent it in summer.

In the case of the first building, the implementation of the mBIGFAC system is proposed to protect the blind wall of the east façade, which does not have any type of solar protection. In this type of façade, the use of climbing vegetation is proposed, being essential to evaluate the most appropriate species according to its adaptation to the environment, water requirements and if they are native species.

It was decided not to intervene on the north façade of the buildings, since it does not receive direct solar radiation during the year, and on the west façade since it does not receive radiation during the school period and is protected by green areas.

**Permeable pavement**

It was decided to replace part of the existing impermeable pavement with a permeable pavement to improve water management. The school is located in an area with moderate rainfall, but with a risk of flooding and surface runoff and soil erosion. The permeable pavement solution reduces these risks along with reducing the cost of rainwater management infrastructure and maintenance.
There are different types of permeable pavements. The use of one type or another will be recommended depending on the specific site conditions. In this case, a pavement with vegetated joints is recommended, since it is a pedestrian area and the pavement does not have to support heavy weight loads, allowing water to seep through the joints and contributing to biodiversity.

**Trees**

The east exterior area of the school does not have any type of vegetation shading. Therefore, it is proposed to implement 3 large trees in this outdoor area. The selected species was Quercus suber, but depending on the area, taking into account temperatures and rainfall, different species will be selected, especially native species that are best adapted.

## 5.3 Conclusion

Thanks to the implementation of these solutions, green areas have increased by 9%, while permeable areas have increased by 4%. These advances make it possible to improve the levels of green and permeable surfaces (24% and 19% respectively) with a low budget (48,178.32 €). Although higher levels of permeable and green surfaces are not achieved mainly due to the lack of implementation of green roofs, green facades have a significant impact on reducing indoor temperatures, despite not generating a significant increase in green areas.

# 7. REPORT 4- SCUOLA MEDIA STATALE MASSARI GALILEI (BARI, ITALY)

## 7.1 General information

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| Location: **Bari**, Italy; Climate risk zone **1**; Budget: **290,923.97 €.** |
| Implemented green area: **1110 m²** ; Implemented permeable area: **1069 m²** |

Based on the bioclimatic analysis of the building in deliverable *C5.1 - Design of 15 NBS projects*, it is determined that the following passive strategies must be applied to increase thermal comfort: shading of openings in summer, thermal discharge of the building mass, evaporative cooling system, management of internal loads, solar gain and protection against external winds. According to this study, the building initially has a percentage of comfort hours in the climate of **16.9%.** After the implementation of the NbS, this percentage could increase to **63%**. The high temperatures in the spring and summer months in this area represent an additional challenge. Therefore, it is necessary to implement adequate measures to control the temperature rise in the building.

Next, the main building characteristics to be taken into account for implementing the NBS prototypes are evaluated:

The N façade of the building includes the main entrance of the school, which is well protected by large trees. The E façade has an auxiliary building, is a partially blind wall and is fully exposed to radiation. The S façade has some trees, so it is partially protected from radiation. The O façade is very well protected by large trees. The roofs of the building are flat and some of them have solar panels already installed, which facilitates the implementation of green roofs. On the other hand, the school has an average percentage of green surfaces and permeable surfaces (both **20%**).

Therefore, the NBSs that are selected seek to meet the following objectives:
- Increase green spaces and permeable surfaces.
- Gap shading
- Thermal discharge of the building mass
- Solar collection
- Water management

## 7.2 Justification

For the Scuola media statale massari galilei school in Bari (Italy), the following NBS have been proposed: mBIGCUVE and mBIGBIOSOL green roofs, mBiGFAC green façade and mBiG-SUVE permeable pavement.


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

### Green roofs

All roofs are flat, which facilitates the installation of green roofs both technically and economically. Two types of roofs have been selected: the mBiGCUVE and the mBIGBIOSOL. The mBIGBIOSOL type roof has been chosen, which combines a green roof with solar panels, since the building already has solar panels installed, so it is only necessary to associate them with the green roof to create this integrated system. On the other hand, the mBiGCUVE roof is easily adaptable and easy to install on different types of roofs and surfaces.

In this case, the roofs are proposed to increase green and permeable areas, promote biodiversity and generate a new accessible green space. These prototypes are easy to implement, modular and adaptable to the characteristics of the building. In roofs of this type, it is recommended to use vegetation of the *Sedum* genus. However, it will be essential to carefully evaluate the most appropriate species for each location based on their adaptation to the environment, water requirements and whether they are native species. In this way, it can be guaranteed that the green roof will have a healthy and sustainable growth, and that its aesthetic and environmental benefits can be enjoyed in the long term.

**Green facades**

The east façade is the façade that is most exposed to direct solar radiation during the school period and that does not have any type of solar protection. Therefore, the installation of the mBIGFAC green façade is recommended to protect the façade.

This prototype of type mBIGFAC, by means of a system of cables supports the development of climbing plant species parallel to the facade and with the birth of the vegetation at ground level. In this type of facade the use of climbing vegetation is proposed, being essential to evaluate the most appropriate species depending on their adaptation to the environment, water requirements and if they are native species.

**Permeable pavement**

It was decided to replace part of the existing impermeable pavement with a permeable pavement to improve water management. The school is located in an area with moderate rainfall, but with a risk of flooding and surface runoff and soil erosion. The permeable pavement solution reduces these risks along with reducing the cost of rainwater management infrastructure and maintenance.
There are different types of permeable pavements. The use of one type or another will be recommended depending on the specific site conditions. In this case, a pavement with vegetated joints is recommended, since it is a pedestrian area and the pavement does not have to support heavy weight loads, allowing water to seep through the joints and contributing to biodiversity.

## 7.3 Conclusion

Thanks to the implementation of these solutions, both green and permeable areas have increased by 21%. These advances make it possible to improve the levels of green and permeable surfaces (31%) with a high budget (290,923.97 €). These improvements also have a significant impact on reducing temperatures.

## 8. BIBLIOGRAPHY .

Deliverable C2.1. Guide for the selection of plant species adapted to climate change Deliverable

C5.1. Design of 15 NBS projects.

Deliverable C2.4. Technical manuals for the implementation of NBS prototypes.

Annex 1. mBiG NBS prototypes. Deliverable A2. Elaboration of NBS Databases and Working Matrix.