LIFE my building is green

LIFE17 ENV/ES/000088

Application of Nature-Based Solutions for local adaptation to climate change in educational and social buildings

Action: E3. Knowledge transfer of NBS as climate adaptation solutions.

Deliverable: E3) Report on contents and results transferred to Climate-Adapt.

Date: 29/02/2024

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Report of content uploaded to Climate-ADAPT.

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1. SUMMARY

This document is part of action *E3. "Knowledge Transfer of NBS as Climate Adaptation Solutions"*.

Although this action has no funds of its own earmarked for its implementation, the project team considered it relevant to dedicate a full action with specific tasks for knowledge transfer from the LIFE-myBUILDINGisGREEN project to the Climate Adaptation Platform "***Climate-ADAPT***".

Climate-ADAPT aims to support Europe in adapting to climate change helping users to access and share data and information on various aspects, such as the publication of adaptation case studies and potential adaptation options. It is the reference platform at European level on information related to climate change adaptation from different perspectives. Therefore, it was considered relevant to dedicate action E3 separately to connect with Climate-ADAPT.

From the early stages of the project, efforts were made to realise a real-time connection between LIFE-myBUILDINGisGREEN and Climate-ADAPT, but this was not possible in practice. However, useful content on the project was produced and published on the European platform and a section was created on the LIFE-myBUILDINGisGREEN website on Climate Adaptation Knowledge Platforms with which the project interacted, such as Climate-ADAPT. In addition, the groundwork was laid to continue updating the project information in the future as more conclusive results are achieved.

This document describes how the connection between the LIFE-myBUILDINGisGREEN project and the Climate-ADAPT Platform has been structured, showing the section of the website where this connection is made visible. Furthermore, it includes the content of the case study carried out by LIFE-myBUILDINGisGREEN in the Gabriela Mistral school, pilot building in Solana de los Barros (Badajoz, Spain) and the future case studies of the pilot buildings in Portugal, which are intended to be published in Climate-ADAPT at the end of the After-LIFE period.

2. INTRODUCTION

Brief presentation of the project

The LIFE-myBUILDINGisGREEN project is a project developed by a group of partners from the Iberian Peninsula, co-funded by the LIFE Programme of the European Union, and whose objective is the design, development and testing of innovative Nature-Based Solutions (NBS prototypes) to improve the bioclimatic comfort of educational buildings that allow the improvement of the well-being of the users of these buildings.

The project consortium is led by the Spanish National Research Council (CSIC) through the Royal Botanical Garden (RJB-CSIC) and the technical support of the Eduardo Torroja Institute for construction sciences (IETcc-CSIC). The beneficiary partners are the CARTIF technology centre, the Provincial Council of Badajoz, the Intermunicipal Community of Central Alentejo (CIMAC) and the Municipality of Oporto.

For the implementation of the Nature-Based Solutions (hereafter NBS), three pilot buildings have been selected in the framework of Action A1 of the project, which are pre-schools and primary schools located in Solana de los Barros (Badajoz, Spain), Évora (Portugal) and Porto (Portugal).

This project arises to address one of the effects of climate change that has intensified in recent years due to the consecutive heat waves experienced throughout Europe, but with more adverse effects in the southern region of the continent. As a result, education and social care centres in southern Europe experience indoor temperatures above 32°C for several months of the year, making it very difficult to live in these buildings.

To this end, the project will implement the mentioned NBS in different parts of these buildings, such as roofs, facades or outdoor spaces, with a view to improving air quality and bioclimatic comfort both inside and outside the buildings, as well as soil permeability.

The development of the project will achieve a series of environmental, social, economic and governance results aimed at improving the adaptation of cities to climate change. Among the results related to the scope of this deliverable, the following stand out:

- Installation of 19 NBS in the 3 pilot buildings in Spain and Portugal;
- Reduction of at least 4°C inside buildings and improvement of the well-being of the users of these buildings;
- Reduction of energy consumption for cooling and water consumption for irrigation;
- Reduced emissions of carbon dioxide (CO_2) and nitrogen oxides (NOx);
- Citizen empowerment for the use of NBS as a way to adapt to climate change;
- Development of good practice manuals for the application of NBS as tools for adaptation to climate change.

3. KNOWLEDGE PLATFORMS ON CLIMATE ADAPTATION

In the framework of communication and dissemination actions, LIFE-myBUILDINGisGREEN committed to publish information about the project and its results on various thematic knowledge platforms at European, national and regional level.

The publication of the learning from LIFE-myBUILDINGisGREEN on a wide range of thematic platforms allows to amplify the impact of the project's communication, making it known to wide audiences, avoiding duplication of efforts and facilitating the transferability of the actions carried out.

On the project's website, a section has been created where all the information shared and the collaborations carried out with the thematic platforms identified are channelled. In some cases, we have already managed to publish useful information about the project, in others, we continue to work on their publication as we continue to obtain results. For more information on these platforms, please visit: https://life-mybuildingisgreen.eu/en/knowledge-platforms-on-climate-adaptation/

4. EUROPEAN CLIMATE ADAPTATION PLATFORM, CLIMATE-ADAPT

Climate-ADAPT aims to support Europe in adapting to climate change helping users to access and share data and information on various aspects, such as the publication of adaptation case studies and potential adaptation options. It is the reference platform at European level on information related to climate change adaptation from different perspectives. Therefore, it was considered relevant to dedicate action E3 separately to connect with Climate-ADAPT. In the following paragraphs, the process followed by LIFE-myBUILDINGisGREEN to connect its information and results with the content of the Climate-ADAPT platform is described.

From the beginning of the project, contacts were maintained with members of the platform to study the possibilities of connecting in real time the measurements and data generated by the LIFE-myBUILDINGisGREEN project with the content of the Climate-ADAPT platform.

In 2021, Climate-ADAPT members published a specific site with descriptive information about the LIFE-myBUILDINGisGREEN project, however, they communicated that the only way to update the content of the project on the platform was by requesting it via email. In order to do so, the project

had to provide any update of the information to the content already published in the LIFE-myBUILDINGisGREEN specific site. It was indicated that the way to make the relevant updates was by copying and pasting the project content into Climate-ADAPT, in a Microsoft Word type file, and then editing it with suggestions for changes to be applied later by the Climate-ADAPT team.

Between June and July 2022, the information in the specific site created in Climate-ADAPT was updated and an article summarising the development of the project and the first results obtained by the project to date was uploaded to the platform. This article can be accessed through this link.

In the last phase of the project, experts from the European Environment Agency contacted the LIFE-myBUILDINGisGREEN coordination team to offer the possibility of publishing a case study on the project. It was decided to publish the construction project of the Gabriela Mistral Elementary and Primary School in Solana de los Barros (Badajoz, Spain), as it was the only pilot building that had almost completely concluded the process of monitoring the impact of the implemented Nature-Based Solutions. This case study, which is accessible through this link, was published on the Climate-ADAPT platform in February 2024, during the last month of the LIFE project implementation. The LIFE-myBUILDINGisGREEN project team committed to update the information of this case study after the implementation of the actions scheduled in the After-LIFE Plan, which will take place between March 2024 and February 2028. These actions will have a significant impact on the transferability of the solutions implemented and will enable long-term results to be obtained. The more advanced state of vegetation growth will translate into a more significant impact of the Nature-Based Solutions used in terms of building adaptation to climate change.

Following the collaborations between the Climate-ADAPT and LIFE-myBUILDINGisGREEN teams in the last phase of the project, the possibility of publishing two new case studies on the construction projects of the pilot buildings in Porto and Évora (both in Portugal) was also raised. Climate-ADAPT showed great interest in publishing these case studies due to the scarcity of climate adaptation initiatives from Portugal on the platform. Once again, the LIFE-myBUILDINGisGREEN team committed to publish these two case studies from Portugal after the implementation of the actions programmed in the After-LIFE Plan, when the full monitoring of the impact indicators of the Nature-Based Solutions used in these buildings will be completed.

Below is the content included in the case study of Solana de los Barros (Badajoz, Spain) and the novelties that would be included in the case studies of each pilot building of the LIFE-myBUILDINGisGREEN project in Portugal.

4.1 NATURE-BASED SOLUTIONS IN SCHOOLS: A GREEN WAY TO ADAPT BUILDINGS TO CLIMATE CHANGE IN SOLANA DE LOS BARROS, EXTREMADURA (SPAIN)

Different types of green roofs, green facades, permeable paving and ventilation systems have been tested in a school building of Spain to address increasing temperatures and water scarcity. The implementation of a detailed monitoring scheme revealed positive results indicating high replication potential and possible incorporation of nature-based solutions in the national building code.

The Spanish school 6 months after the implementation of NBS

In a school located in Solana de los Barros (Badajoz, Extremadura, Spain) several nature-based solutions (NBS) have been designed and implemented to minimise climate impacts, as part of the EU LIFE project myBUILDINGisGREEN LIFE. The implemented NBS consist of a series of green roofs, green facades, and other diverse NBS for shading and “water harvesting” that are intended to: (i)

keep indoor temperatures low during hot periods and as such minimise energy use for cooling, (ii) create shade, and (iii) improve water retention around the buildings by minimising rainwater run-off. A rainwater-collecting system has also been implemented to feed the irrigation system needed for the maintenance of the green areas of the school. To enhance the effect of those NBS, more trees were planted in outdoor areas and an automated ventilation system was implemented for closing and opening windows in the school to cool and reduce the CO_2 concentration inside the building during the night and morning hours. A permeable paving installation allows the growth of vegetation and facilitates the infiltration of water into the soil, reducing the amount of water going into the sewage system.

Local and regional authorities and the educational community of nearby towns and neighbourhoods were actively involved in the project to enhance replication potential. Moreover, specific stakeholders were engaged to explore possible modifications of the Spanish Technical Building Code and to discuss the possibilities of transferring the implemented NBS to other contexts. As part of the same myBUILDINGisGREEN LIFE project, additional pilot buildings located in Portugal were tested for NBS.

CASE STUDY DESCRIPTION

Challenges

Solana de los Barros is a municipality located in the province of Badajoz, which belongs to Extremadura, one of the seventeen autonomous communities of Spain.

Based on climate models developed by the IPCC and included in the Regionalised Climate Change Scenarios for Extremadura, both maximum and minimum average temperatures in this region are expected to increase by approximately 4 °C by the end of the 21st century (high emission scenario - A2). Considering that in the hottest months the temperature can reach 35 °C, it is of great importance to take measures to counteract the thermal increase that can be experienced inside buildings. In addition, a decrease in cold days and an increase in hot days has been observed. If this trend continues, an increase in heat waves is to be expected. Considering the same scenario, the annual rainfall is expected to decrease slightly by the end of the 21st century, with the final percentage expected to be 20 % lower than at present.

School buildings are expected to face multiple challenges in the coming decades, calling for complete renovation and better consideration of insulation measures to ensure health and wellbeing of students and school staff.

In a climate change perspective, the management of runoff water, represents an additional challenge, leading to an increase in the cost of wastewater treatment to sewers and a decrease in the water available in aquifers.

Along with climate change, as already recognised since the Millennium Ecosystem Assessment 2011, over the last 50 years Spain has undergone an accelerated and unprecedented process of alterations as a consequence of the unsustainability of the predominant economic development model and the lifestyle associated with it. Drastic changes in land use have been promoted, which are currently the main direct driver of ecosystem deterioration and biodiversity loss in the country.

Objectives

The overall objective of the implemented NBS is to contribute to increasing the resilience of buildings used for education in the Extremadura region to the increasingly frequent periods of heat and water scarcity caused by climate change in southern European countries, improving the well-being of students and staff working in this type of buildings.

To achieve this general objective, this case study pursues a number of specific objectives:

- Improving the knowledge of NBS at building level.
- Analysing the cost-benefit of NBS as climate adaptation tools.
- Promoting governance actions to improve the transferability of the implemented solutions by facilitating their inclusion in local, regional and national regulations.
- Transferring and replicating the prototypes of NBS implemented and tested in this case study, through capacity building initiatives for specialised staff.

Adaptation Options Implemented In This Case

1. Urban green infrastructure planning and nature-based solutions
2. Water sensitive urban and building design
3. Water reuse
4. Awareness raising campaigns for stakeholders' behavioural change
5. Capacity building on climate change adaptation

Solutions

Several NBS were designed, implemented, and tested in a primary school in Solana de los Barros (Badajoz, Extremadura, Spain), as part of the myBUILDINGisGREEN LIFE project.

The implemented measures can be classified in four main categories: green roofs, green facades, ventilation, and development of outdoor areas.

Firstly, green roofs have been implemented in the school building. Green roofs are a promising option to reduce the temperature in buildings while increasing local biodiversity, making the living environment more pleasant and providing the option of a direct learning experience on adaptation to climate change for the students.

One of the green roofs implemented in the project (mBiGCUVE 2 prototype)

The pilot building tested three types of *green roofs* with a variety of more than 25 native plant species. The first solution was an extensive green roof (mBiGCUVE 1), while the second solution

was a roof with an inner air chamber located between the roof and the vegetation substrate (mBiGCUVE 2). It was tested to retain higher temperature, while also improving humidity levels and thus reducing auxiliary irrigation demands. The third solution included a more sustainable substrate (mBiG-SUS) that allows for better rainwater filtration. The main sustainability of this substrate lies in the fact that it is composed of recycled aggregates for the realisation of the roof drainage. Two of these green roofs reuse excess water by gravity to make it available for irrigation.

The second category of NBS is *green facades*. The implemented green facades system includes a system of planters set on metal structures parallel and perpendicular to building facades. It includes climbing plants that protect the facade from sunlight. There is also a vertical awning system with mineral substrate for vertical vegetation growth. It includes plants for hydroponic irrigation that incorporates nutrients into the system and allows their growth on the mineral substrate. In an internal corridor of the building, an indoor vertical garden with a wide variety of plant species has been installed to maintain adequate humidity levels and contain the high temperatures experienced in this room. This system requires continued maintenance and pruning to avoid the fall of the wall due to overweight.

One of the green facades implemented during the project (prototype mBiGToldo)

Next, a *ventilation system* was included in the building, allowing fresh air to circulate in the school during the night and morning hours (9:30-10:00 / 12:30-13:00). The induced natural ventilation system was created by programming the automatic closing and opening of five windows. This measure cools the environment and reduces the indoor CO_2 concentrations and favours re-oxygenation inside the classrooms.

Further interventions were carried out in the school playground. In addition to planting trees for natural shading, several measures have been implemented such as:

- Vegetated Pergola: it includes a planter system set on metal structures similar to the one described for the green facade but without anchoring to building facades. It includes deciduous climbing plants.
- Porous paving: permeable surfaces that improves rainwater infiltration, reducing runoff into the sewage system. This type of pavement also allows the growth of natural vegetation.
- Wooden structures for shading of recreational areas: these structures are located in playgrounds with a high occupancy rate by pupils. They were designed in collaboration with the educational community of the pilot building.

In order to measure the impact of the solutions implemented in the pilot building, a monitoring plan has been developed and the measurements were carried out. As NBS require long time before all the effects become measurable, the monitoring scheme will continue after the end of the project, until spring 2028. This long-term monitoring scheme has been included in the After-LIFE Plan of the myBUILDINGisGREEN LIFE project, which is available in the results section of the project website. A framework of 22 indicators was established to measure: a) temperature change (indoor temperature inside and in the building envelope, outdoor temperature and humidity, and estimated energy and heating savings); b) water management (estimated savings related to water consumption and savings in rainwater management); c) green area management (increased plant and animal biodiversity and number of recovered native plant species suitable for integration in green areas); d) indoor air quality and noise reduction (CO_2 concentration levels inside the classrooms, noise reduction levels from outside and pollution levels through installation of bio-indicator species and training in their observation); e) urban regeneration (energy efficiency and increase in green area (surface area and percentage));, f) governance and participation (citizens' perception of urban nature, number of education policies and strategic plans for climate change

adaptation that include NBS and open participatory processes); g) social cohesion (number of agreements with stakeholders for possible replication activities); h) public health and well-being (reduction in the number of pupil absences and teacher sick leaves) and i) economic opportunities and employment (number of jobs created, creation of new skills in self-employed and NBS-related businesses in the area and reduction of school staff absenteeism). More information on the monitoring plan can be found in a dedicated video from the online training created in the framework of the myBUILDINGisGREEN LIFE project.

Relevance

Case developed and implemented as a Climate Change Adaptation Measure.

ADDITIONAL DETAILS

Stakeholders Participation

The implementation of the NBS was coordinated by the local authority, Badajoz Provincial Council, and carried out by a private company that was awarded the project. It was supported by experts from the Spanish National Research Council (CSIC) in technical issues on buildings and for the selection and maintenance of plants. The CARTIF Foundation, based in Valladolid (Spain), was one of the leading technical partners during the design, implementation and testing of the NBS.

These organisations were supported by the local authorities involved in the construction projects and by the school staff where the NBS were implemented. They facilitated collecting data about electricity, energy or water consumption, student and teacher absences, etc., and assisted the sampling campaigns following indications from the CARTIF and CSIC experts.

The implementation of the NBS needed the active participation of the educational community of the primary school in order to support their design, the implementation of the monitoring system and the promotion of the activities organised in the pilot building. There were some participatory workshops with the students, their parents and the school staff to design the NBS of the playgrounds according to their actual needs. The students at this school were also involved in some data collection initiatives through practical classes leaded by their science teachers. Opportunities for disseminating the importance of NBS in adapting buildings to climate change to students' families and neighbours were used.

Among the dissemination events, three exhibitions were organised to show the implemented solutions to the educational community and the inhabitants of the surroundings. Almost 100 people attended those events. A conference in Badajoz, a congress in Madrid and two online round tables were also organised, with a total attendance of more than 400 people. In addition, more than 100 news items were published in various media and information was exchanged with various knowledge platforms on climate adaptation at national and international level.

Finally, two face-to-face courses on green roofs and green facades and an online course on the experience gained during the implementation of the NBS at the school were held, with a total attendance of more than 250 people.

Success and Limiting Factors

Factors that favoured the success of the adaptation actions were the fruitful collaboration created among project partners and the school community. This collaborative environment allowed to design solutions in a tailored way, addressing actual needs of students and school staff. This also allowed to gather data useful to monitor the adaptation outcomes. The project partner composition, bringing together different skills and expertise, was also crucial to properly design and monitor the selected measures. The monitoring programme, showing encouraging results was also a success factor. They can be used to replicate the tested solutions in other schools and buildings.

Many local, regional and national authorities were involved to study the transferability potential of the solutions designed and tested. These institutions provided advice on several key aspects such as: (i) incorporating NBS in the Catalogue of Construction Solutions of the national Technical Building Code of cities, (ii) designing municipal and regional regulations and tax incentives to encourage the use of this type of solutions, and (iii) finding out about ways to certify buildings with NBS under sustainability standards in buildings. After the consultation process, declarations of interest were signed with 8 municipalities in the province of Badajoz (Spain) to promote the use of NBS for climate adaptation in public buildings in these municipalities. A letter of support was obtained from the Spanish Ministry of Transport, Mobility and Urban Agenda confirming the interest in the project and offering advice for the future inclusion of the project's NBS in the Technical Building Code.

This renovated school building has become a reference in the Extremadura region for sustainable construction to be followed in the future. The interest in its maintenance (provided by the Badajoz Provincial Council and the Solana de los Barros municipality) is very high.

View from one of the green roofs implemented in the Gabriela Mistral primary school

At the same time, some barriers were also encountered which delayed some of the planned tasks and made it necessary to look for alternative solutions in order to proceed with the implementation of the project. Some of these barriers (need for highly specialised technical capacity) might hinder the transferability potential. The main limiting factors are summarised below:

- Limited local availability of construction companies able to implement the measures. To address this issue, specialised companies were identified at national level. The correct drafting of the construction project is essential. The greater the level of detail, the more successful the project will be. The specialisation of the work (green roofs, NBS shading systems) requires prior market research during the drafting of the project. By contacting professionals in the field, it is possible to obtain prior conditions and budgets for implementation, which must be transferred to the project together with the rest of the necessary work. This avoids unforeseen implementation problems or out-of-market budgets and possible public tenders that may not be awarded.

- Inaccurate scheduling of maintenance services. For maintaining NBS, constant monitoring of their condition is necessary, especially in hot periods to ensure irrigation and the availability of water.
- Conflictual issues among contractors for operating the irrigation control system and lack of technical skills for its optimal use. It was necessary to search for companies specialised in this type of operations at national level and to organise public tenders in an appropriate manner.
- Some of the species selected for use in the NBS revealed to be poorly suited to survive in those environmental conditions. During the course of the project some of these plant species were replaced by other species from provincial nurseries or through external contracts.
- Lack of some crucial data to properly assess some adaptation outcomes. Water meters were not available in the building to measure water consumption before and after the implementation of NBS.
- Slow and insufficient growth of shaded plant spaces (virgin vines). NBS may requires long time before their outcomes are measurable. Specific problems with low growth rate of some species (vine arbour) have been addressed by the Royal Botanical Garden (RJB-CSIC), a specific consultancy service for the Badajoz Provincial Council.
- High costs of some NBS. A permeable pavement with photocatalytic activity has been developed at laboratory level, but has not been implemented in the school mainly for cost reasons.

Costs and Benefits

Benefits of NBS implemented in the school building are manyfold, suggesting that these types of solutions can be part of a holistic response to multiple challenges. Benefits include savings in electricity and water consumption, increase in local biodiversity, creation of green corridors for pollinators, and improvement of building aesthetics. The use of native species to green the buildings also prevents the spread of invasive alien species.

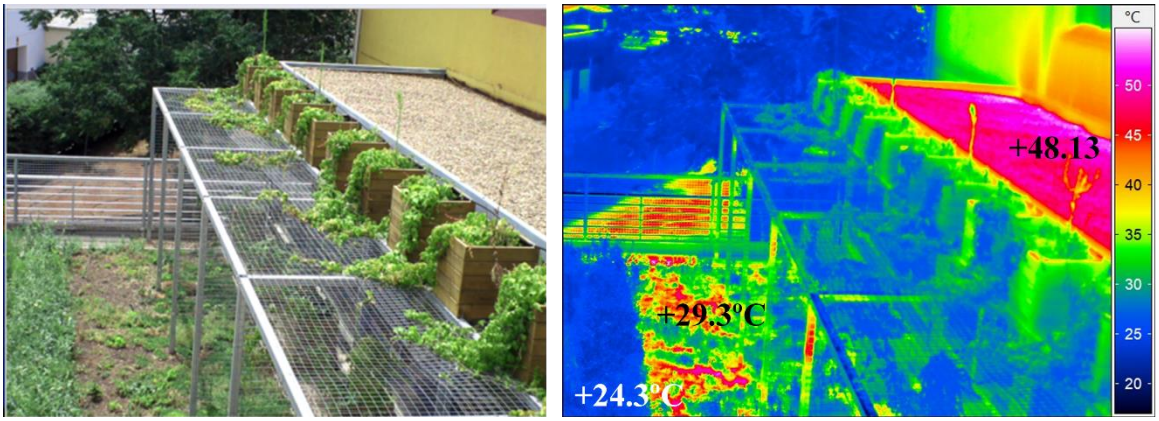
Moreover, NBS are providing living materials for pupil's education, and are expected to provide improved concentration and performance of the students, improved well-being of school workers, and acoustic isolation of classrooms. Some of these benefits can only be measured after some years and are not always monetizable, although their value is indisputable.

However, by the end of 2023 (about two years from the implementation), first results of the monitoring activities suggest the following outcomes:

- Increase of 1,991.20 m^2 of green area and 451.70 m^2 of permeable paving in the pilot building.
- Reduction of 5.4 °C in the average temperature of the surfaces with green roofs compared to those without vegetation.
- Reduction of the temperature inside the classrooms to below 27 °C (recommended value for indoor thermal comfort) in September, after the installation of the NBS. During the hottest months of June, July and August, this objective was not achieved but temperature has decreased compared to the previous situation. The desired reduction is expected to be achieved in the coming years when the state of vegetation development is optimal.
- Reduction of rainwater lost through runoff from an average of 13 % in the situation without interventions to 3 % in the building with the implemented solutions.
- Increase of 77 animal species (mainly flying insects, flies, mosquitoes and Hymenoptera) and colonisation of 16 additional native plant species in the renovated building compared to the previous situation. Biodiversity data will be even more positive after years of maturation of the ecosystems created by the Nature-Based Solutions.

In terms of costs, the most significant share includes the materials needed for the installation of the prototypes and the cost of the staff involved in the various phases of design, implementation, monitoring and dissemination of the NBS.

The initial costs for implementing the solution per square metre (m2) are: 130.40-301.83 €/m^2 for green roofs, 88.59-105.51 €/m^2 for green facades, 54.29 €/m^2 for draining pavements, 2,862.04 €/m2 for the automated windows, 252.71 €/m^2 for the vegetable pergola and about 400 €/m^2 for the tree planting (depending on the species to be planted). Some rough estimations of maintenance costs were made and included in the After-LIFE Plan (results section of the project website).



Temperature monitoring of green roofs

Legal Aspects

The main legal framework that regulates the green infrastructure in Spain is composed of the following regulations:

- The Spanish Technical Building Code. It is the regulatory framework that establishes the basic quality requirements that buildings must meet in relation to safety and habitability established in Law 38/1999, of November 5, of the Construction Regulation (LOE).
- The Spanish National Strategy for Green Infrastructure and Connectivity and Ecological Restoration. It entered into force in July 2021 and is the strategic planning document that regulates the implementation and development of Green Infrastructure in Spain, establishing a harmonized administrative and technical framework for the entire Spanish territory, including maritime waters under national sovereignty or jurisdiction.
- The Spanish National Plan for Adaptation to Climate Change (PNACC) 2021-2030. It is the basic planning instrument to promote coordinated action against the effects of climate change in Spain. The PNACC embraces NBS as desired options for cities, urban planning and buildings.

Implementation Time

The implementation of this project started in 2019 with the selection of the pilot building and ended in 2021 with the implementation of the NBS in the selected school. Dissemination activities, monitoring activities and works to incorporate NBS in the building code took place in the following years and are expected to last until 2028.

Life Time

The pilot building is maintained by the Badajoz Provincial Council and the Solana de los Barros municipality. Provided that the NBS are well maintained, its useful life is estimated to be over 30 years.

Contact information, websites and background documentation on the project are included.

4.2 CASE STUDY 2 – PROJECT FOR THE IMPLEMENTATION OF NATURE-BASED SOLUTIONS AT FALCÃO SCHOOL, PORTO (PORTUGAL)

The Basic School 1 (EB1) Falcão, located in the city of Porto (Portugal), is another of the pilot buildings where Nature-Based Solutions (NBS) have been implemented in the framework of the LIFE-myBUILDINGisGREEN project.

In addition to the NBS implemented, the communication, dissemination and transferability actions in this case differ from those carried out in the other pilot buildings of the project. Therefore, we believe it is relevant to publish a new case study in Climate-ADAPT for the Porto pilot building, including the specifications of LIFE-myBUILDINGisGREEN in this building.

Some of the sections of the case study of the Solana de los Barros building will coincide with those of the Porto pilot building, such as the objectives to be achieved, the adaptation options implemented, the relevance of the case study, and certain contents of the stakeholders and participation section, as well as success and limiting factors. However, the case study will provide a multitude of different aspects that we will describe below by classifying them into the categories of the Climate-ADAPT case study model.

Title and summary: will be tailored to the content of the Porto case study.

Challenges

In this case, the challenges will be specific to the area of influence of the city of Porto, which belongs to the Metropolitan Area of Porto and the Norte region of Portugal.

The challenges that the population of this region will face related to the effects of climate change will be described. Specific documents on the subject for this region will be used. Examples will include updates of documents such as the Diagnosis of the Social Reality of Porto 2018, the Economic Bulletin of Porto 2022, articles on the increase of respiratory diseases in Porto due to climate change (Monteiro et al. 2013), etc.

Solutions

In the Porto pilot building, all the solutions implemented have been different from those already described in the Solana de los Barros case study.

This section will provide a detailed description of the solutions implemented in EB1 Falçao, some of which are prototypes whose effectiveness will be tested during the After-LIFE period (March 2024 - February 2028).

Three green roofs have been implemented in the Porto building. The most extensive (mBiGUL) is a roof that covers a large part of the building and whose vegetation is planted in substrate on natural cork. Another of the roofs includes a series of photovoltaic panels (mBiGBioSol) that reduces the building's energy dependence and allows the production of energy for other municipal facilities, while also allowing the growth of plant species of the genus *Sedum sp*. The third roof is a sloped roof (mBiGSECAR) which also includes *Sedum sp*. species and allows rainwater to be collected and channelled to a pond (mBiGPond) which serves as a reservoir of biodiversity in the environment and which has also been one of the NBS implemented by the LIFE-myBUILDINGisGREEN project.

One of the green roofs implemented in EB1 Falcão

On a trial basis, a plant façade (mBiGFAC) has also been implemented at EB1 Falcão to reduce the insolation of two classrooms that are highly exposed to solar radiation during the months of May to September. It is a system of cables that guide the growth of climbing plants whose base is located in planters placed on the ground and that will cover the façade. Deciduous species are planted to allow sunlight to reach the classrooms in winter, improving the temperature inside the classrooms.

As for the monitoring plan, the indicators to be measured will be the same as those described for the case of Solana de los Barros, but specific to the solutions implemented in Oporto.

Stakeholders Participation

The three interventions of the LIFE-myBUILDINGisGREEN project (Porto, Solana de los Barros and Évora) have counted with the participation of the Spanish National Research Council (CSIC) and CARTIF to coordinate the technical part of the project. However, in the specific case of Porto, work has been carried out with various departments of the Porto City Council (project partner).

Among the specificities of this section of the case study, there would be the local authorities and the educational community specific to this city, the round table and the conference organised in the city in 2020 and October 2023, respectively, the various workshops with pupils on NBS in the framework of the training programme "My School is Green", created by the City Council of Porto following the intervention in Falcão and which will be replicated with pupils from various schools in the city, etc.

First NBS workshop organised with EB1 Falcão students

In the case of the Porto project, the National Association of Green Roofs (ANCV) is of great importance, as it has been one of the advisory bodies in the execution of the construction project.

They also had the collaboration of the Faculty of Science of the University of Porto and the Interdisciplinary Centre for Marine and Environmental Research (CIIMAR).

One aspect to highlight in this section is the integration of the knowledge generated during LIFE-myBUILDINGisGREEN in the Falcão pilot building in a new regulation being developed by the Porto City Council together with private sector entities, technical associations and civil society organisations to promote the use of NBS in new constructions through tax benefits. This regulation is called the Porto Environmental Index.

Success and Limiting Factors

Although certain success factors and constraints included in this section are the same for all three case studies of the LIFE-myBUILDINGisGREEN project, there are a multitude of factors specific to each case.

In the case study of EB1 Falcão, success factors such as improved energy efficiency thanks to the photovoltaic panels combined with the green roof, the combination of previous building renovations and the subsequent implementation of NBS, the integrated school management of NBS, the involvement of the school coordination in the installation of NBS by providing information on the real needs of the school's students, the use of easily accessible materials that enhances the transferability of the implemented NBS, etc., stand out.

A number of specific limiting factors were also identified for the Falçao case study, such as the difficulty of propagating the vegetation on the cables of the mBiGFAC prototype (the design had to be rethought and made in the form of a grid, rather than solely linear), the difficulties in integrating the planning of such disparate elements as green areas and energy infrastructures, which required the involvement and coordination of various departments of the City Council and the granting of numerous permits, the impossibility of reusing rainwater as running water in the building due to incompatibilities with health regulations, the challenge of relocating the school's students to other schools during the works, etc.

Costs and Benefits

Although the benefits are mostly shared with the Solana de los Barros and Évora case studies, there are also some specific ones for the Porto pilot building due to the uniqueness of the implemented solutions. Some examples are the issue of energy efficiency due to the placement

of the photovoltaic panels or the biodiversity reservoir function provided by the installed shell, which will serve as a living educational resource for the school community of the Falcão school.

In turn, the costs will also be specific to the context and type of solutions related to the Porto case study.

Legal Aspects

This section will include specific local regulations enacted by the City Council itself, regional regulations for the Northern region of Portugal and national regulations, which will be shared with the Évora case study.

Implementation Time

The implementation of the Porto project started in 2019 with the selection of the pilot building and concluded in February 2023 with the implementation of the NBS in the selected school. Dissemination, monitoring and transferability activities started in September 2022 and are expected to continue until February 2028.

Life Time

The pilot building is maintained by the Porto City Council itself. In case of proper maintenance of the implemented NBS, the lifetime of the solutions is estimated at more than 30 years.

Contact information, websites and background documentation on the project specific to this case study will be included.

4.3 CASE STUDY 3 – PROJECT FOR THE IMPLEMENTATION OF NATURE-BASED SOLUTIONS AT HORTA DAS FIGUEIRAS SCHOOL, ÉVORA (CENTRAL ALENTEJO, PORTUGAL)

The Basic School 1 (EB1) Horta das Figueiras, located in the city of Évora (Portugal), is another of the pilot buildings where Nature-Based Solutions (NBS) have been implemented in the framework of the LIFE-myBUILDINGisGREEN project.

In addition to the NBS implemented, the communication, dissemination and transferability actions in this case differ from those carried out in the other pilot buildings of the project. Therefore, we believe it is relevant to publish a new case study in Climate-ADAPT for the Évora pilot building, including the specifications of LIFE-myBUILDINGisGREEN in this building.

Some of the sections of the case study of the Solana de los Barros building will coincide with those of the Évora pilot building, such as the objectives to be achieved, the adaptation options implemented, the relevance of the case study, and certain contents of the stakeholders and participation section, as well as success and limiting factors. However, the case study will provide a multitude of different aspects that we will describe below by classifying them into the categories of the Climate-ADAPT case study model.

Title and summary: will be tailored to the content of the Évora case study.

Challenges

In this case, the challenges will be specific to the area of influence of the city of Évora, which belongs to the Intermunicipal Community of Central Alentejo and the Alentejo region in Portugal.

The challenges that the population of this region will face in relation to the effects of climate change will be described. Specific documents on the subject for this region will be used. Some examples will be the updates of documents such as the GADE's Network of the District of Évora, the Social Diagnosis of the Municipality of Évora 2022, the Final Report on Adaptation to Climate Change in Central Alentejo, the Municipal Climate Adaptation Plan in Central Alentejo, the Diagnosis and Strategies of the Educational Charter of Évora 2023-2033, data from the National Observatory for the fight against poverty, etc.

Solutions

In the Évora pilot building, the solutions implemented have been a replica of some of those already described in the Solana de los Barros and Porto case studies, however, they present certain specificities related to the context of this pilot building. In addition, a different type of green roof to those implemented in the other buildings has been included, which is also a prototype version whose effectiveness will be tested during the NBS impact monitoring process.

The implemented green roof (mBiGTray) consists of a series of trays where carefully selected vegetation is planted to withstand the arid climate of the Evora environment. The design of this system is intended to reduce the loss of rainwater and moisture generated by the plants themselves, so that additional irrigation is practically nil.

Green roof implemented at EB1 Horta das Figueiras

As for the façades, an adaptation of the Porto cable system (mBiGFAC) has been installed, but taking into account the lessons learned by the Porto City Council, so that the solution implemented has been an improvement of the original one. The awning system (mBiGToldo) used in Solana de los Barros was also implemented, also incorporating the lessons learned by the Badajoz Provincial Council.

The outdoor solutions consisted of a type of draining wooden paving that improves rainwater filtration and the growth of vegetation while reducing the heat island effect produced by intense

and constant solar radiation on inert construction materials, a wooden structure for shading similar to the one installed in the case of Solana de los Barros and the replanting of the existing flowerbeds with native species.

As for the monitoring plan, the indicators to be measured will be the same as those described for the case of Solana de los Barros, but specific to the solutions implemented in Évora.

Stakeholders Participation

The three interventions of the LIFE-myBUILDINGisGREEN project (Porto, Solana de los Barros and Évora) have counted with the participation of the Consejo Superior de Investigaciones Científicas (CSIC) and CARTIF to coordinate the technical part of the project. However, in the specific case of Porto, work has been carried out with the Intermunicipal Community of Central Alentejo, CIMAC (project partner), as well as with the Municipality of Évora.

Among the specificities of this section of the case study, there would be the local authorities and the educational community specific to this city and the various round tables held in the city in 2019 and 2020.

CIMAC meeting with the municipalities of Central Alentejo in which commitment agreements were obtained for the use of the project's NBS

In the case of the project in Évora, the University of Évora has collaborated with the University of Évora to advise on the design and execution stages of the construction project.

Success and Limiting Factors

Although certain success factors and constraints included in this section are the same for all three case studies of the LIFE-myBUILDINGisGREEN project, there are a multitude of factors specific to each case.

In the case study of EB1 Horta das Figueiras, success factors such as the appropriation of the project by the educational community thanks to their active participation in the co-design of the used NBS, the use of improved versions of some prototypes previously implemented in Solana de los Barros and Porto, etc., stand out.

On the other hand, a series of specific limiting factors were also identified for the Horta das Figueiras case study, such as the lack of CIMAC's competences in the management of the building, which made it difficult to make decisions about it, the lack of precise diagnoses about the state of conservation of the building, which led to unforeseen events in the works, and the lack of a precise diagnosis of the state of conservation of the building, which led to unforeseen events in the works, The lack of safety measures for the subsequent maintenance of the green roof, as contemplated in the construction project, which led to a new design in extremis, etc..

Costs and Benefits

Although the benefits are mostly shared with the Solana de los Barros and Porto case studies, there are also some specific ones for the Évora pilot building due to the uniqueness of the implemented solutions. Some examples are the issue of the further reduction of the heat island by using a large amount of wood materials or the more pronounced reduction of water use for irrigation, as the roof requires irrigation inputs only during the first months of operation.

In turn, the costs will also be specific to the context and type of solutions related to the Évora case study.

Legal Aspects

This section will include specific local regulations enacted by the Évora City Council, regional regulations promoted by CIMAC and authorities of the Alentejo region and national regulations, which will be shared with the Porto case study.

Implementation Time

The implementation of the Porto project started in 2019 with the selection of the pilot building and concluded in February 2024 with the implementation of the NBS in the selected school. Dissemination, monitoring and transferability activities started in September 2022 and are expected to continue until February 2028.

Life Time

The pilot building is maintained by the Municipality of Évora and supported by CIMAC in certain issues. In case of proper maintenance of the implemented NBS, the lifetime of the solutions is estimated at more than 30 years.

Contact information, websites and background documentation on the project specific to this case study will be included.