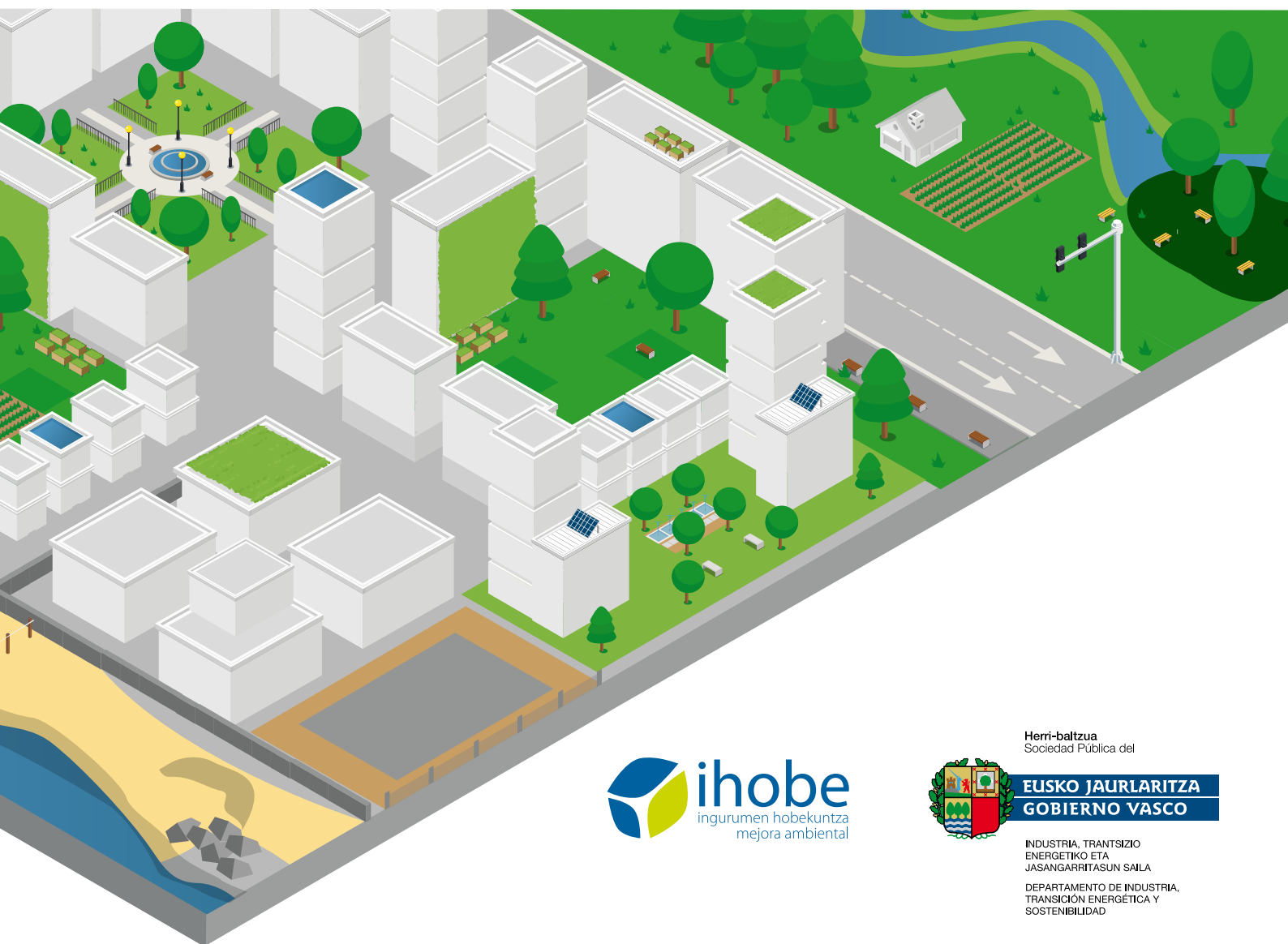




# NATURE-BASED SOLUTIONS IN THE BASQUE COUNTRY

20 success stories for adapting to climate change by applying NBS

2024 edition



INDUSTRIA, TRANSIZIO  
ENERGETIKO ETA  
JASANGARRITASUN SAILA  
DEPARTAMENTO DE INDUSTRIA,  
TRANSICIÓN ENERGÉTICA Y  
SOSTENIBILIDAD



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**EDITED BY**

**Ihobe, Public Environmental Management Company**  
Basque Government

Alda. de Urquijo 36 - 6th floor  
48011 Bilbo  
[www.ihobe.eus](http://www.ihobe.eus) • [www.euskadi.eus](http://www.euskadi.eus)  
Tel.: 94 423 07 43

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20 success stories for adapting to climate  
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# PRESENTATION

In recent years, Nature Based Solutions (NBS) have been promoted at international and European level as one of the keys to addressing the major threats facing society, including climate change and ecosystem degradation. The IPCC Sixth Assessment Report<sup>1</sup>, the European Green Pact<sup>2</sup>, the EU Biodiversity Strategy 2030<sup>3</sup>, the European Climate Change Adaptation Strategy<sup>4</sup>, as well as the European Union's proposed Regulation on Nature Restoration<sup>5</sup> and its proposed Directive on Soil Monitoring and Resilience<sup>6</sup>, identify NBS as multi-disciplinary solutions that meet various environmental, social and economic objectives, and are instrumental in

increasing the resilience and sustainability of the region. Given their transformative nature, the United Nations Environment Programme<sup>7</sup> has estimated that investment in NBS would need to at least triple in real terms by 2030 and quadruple between now and 2050 to meet climate change, biodiversity, and soil degradation targets.

While climate change adaptation policies and actions are being increasingly developed and applied at all levels of governance, the competence to implement such measures lies within the framework of cities and municipalities, as well as regions.

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<sup>1</sup> IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. <https://www.ipcc.ch/report/ar6/wg2/>

<sup>2</sup> [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)

<sup>3</sup> [https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC_1&format=PDF); [https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC\\_2&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC_2&format=PDF)

<sup>4</sup> <https://eur-lex.europa.eu/legal-content/ES/TXT/PDF/?uri=CELEX:52021DC0082>

<sup>5</sup> <https://eur-lex.europa.eu/legal-content/ES/TXT/HTML/?uri=CELEX:52022PC0304>

<sup>6</sup> [https://environment.ec.europa.eu/publications/proposal-directive-soil-monitoring-and-resilience\\_en](https://environment.ec.europa.eu/publications/proposal-directive-soil-monitoring-and-resilience_en)

<sup>7</sup> United Nations Environment Programme (2021). State of Finance for Nature 2021. Nairobi. <https://www.unep.org/resources/state-finance-nature-2021>

In this sense, the Basque Country has created the context required to develop new climate governance; close collaboration has been created between the varying government departments and knowledge agents to integrate energy transition and climate action in a real way. A significant number of NBS have been able to be implemented in the territory thanks to this participatory and shared style of governance. The involvement of the Basque Network of Sustainable Municipalities, Udalsarea 2030<sup>8</sup>, has been a key success factor in this sense.

This joint work has resulted in a compilation of good practices in natural solutions<sup>9</sup> implemented in Basque municipalities up to 2017 when it was published. This document aims to continue on from the previous publication, by compiling new NBS interventions implemented in Basque municipalities from 2017 to the publication date.

This document also provides a brief contextualisation of the NBS, as well as their role in the policy, planning, and financing framework in the Basque Country. The aim is to provide agents involved in proposing, designing, and implementing this type of solution with the essential foundations for their conception and deployment. Accordingly, each section of this document ends with some "considerations for the user or reader", the intention of which is to provide guidance on how the document content can be of use when actually implementing these solutions.

In addition, the NBS have been classified based on their scale of intervention at the municipal level, and characterised in terms of the climate challenges they address and the co-benefits they provide.

Finally, a catalogue of NBS interventions for climate adaptation is presented in this document. This includes a technical explanation of the interventions, as well as lessons learned, barriers, success factors, and practical information that it is hoped will serve as inspiration to expand the implementation of NBS to all Basque municipalities.

Therefore, this document demonstrates the real application of NBS in the Basque Country that respond to the climatic reality, socio-economic context, and unique characteristics of our region. It also aims to demonstrate the versatility, replicability, and transversality of this type of solution when responding to climate challenges, in addition to their potential to provide environmental, social, and economic co-benefits. Therefore, this catalogue of NBS interventions pursues a dual objective: on the one hand, to disseminate and highlight projects and interventions that integrate NBS for climate adaptation in municipalities in the Basque Country and, on the other hand, to support and guide local and regional decision-makers in their efforts to tackle climate change through nature-based adaptation.

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<sup>8</sup> <http://www.udalsarea2030.eus/home>

<sup>9</sup> Selection of nature based solutions. Good practices in the Basque Autonomous Community. <https://www.ihobe.eus/publications/selection-of-nature-based-solutions-good-practices-in-the-basque-autonomous-community>

# GENERAL CONCEPTUAL FRAMEWORK OF THE NATURE-BASED SOLUTIONS FOR CLIMATE ADAPTATION

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## 1.1. What are the Nature-Based Solutions?

Multiple terms have been used to refer to the NBS in recent decades, both from the scientific, policy, and planning domains. Similar terms can be found for similar concepts such as ecosystem-based adaptation, nature-based adaptation, green and blue infrastructure, natural water retention systems, etc.

The United Nations Environment Assembly<sup>10</sup> defines NBS as actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while

simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits.

More specifically, the European Environment Agency<sup>11</sup> defines NBS for climate adaptation and disaster reduction as actions that work with and enhance nature to restore and protect ecosystems and to help society adapt to the impacts of climate change and slow further warming, while providing multiple additional environmental, social, and economic benefits.

While there is no unambiguous and universal definition of NBS, the International Union for Conservation of Nature (IUCN), the European Commission, and the United Nations all stress that these solutions are a tool with a high capacity to

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<sup>10</sup> Resolution adopted by the United Nations Environment Assembly on 2 March 2022. Nature-based solutions for supporting sustainable development <https://wedocs.unep.org/bitstream/handle/20.500.11822/39864/NATURE-BASED%20SOLUTIONS%20FOR%20SUPPORTING%20SUSTAINABLE%20DEVELOPMENT.%20English.pdf?sequence=1&isAllowed=y>

<sup>11</sup> "Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction" European Environmental Agency Report. No 01/2021. <https://www.eea.europa.eu/publications/nature-based-solutions-in-europe/>

increase climate resilience and promote biodiversity, while providing a range of co-benefits for humanity. In short, the term NBS encompasses diverse conceptual terminology expressing similar ideas that can be applied in the strategic and planning domain, as well as in the development of soft and traditional engineering works. NBS can therefore range from the creation of new green or blue spaces (such as a community garden, an urban park or the recovery of dune ecosystems), to non-intervention or minimal intervention projects (establishing biodiversity conservation areas for example).

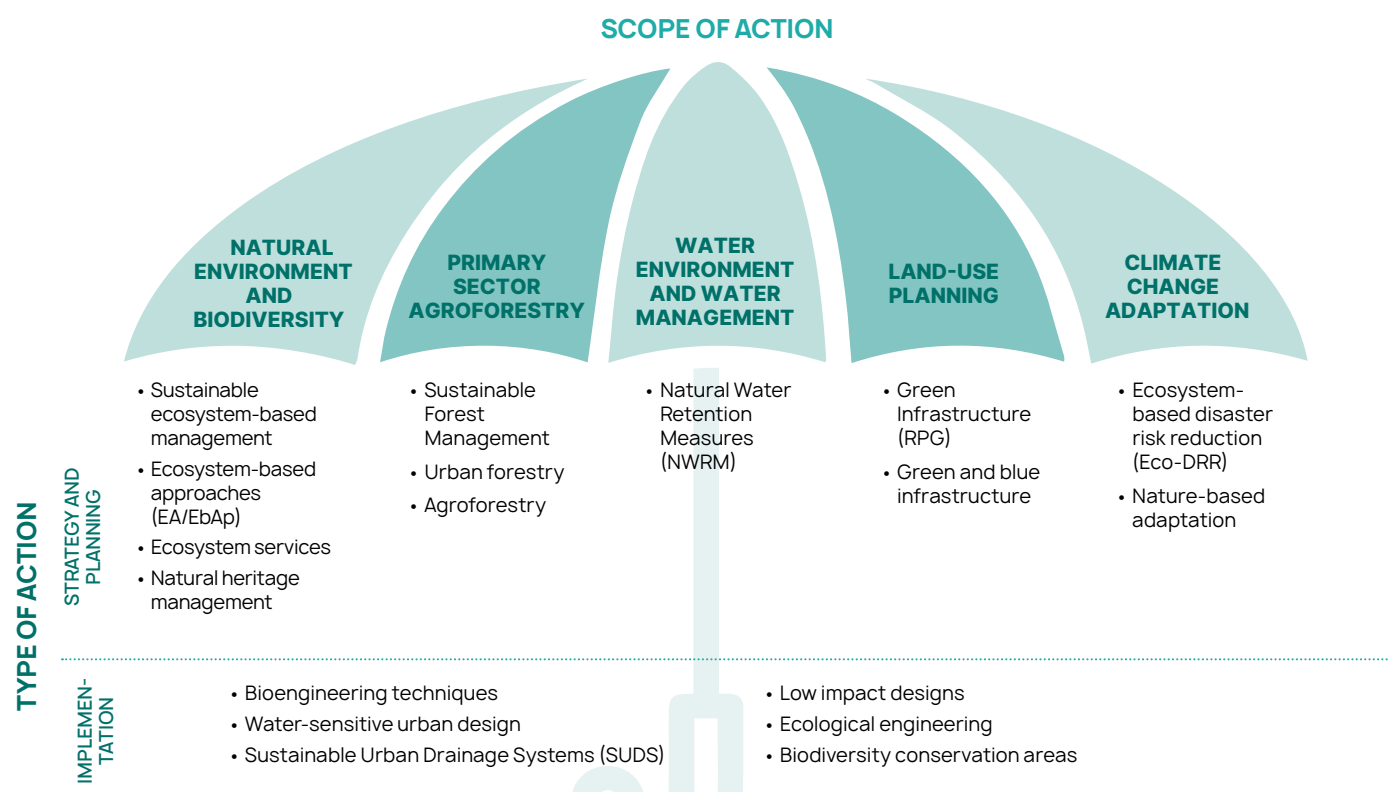
A collection of terms that can be considered to fall under the conceptual umbrella of NBS is shown in Figure 1. Depending on the field of the intervention, it can be observed that some terms prevail over others. For example, in the spatial planning field

it is more common to use the term green or blue infrastructure, as stated in the Basque Country RPG<sup>12</sup>, while terms such as bioengineering or Sustainable Urban Drainage Systems prevail in the implementation field.

#### CONSIDERATIONS FOR THE USER/READER

It is important to understand the conceptual framework of the NBS; however, given its transverse nature, the lack of standards, and the multiple meanings of this concept, this document includes experiences implemented in the Basque Country which, in one way or another, are included in the umbrella concept of NBS and which have a naturalistic basis as their main aspect.

**FIGURE 1.** NBS for climate adaptation as an umbrella concept and its relation to the environmental policy framework relevant for climate resilience



**Own source based on:** the European Commission, Directorate-General for Research and Innovation, *Evaluating the impact of nature-based solutions: a summary for policy makers*, Publications Office, 2021, <https://data.europa.eu/doi/10.2777/521937> and *Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction* — European Environment Agency (europa.eu)

<sup>12</sup> Regional Planning Guidelines of the Basque Country 2019 (RPG). <https://www.euskadi.eus/directrices-de-ordenacion-territorial-dot/web01-a2lurral/es/#tabdot2018>

## 1.2. Nature-Based Solutions for climate action

Ecosystems are natural buffers to climate variability and extremes. NBS therefore help to strengthen climate resilience while contributing to climate change mitigation. Thus, according to the IUCN<sup>13</sup>, NBS address the challenge of climate change from different perspectives:

- They improve the resilience of ecosystems and thus contribute to society's ability to adapt to climate risks, the intensity of which can be reduced by as much as 26% by implementing these types of natural solutions, resulting in cost savings of EUR 361 billion by 2050.
- They capture and store carbon dioxide from the atmosphere, estimated to be at least 5 GtCO<sub>2</sub> equivalent per year by 2030 (maximum of 11.7 GtCO<sub>2</sub> equivalent/year), and could contribute to 30% of the mitigation required by 2030/2050 to reach the goal agreed in the Paris Agreement (1.5 - 2 °C). This carbon dioxide capture and storage would reduce emissions from deforestation and land use.

Opting for solutions that contribute to both mitigation and adaptation, and that do so jointly through planning, financing and implementation, is the key to success in advancing climate action. There are numerous examples of measures that contribute to both aspects. Reforestation with native species, for example, acts as a carbon sink while reducing the

risk of erosion and landslides from extreme rainfall events. The recovery of coastal wetlands is another clear example, as these ecosystems contribute to sequestering and storing CO<sub>2</sub>, are a natural reserve of organic carbon, and are more resilient to coastal stresses, thus reducing the risk of flooding.

A range of evidence has been generated over the past few decades from academic research<sup>14</sup>, demonstration projects<sup>15</sup>, technical reports, and policy documents which support the successful implementation of NBS. These sources of scientific endorsement help to inspire confidence in the return on investment, the efficiency and effectiveness of the intervention, and the balance between the distribution of the multiple benefits provided by the NBS and the cost of the intervention.

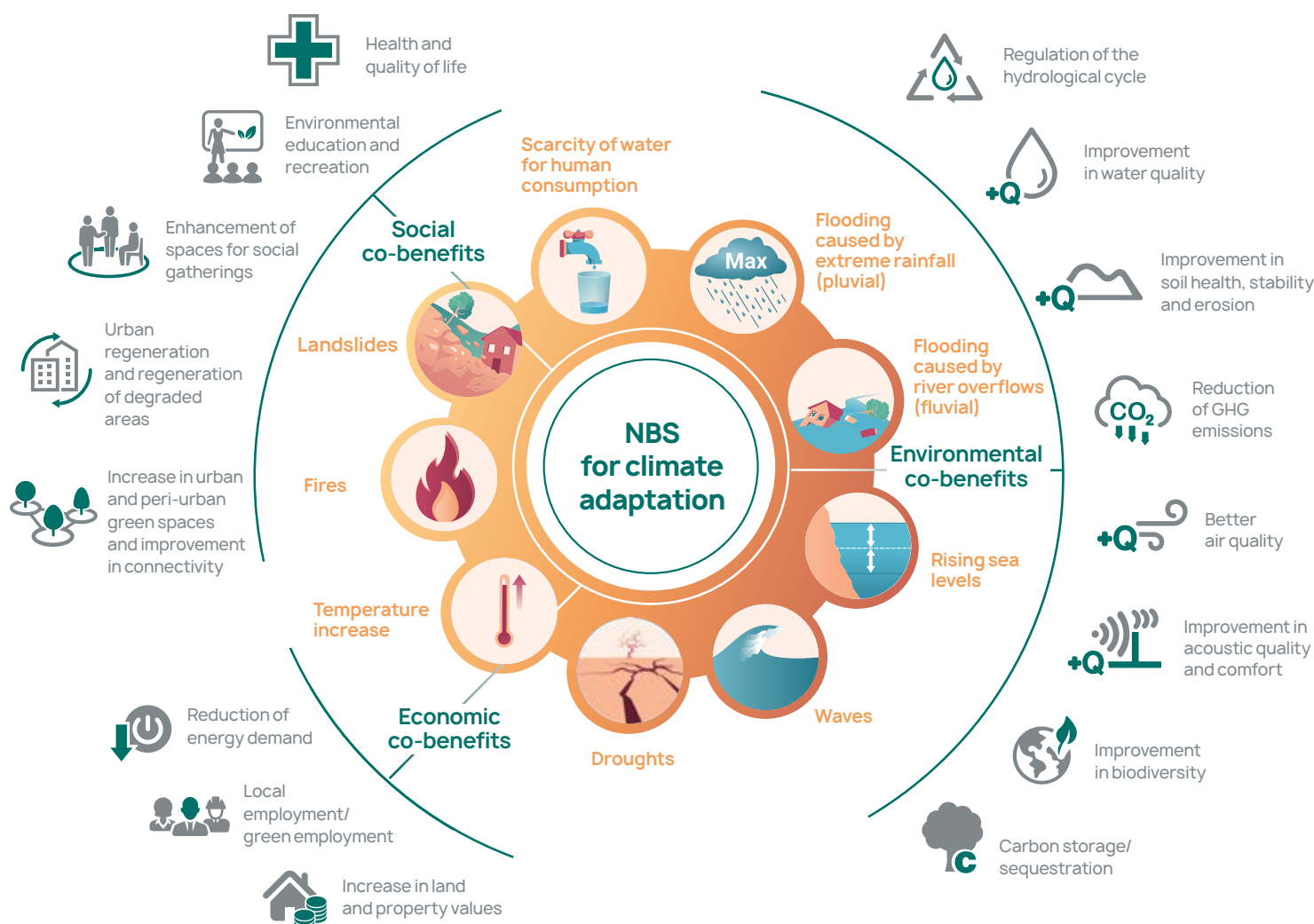
In this context, the catalogue of interventions compiled in this document focusses on increasing the resilience of the territory and the municipalities in response to various climate threats. The focus is therefore on NBS as climate change adaptation measures; the other advantages of these solutions are considered to be co-benefits, and this is depicted in the graph in Figure 2. Section 3.3 outlines the different climate threats that NBS can respond to, as well as the co-benefits they are expected to provide once implemented. A detailed description of each of these co-benefits is provided in Annex I.

<sup>13</sup> <https://www.iucn.org/our-work/topic/nature-based-solutions-climate>

<sup>14</sup> <https://networknature.eu/>

<sup>15</sup> <https://www.greatermanchester-ca.gov.uk/what-we-do/environment/natural-environment/ignition/>

**FIGURE 2 .** Climate threats to be addressed with NBS and the co-benefits they provide



Source: produced by the author.

#### CONSIDERATIONS FOR THE USER/READER

The interventions compiled in this document respond to the different climate threats that the Basque Country is exposed to, and therefore have a climate adaptation focus. The environmental, social, and economic benefits that NBS provide are seen as co-benefits, in addition to the climate adaptation benefit itself.

# NATURE-BASED CLIMATE ADAPTATION IN THE BASQUE COUNTRY.

## STRATEGIC CONTEXT AND SOURCES OF FUNDING

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The Basque Country has been increasing its commitment and efforts in terms of nature-based adaptation for some time, in line with multiple agreements, initiatives, and trends at international and European level (a compilation of which is provided in Annex II). Throughout this long history, the Basque Country has contemplated this type of intervention through its planning activities and has created the instruments required to effectively develop and implement the interventions in the region. In this sense, the Basque Country has been taking climate adaptation actions through a range of mechanisms, including: a regulatory framework that governs and promotes the NBS; a multilevel governance model in which the municipalities, supported by different funding programmes, are key to the effective adaptation of the region; a firm commitment to local climate innovation and

adaptation demonstration projects; the alliances at regional and international level that result from collaborative climate action projects; and the generation of various climate tools (Figure 3). The next two sections briefly review this history.

### 2.1. Nature-Based Solutions in Basque Country planning activities

Basque Country planning activities began to incorporate NBS in 2015 with the approval of the *Basque Climate Change Strategy KLIMA 2050*<sup>16</sup>, currently under review. These planning activities aimed to foster a climate-resilient urban structure by diagnosing and detecting vulnerable areas, and

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<sup>16</sup> <https://www.euskadi.eus/documentacion/2015/estrategia-vasca-de-cambio-climatico-2050/web01-a2ingkli/es/>



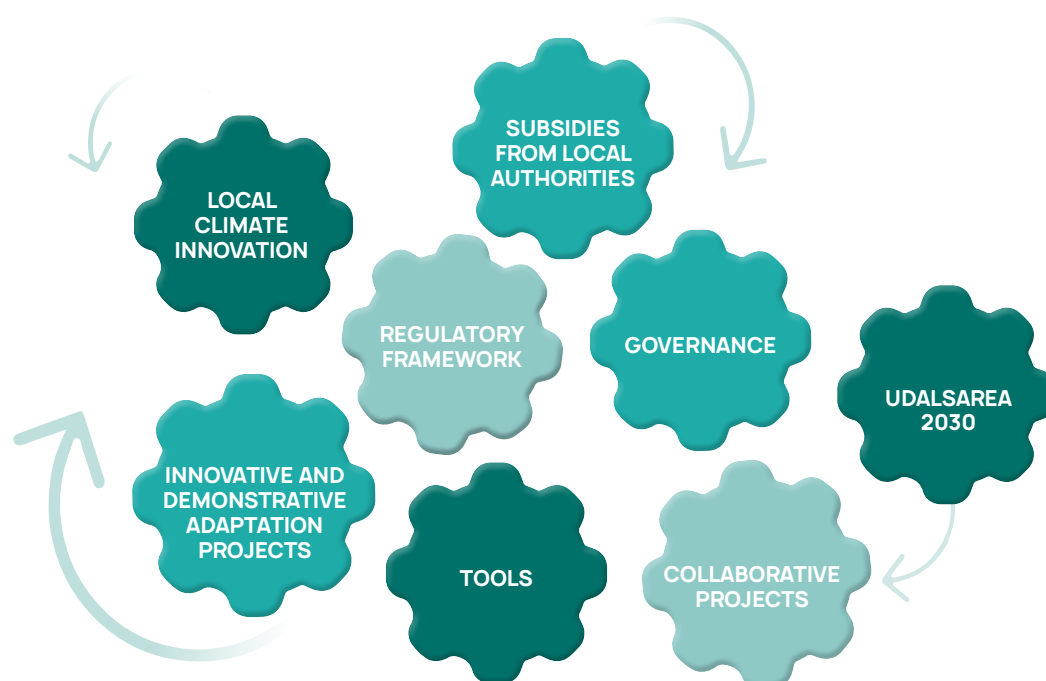
designing resilient urban and architectural solutions based primarily on nature. Line of action 7 to "Promote climate-resilient, compact, and mixed-use urban structure" therefore included among its actions to "promote green infrastructure and nature-based solutions as measures for climate change adaptation and urban sustainability".

Furthermore, the LIFE IP Urban Klima 2050<sup>17</sup> project, approved in 2019 and with a duration until 2025, represents a relevant milestone in the deployment of NBS. This is a collaborative and transformative project in the Basque Country which aims to promote the energy and climate transition with the objective of improving the resilience of the Basque region. This project is developed through 40 actions and puts an important focus on nature-based adaptation in three areas of intervention: urban/peri-urban, coastal zone, and river basins; demonstrative NBS were actually implemented in different Basque municipalities as part of this project.

Subsequently, the Climate Change and Energy Transition Plan 2021-2024<sup>18</sup> (CCETP 2021-2024), following an innovative approach, sets out the deployment of 15 flagship initiatives covering the three strategic axes of the plan: energy transition, climate resilience, and just transition. One of these initiatives, number 12, specifically refers to NBS as a source of innovation for the resilience of municipalities, and is aimed at deploying these types of solutions in Basque municipalities to respond to the need to adapt to climate change.

Lastly, and most recently, Law 1/2024 of 8 February on Climate Change and Energy Transition in the Basque Country expressly refers to the promotion, planning, and use of green and blue infrastructure, as well as NBS; it does so in several of the articles referring to sectoral and regional policies that contribute to climate neutrality, regional resilience, and adaptation to climate change. These sectoral policies, which specifically mention NBS, are spatial

**FIGURE 3 . Mechanisms for the deployment of climate adaptation action in the Basque Country**



*Source: produced by the author*

<sup>17</sup> <https://www.urbanklima2050.eu/en/>

<sup>18</sup> <https://urbanklima2050.eu/en/dossier-plan-transicion-en.pdf>

planning, urban planning and urban regeneration, carbon sinks, and protection of natural heritage.

Likewise, the Basque Country has specific strategies such as the *Biodiversity Strategy of the Basque Autonomous Community 2030*<sup>19</sup> and the *Basque Soil Protection Strategy 2030*<sup>20</sup>, which promote the implementation of NBS as an effective alternative to face the specific challenges they have been developed for. Thus, in "Goal 4. Effectiveness and efficiency in the management of the territory and the Natural Heritage", the Biodiversity Strategy is committed to developing NBS in the urban environment, promoting the active role of the municipalities through the Udalsarea 2030 network of sustainable municipalities. Furthermore, the objective of the Basque Soil Protection Strategy 2030 is to sustainably manage soil to prevent its degradation and guarantee its health; it considers soil to be key to nature-based climate adaptation in the Basque Country, both in urban, rural and forestry environments, due to its capacity for water and thermal regulation and because it supports vegetation.

On the other hand, it is worth mentioning that the promotion and approval of other sectoral plans and programmes, such as the Regional Planning Guidelines for the Basque Country<sup>21</sup> and the Green Procurement and Contracting Programme of the Basque Country 2030<sup>22</sup>, have also contributed to highlighting this type of action and to promoting the application of the NBS approach from very different and multidisciplinary fields.

#### CONSIDERATIONS FOR THE USER/READER

The Basque Country is and will continue to be committed to NBS through its planning activities. Basque public policies act as a catalyst for their deployment throughout the Basque Country

## 2.2. Funding and governance model for nature-based adaptation in the Basque Country

Planning in the Basque Country has been accompanied by various funding programmes that have made it possible to effectively implement NBS in the region, making the Basque Country a benchmark demonstrator region in Europe in the application of this type of solution.

In this sense, the Basque Country has several public funding instruments that promote innovative and demonstrative projects on climate change adaptation. These projects, in collaboration with Basque knowledge creators, apply new tools and technologies to real case studies in Basque municipalities.

To encourage the transferability of climate adaptation actions between municipalities, the Basque Government has other funding programmes for sustainability and eco-innovation. These programmes are specifically aimed at financing interventions that promote sustainability and climate adaptation, in line with Basque Country's objectives.

These tools and public funding programmes therefore aim to stimulate and activate the public sector, knowledge creators, and the varying local actors to drive the integration of NBS in municipal and government agendas and policies.

Numerous Basque municipalities have carried out eco-innovation and local climate adaptation projects through the mobilisation of these funding mechanisms. These projects address the climate risk to which each case is exposed to and contribute to increasing their resilience by integrating NBS. Throughout all these years, around 90 projects that integrate NBS have been financed in 54 Basque municipalities. Figure 4 shows the

<sup>19</sup> [https://www.euskadi.eus/contenidos/documentacion/biodiversidad2030/en\\_def/adjuntos/BiodiversityStrategy2030.pdf](https://www.euskadi.eus/contenidos/documentacion/biodiversidad2030/en_def/adjuntos/BiodiversityStrategy2030.pdf)

<sup>20</sup> <https://www.ihobe.eus/publications/soil-protection-strategy-2030>

<sup>21</sup> Decree 128/2019, of 30 July, finally approving the Regional Planning Guidelines for the Basque Autonomous Community <https://www.euskadi.eus/y22-bopv/es/bopv2/datos/2019/09/1904315a.pdf>

<sup>22</sup> <https://www.ihobe.eus/publications/green-procurement-and-contracting-program-of-basque-country-2030>

regional distribution of this type of solution and its implementation, aimed at using nature and its processes to provide integrative and adaptive solutions, and which contribute to the resilience of environments threatened by climate change.

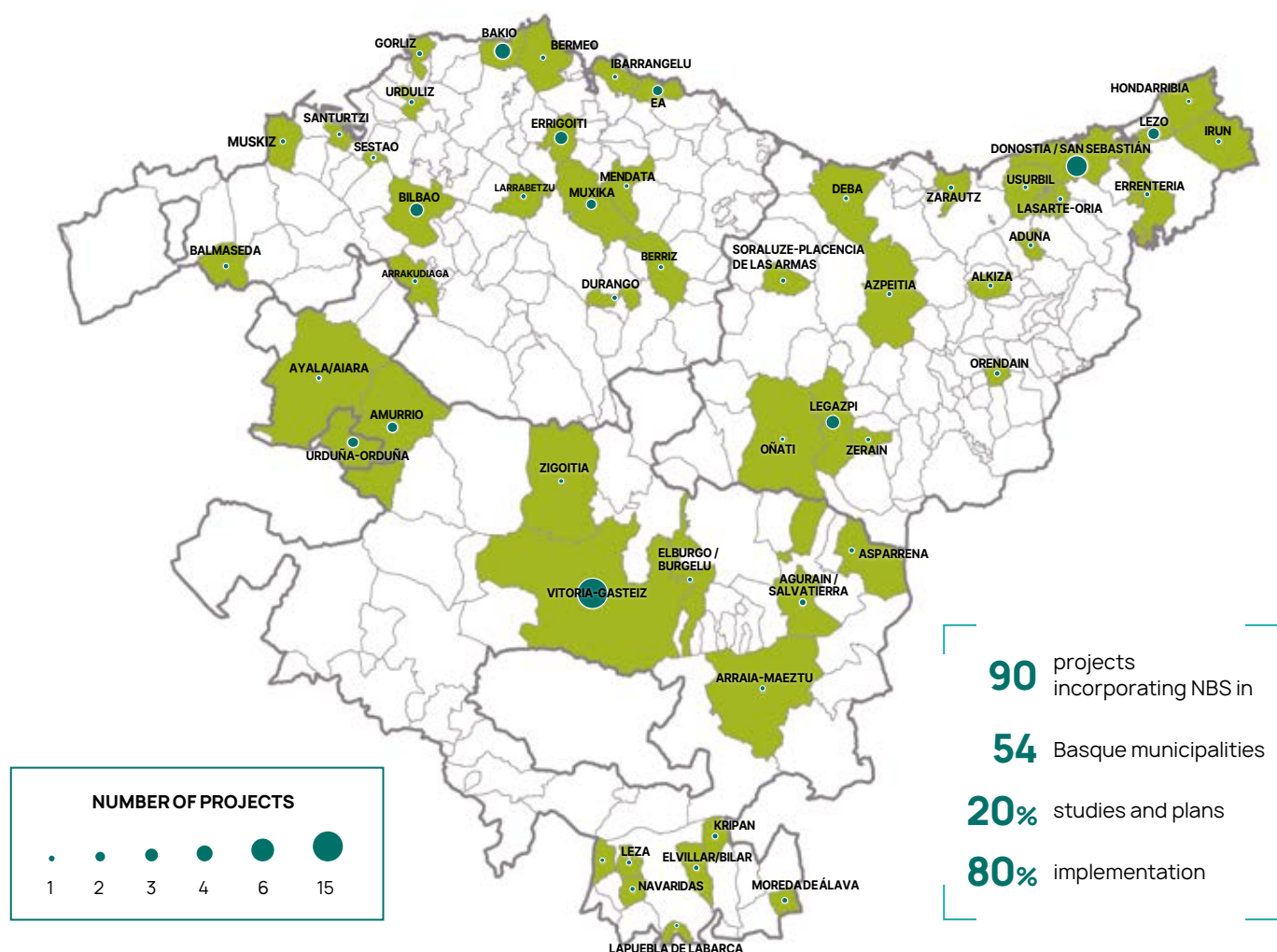
It should also be noted that collaboration between knowledge creators and local administration is feasible and successful thanks to the local commitment within the Basque network of sustainable municipalities, Udalsarea 2030<sup>23</sup>. This network of county and local entities plays a fundamental role in the context of climate governance as it provides members with advanced and innovative services in coordination with other actors. Udalsarea 2030 therefore enables the knowledge and lessons learned from subsidised demonstration projects to be transferred between

Basque municipalities. In this way, the network can develop methodologies, manuals, and other types of tools that contribute to developing personalised approaches in response to the specific needs and realities of each entity.

#### CONSIDERATIONS FOR THE USER/READER

The Basque Country has a long track record in climate change adaptation that translates into a wide range of facilitating mechanisms, as well as a solid governance model that drives the deployment of climate action in this field. The knowledge of local and regional decision-makers and the application of this knowledge are key to generalising the implementation of NBS and extending it to the entire Basque region.

**FIGURE 4 .** Basque municipalities where projects integrating NBS for climate change adaptation have been implemented



<sup>23</sup> <http://www.udalsarea2030.eus/home>

# NATURE-BASED SOLUTIONS IN BASQUE MUNICIPALITIES FOR CLIMATE ADAPTATION

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## 3.1. Background: Nature-Based Solutions Guides in the Basque Country

The Basque Country has produced a range of publications to disseminate and implement NBS as a result of the funding programmes mentioned in the previous section. After the KLIMA 2050 Strategy was approved, a methodology was published to incorporate NBS at different scales of implementation at the local level that, depending on their needs, would allow municipalities to start adapting to climate change through nature. This methodology was piloted through its application in the municipality

of Donostia/San Sebastian to reinforce the practical and demonstrative nature of the project, as well as to favour the transferability of the results. The development of this work resulted in the publication of a guide entitled *Nature-based solutions for local climate adaptation in the Basque Country. Methodological guide for their identification and mapping*<sup>24</sup> in 2017, with Donostia/San Sebastian as a case study. It should be noted that this methodology is used by all projects that are co-financed by any of the

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<sup>24</sup> <https://www.ihobe.eus/publications/nature-based-solutions-for-local-climate-adaptation-in-the-basque-country>

subsidy programmes mentioned in the previous section and integrate NBS for climate adaptation.

Another guide was published in 2017, *Selection of nature-based solutions. Good practices in the Basque Autonomous Community*<sup>25</sup> which included several information sheets, representing the first compilation of reference projects developed to date in municipalities in the three historical territories. This work served to carry out a first exploration of the Basque Country and to provide an inventory of good number of nature-based projects implemented.

Both publications have served to promote NBS in the Basque Country, mainly in the field of climate change adaptation.

The catalogue of interventions presented in this publication is intended to be a continuation, as well as an update, of the two previous publications on NBS in the Basque Country. Conceptual and strategic-legislative aspects on NBS are updated (see section 1 and Annex II), and climate threats, scales of intervention and co-benefits are reviewed with respect to the document "Nature-based solutions for local climate adaptation in the Basque Country" according to the progress made in the regional, European, and international spheres in this area since 2017.

#### CONSIDERATIONS FOR THE USER/READER

We recommend reading, or at least consulting, the two NBS guides mentioned above, both of which precede this document, to broaden your knowledge on the subject.

## 3.2. Classification of Nature-Based Solutions according to scale of intervention

In the same way that there is no single universal definition for NBS, there is no single standard for the classification of NBS. Throughout the extensive literature on the subject, NBS are classified according to their contribution to the problem addressed, the climate threats they respond to, their benefits, or the urban scale at which they are implemented.

Bearing in mind that climate adaptation requires intervention in the region and in its planning activities, in the framework of this document NBS are classified based on their scale or scope of intervention; this criterion is already used in the guide published in 2017 on "Nature-based solutions for local climate adaptation in the Basque Country".

In addition to the NBS included in the aforementioned 2017 guide, new solutions have been incorporated that have been implemented in different Basque municipalities and represent an extension of the previous catalogue of solutions. It is not intended to be an exhaustive or complete catalogue, but rather a sample of the types of NBS or naturalistic-based interventions that from a municipal management perspective can be adopted with a high benefit in terms of climate adaptation. Therefore, we decided to maintain the classification used in the 2017 publication, albeit with some modifications and adjustments in response to recent trends to classify most of the NBS as Sustainable Urban Drainage Systems (SUDS)<sup>26,27</sup>.

Within the framework of this work, the NBS are classified in the following scales of intervention (Figure 5).

<sup>25</sup> <https://www.ihobe.eus/publications/selection-of-nature-based-solutions-good-practices-in-the-basque-autonomous-community>

<sup>26</sup> Guide on the adaptation to flood risks: Sustainable Urban Drainage Systems. Ministry for Ecological Transition, Government of Spain, 2019 [guia-adaptacion-risgo-inundacion-sistemas-urbano-drenaje-sostenible\\_tcm30-503726.pdf](https://www.miteco.gob.es/guia-adaptacion-risgo-inundacion-sistemas-urbano-drenaje-sostenible_tcm30-503726.pdf) (miteco.gob.es)

<sup>27</sup> De la Fuente García, L., Perales Momparler, S., Rico Cortés, M., Andrés Doménech, I., Marco Segura, J. B. (2021) Basic Guide on the Design of Sustainable Urban Drainage Systems in the City of Valencia. Cicle Integral de l'Aigua. Ajuntament de València. [https://www.ciclointegraldelagua.com/files/normativa/Guia\\_Basica\\_para\\_el\\_Diseño\\_de\\_Sistemas\\_Urbanos\\_de\\_Drenaje\\_Sostenible\\_en\\_la\\_Ciudad\\_de\\_Valencia\\_V01.pdf](https://www.ciclointegraldelagua.com/files/normativa/Guia_Basica_para_el_Diseño_de_Sistemas_Urbanos_de_Drenaje_Sostenible_en_la_Ciudad_de_Valencia_V01.pdf)

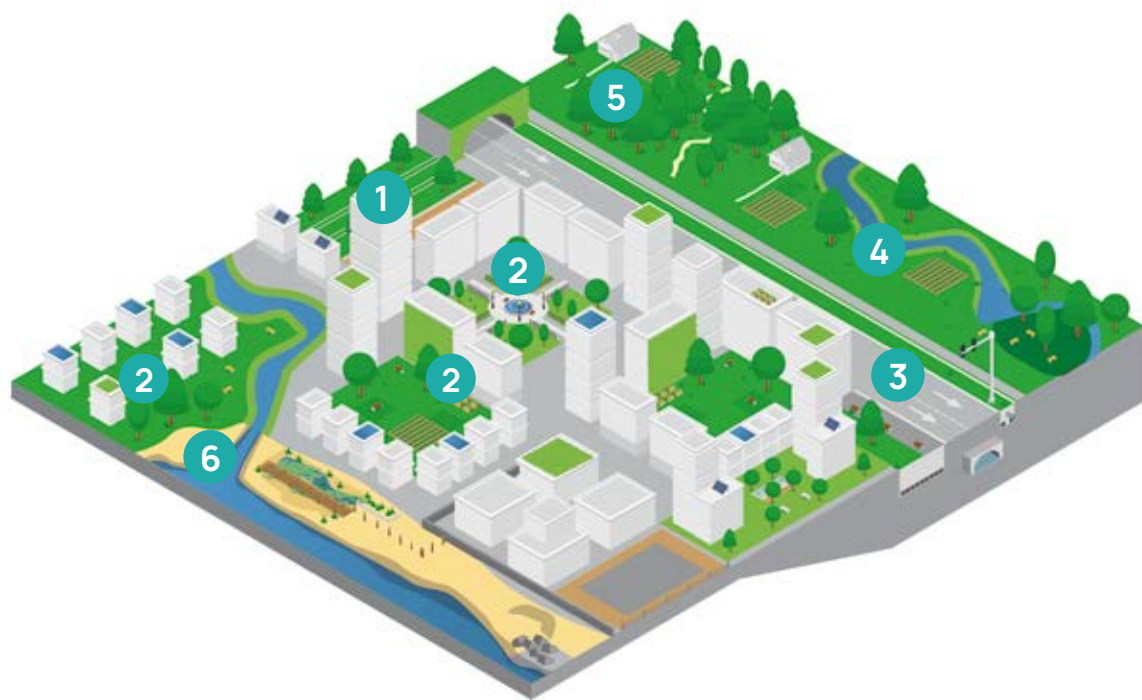


The NBS that can be implemented at each of the 6 scales of intervention are indicated, categorising them by type of space and detailing the constructive elements in which they can be developed. For example, at the building scale there are two types of buildings depending on ownership (public and private); and the constructive elements in which NBS can be

implemented are the roofs, façades, and the building interior.

A detailed update of the NBS classification based on scale of intervention, type of space, and constructive element in which the NBS are developed is provided below (see details of scales, types of spaces, and elements in table 1).

**FIGURE 5 .** Different scales of application of the NBS in the municipality



1 Building

2 Outdoor space

3 Transport infrastructure

4 Water bodies and watercourses

5 Rural and agroforestry

6 Coast and coastline

## Renaturalisation or greening as a basis for NBS interventions

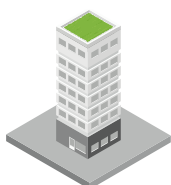
The renaturalisation or greening of spaces, an intervention that can involve anything from removing the pavement from a previously asphalted space to merely increasing vegetation, is considered in this classification as the central action at any of the scales of intervention. Furthermore, the tree is a key component in addressing climate threats and providing environmental, social, and economic co-benefits; as the EU Biodiversity Strategy

for 2030 indicates, tree planting is particularly beneficial in urban areas as they strive to adapt to the new climate reality. As a result, naturalisation interventions with trees are given a key role in this document which places them at the heart of the vast majority of the NBS interventions included in this catalogue.

We recommend consulting the manual on the design of sustainable gardens and green areas published by Ihobe in 2017<sup>28</sup> regarding renaturalisation interventions.

### EXAMPLES OF SPACES WITH RENATURALISATION POTENTIAL (corresponding to different scales of intervention)

Green roofs



Renaturalisation of courtyards



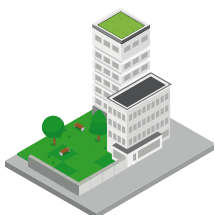
Renaturalisation of school playgrounds



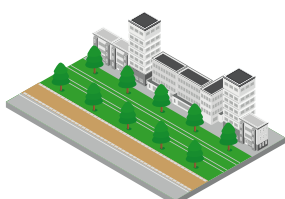
Comfortable squares



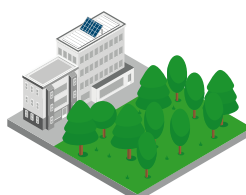
Renaturalisation of opportunity spaces / degraded spaces



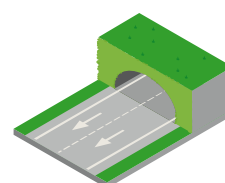
Renaturalisation of transport infrastructure



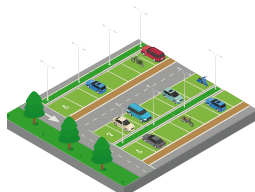
Urban parks and forests



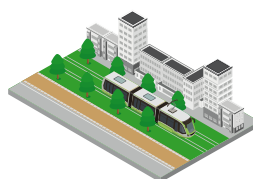
Greening of spaces under viaducts / Climate havens



Car park permeabilisation



Greening of urban railway tracks



<sup>28</sup> Udalsarea21 Notebook No. 20b. Manual for the design of sustainable gardens and green areas. Ihobe 2017. <https://www.ihobe.eus/publicaciones/cuaderno-udalsarea21-n-20b-manual-para-diseno-jardines-y-zonas-verdes-sostenibles-2>.

## 1 Interventions at building scale

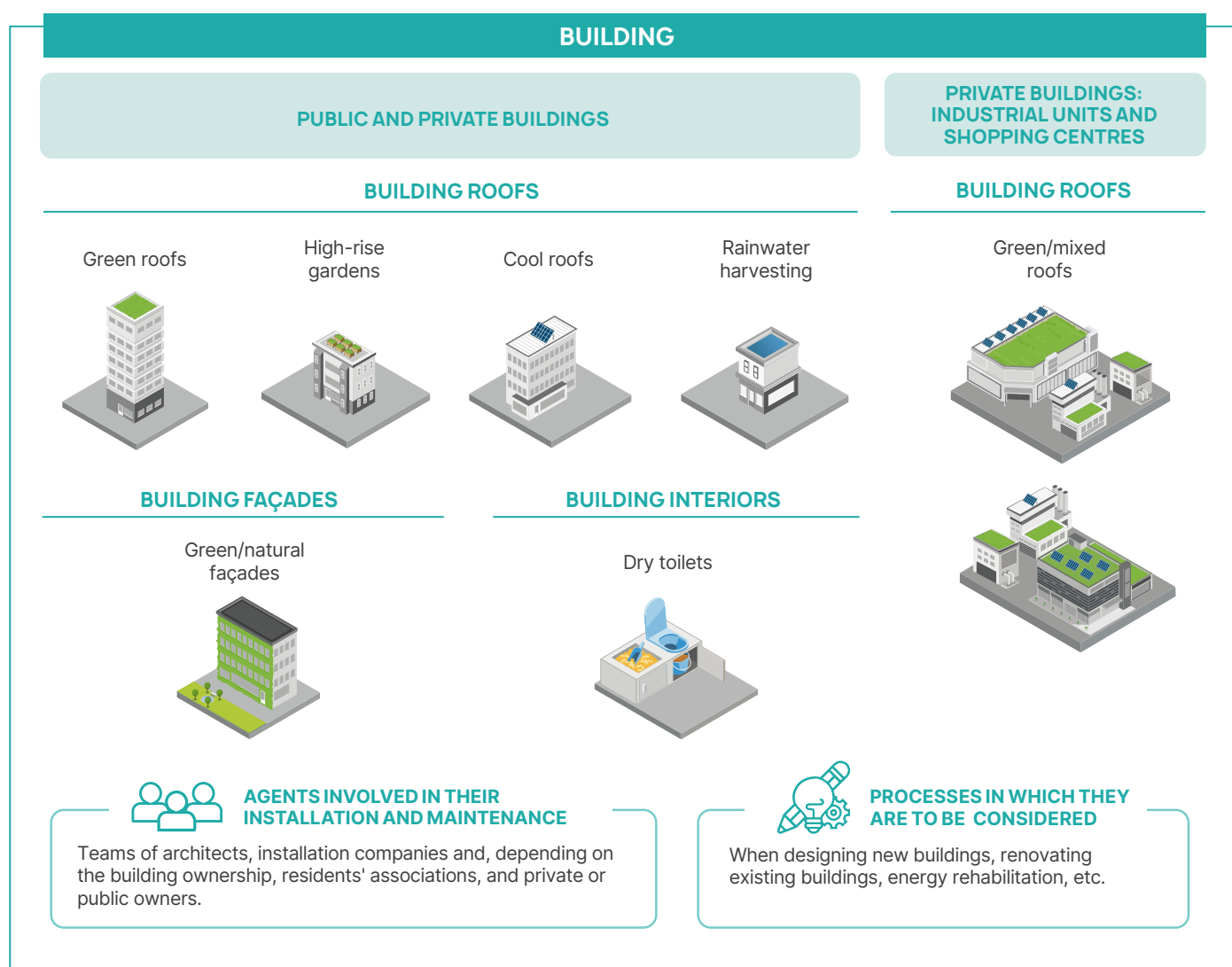
At the building scale, NBS can be applied to both public and privately owned buildings, examples of the latter being industrial, commercial or residential buildings. In buildings, regardless of their typology, the constructive elements on which NBS can be applied are the following:

- Roofs: building roofs can accommodate various arrangements combining vegetated areas with or without horticultural production, solar gain, and even rainwater harvesting and storage. We recommend consulting the *Guide to living terrace roofs and roof gardens published by Barcelona City Council in 2015*<sup>29</sup>.

The potential for implementing this type of solution in industrial pavilions, shopping centres and hypermarkets is worth highlighting given the vast extension of this type of roof and its arrangement, which is normally flat. Roofed car parks can also include vegetation or solar gain.

- Façades: buildings façades are another potential area for greening, either through green façades or by individually planting vegetation on balconies.

- Building interiors: dry toilets and rainwater harvesting systems are considered as NBS inside buildings.

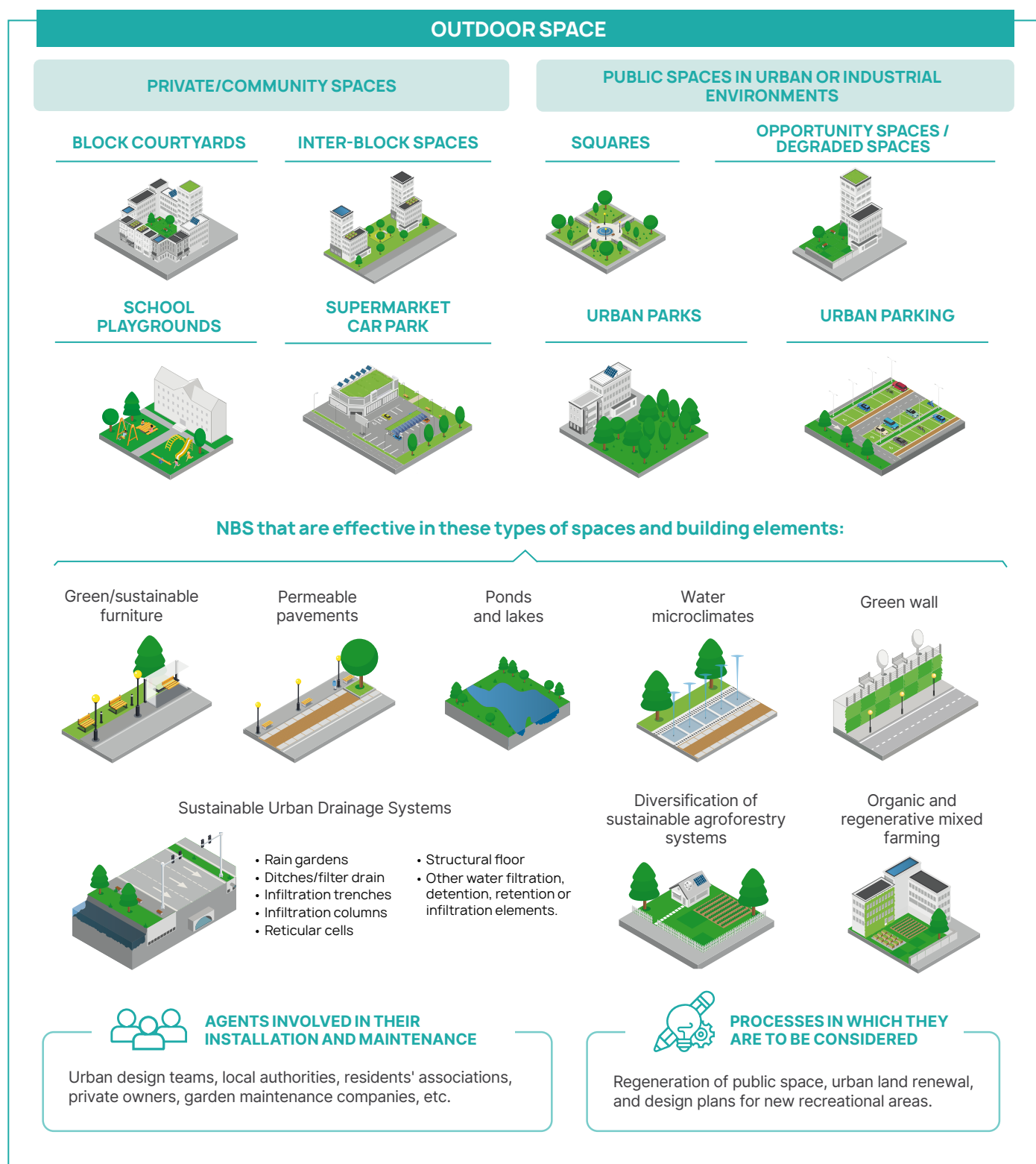


<sup>29</sup> Guide to living terrace roofs and green roofs. Barcelona City Council 2015. <https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/98795>



## 2 Interventions in outdoor space

There are different types of intervention depending on the ownership and location of the outdoor spaces: private or community spaces, public spaces, or private outdoor spaces in industrial or commercial environments. In the first case, action can be taken in community courtyards, inter-block spaces or school playgrounds. In public spaces, whether they are located in urban, peri-urban, or industrial areas, action can be taken in squares, parks, streets, degraded spaces, car parks, etc.



While it is true that the ownership of the spaces is diverse, the constructive elements that are intervened on are common; the NBS can be deployed to increase vegetation, for naturalising or greening, to install green urban furniture, to create or improve existing water features, or to act on pavements or drainage systems.

- Implementation of green or sustainable urban furniture, including items that use water as an element to improve thermal perception on hot days.
- Creation or improvement of water bodies such as lakes, ponds or artificial wetlands.
- Permeabilisation of surfaces, by removing pavement or asphalt, opting for permeable pavements, or using sustainable urban drainage systems which may consist of one or more of the following elements: rain gardens, drainage ditches, filter trenches, infiltration wells, drainage cells, structural soil or other water filtration, detention, retention or infiltration elements. We recommend consulting the guide on SUDS published by the Government of Navarre in 2023<sup>30</sup> and the two previously cited guides<sup>27, 28</sup> for further details on the technical design of SUDS.

The potential to permeabilise and implement SUDS in parking areas in industrial areas, shopping centres and supermarkets is worth highlighting, due to their extension.

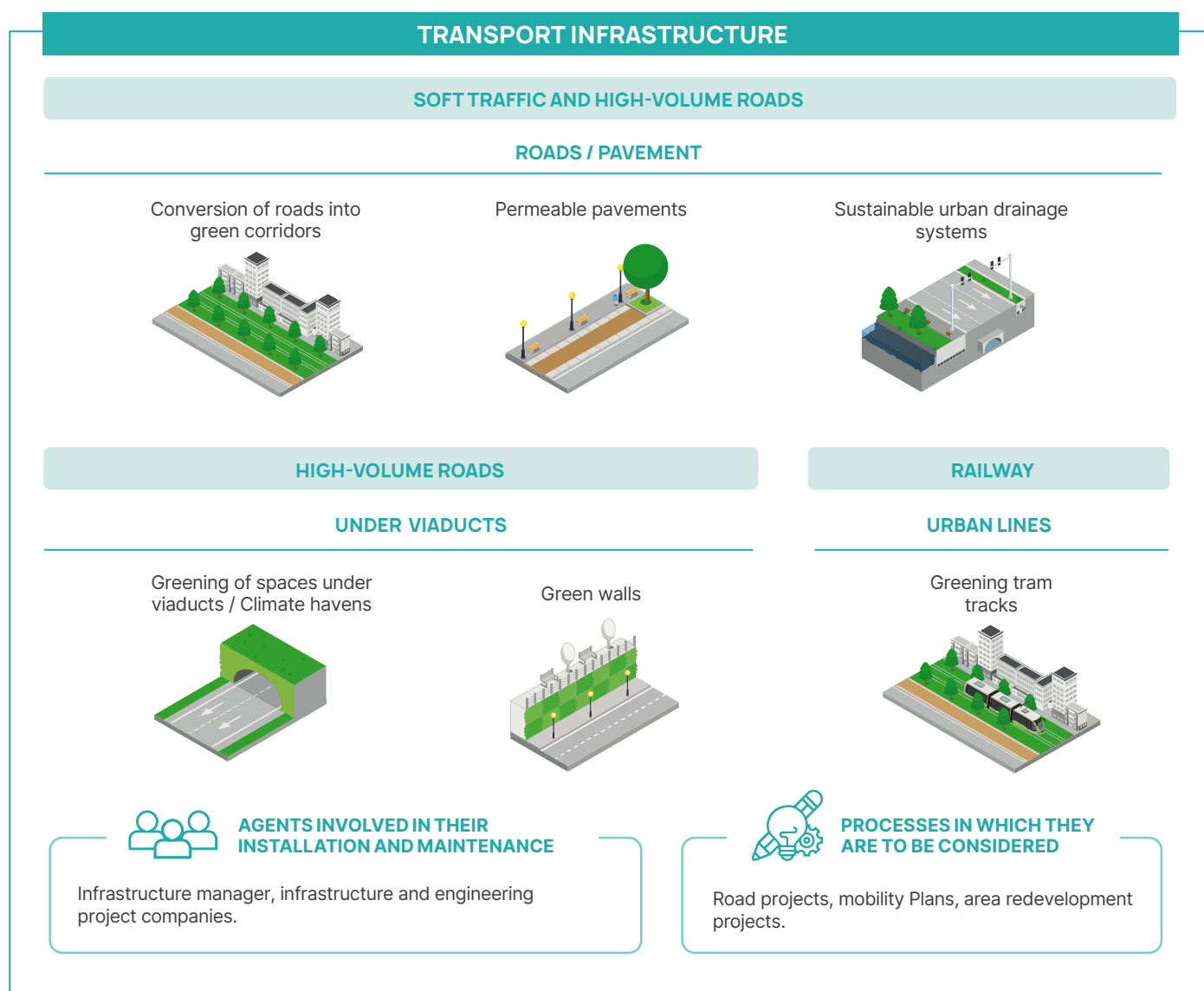
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<sup>30</sup> Basic recommendations. Design of Sustainable Urban Drainage Systems in Navarre (SUDS). Government of Navarre, 2023. [2023-feb-guia-drenaje-nilsa.pdf](#)

### 3 Transport infrastructure interventions

The renaturalisation of linear transport infrastructures can be a measure to revitalise urban areas and make them more resilient in increasingly dense and populated cities. The following are some nature-based interventions that can be effective in different types of space at this scale.

- Linear soft traffic infrastructures: interventions that normally occur in urban centres and that can be combined with works carried out on streets and pavements to increase vegetation and use permeable pavements or SUDS. For example, converting traffic routes into green corridors or green areas is therefore an increasingly common trend in cities that is very effective from the point of view of climate mitigation and adaptation.
- High-capacity infrastructure: in these cases, the renaturalisation or permeabilisation of the pavements used in these infrastructures is usually more complex due to their construction requirements. However, one intervention that can be of great benefit to people's well-being is the greening of spaces under the viaducts of these infrastructures. This is a way to convert these shady spaces into ideal climate shelters on hot days.
- Railway infrastructure: interventions on railway lines that run through urban environments, using vegetation or greening tram tracks for example.



## 4 Interventions on water bodies and watercourses

Interventions on water bodies and watercourses promote connectivity across all dimensions of rivers (longitudinal, transverse and vertical) and can be undertaken on the following elements:

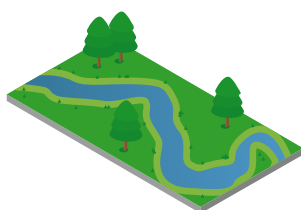
- Watercourses: the longitudinal connectivity of watercourses can be improved by removing existing barriers such as dams and weirs. Removing barriers that are no longer in use is of particular interest.
- Riverbanks: improving riverbank vegetation improves the state of conservation of the river ecosystem itself and its surroundings.
- Flood plains: this applies to channelled rivers flowing through the built environment of towns and cities. Removing these channels and greening the riverbed in undeveloped areas to favour controlled flooding during high river flows is a measure that reduces the risk of flooding the urban fabric. Flood forests or flood plains are created in this way.
- Wetlands: restoring and improving wetlands is an important climate action measure, as wetlands have carbon sequestration capacity and can act as a barrier to extreme events such as heavy rainfall and flooding.

It should be noted that these actions normally take place in areas shared between municipal entities and the entity that manages the water bodies, the Basque Water Agency (URA), in the case of the Basque Country. Inter-institutional coordination in these cases is essential for the successful implementation of such interventions.

### WATER BODIES AND WATERCOURSES

#### RIVER COURSES

Removal of barriers in watercourses (dams / weirs)



#### AGENTS INVOLVED IN THEIR INSTALLATION AND MAINTENANCE

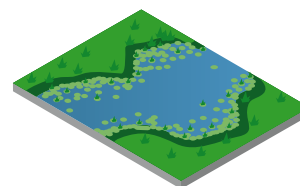
Basque Water Agency (URA), local administrations, and water solution and river restoration companies.

#### RIVER BANKS / FLOOD PLAINS

Forests / controlled floodplains



Wetlands



#### PROCESSES IN WHICH THEY ARE TO BE CONSIDERED

Renaturalisation and recovery processes for watercourses and wetlands.

## 5 Interventions in rural and agroforestry environments

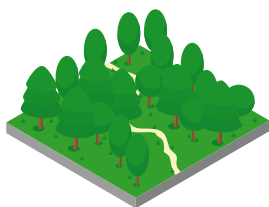
Various actions can be implemented within this scale of intervention, ranging from sustainable forest management to regenerative mixed farming, and the diversification of sustainable agroforestry systems.

Installing phyto-purification systems in dispersed rural population centres can be a very efficient NBS in areas where there is no access to the municipal sewerage network.

### RURAL AND AGROFORESTRY

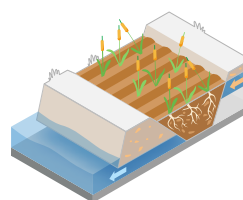
#### FOREST PLANTATIONS

Restoration / reforestation  
with native species



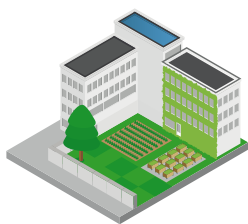
#### SCATTERED POPULATION CENTRES

Phyto-purification systems

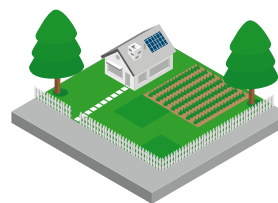


#### AGRICULTURAL AREAS

Organic and regenerative  
mixed farming



Diversification of sustainable  
agroforestry systems



#### AGENTS INVOLVED IN THEIR INSTALLATION AND MAINTENANCE

Local administrations, rural/agroforestry area managers, land stewardship organisations, companies and associations in the primary sector.



#### PROCESSES IN WHICH THEY ARE TO BE CONSIDERED

Master plans for the use and management of spaces, public space plans, green belt strategies, plans to promote the primary sector, etc.

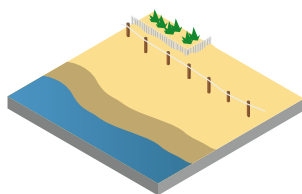
## 6 Coastal interventions

On the coastline or waterfront, adaptation measures are aimed at slowing the advancing coastline and improving the resilience of the waterfront to the action of the waves and coastal flooding. Interventions on beaches are aimed at reducing erosion COusing dune systems or sand banks. Cliff stabilisation using bioengineering techniques and appropriate land-use management and planning is another effective climate adaptation measure. Finally, reclaiming estuarine marshes, historically used for other purposes such as agriculture, is another measure that contributes to reducing the flooding of coastal areas while improving the resilience of the area and capturing CO<sub>2</sub>.

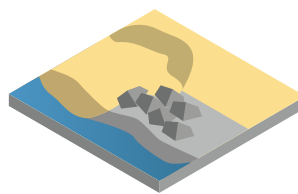
### COAST AND COASTLINE

#### BEACHES

Restauración de dunas

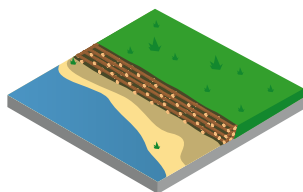


Regeneración / estabilización de playas

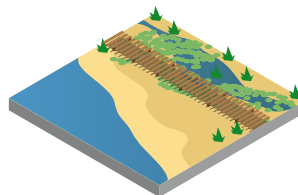


#### COASTLINE/COASTAL STRIP (INCLUDING CLIFFS AND ESTUARIES)

Renaturalisation / stabilisation of cliffs



Regeneration of marshes and coastal wetlands



#### AGENTS INVOLVED IN THEIR INSTALLATION AND MAINTENANCE

Ministerial Coastal and Marine Environment Area at State level, Provincial Councils, and local administrations.



#### PROCESSES IN WHICH THEY ARE TO BE CONSIDERED

Coastal restoration and improvement plans, Integrated Coastal Area Management Plans, Sectoral Territorial Plans, etc.

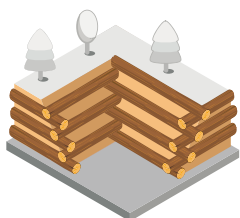
## Other cross-cutting interventions

Phyto-purification systems and bioengineering techniques for wall stabilisation may be more common in rural areas, but they are types of NBS that can be implemented at any scale, so they are added as cross-cutting NBS.

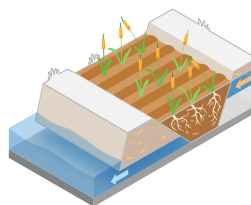
Phyto-purification systems are effective in treating effluents of different nature such as sewage or storm water with pollutants from road traffic.

### TRANSVERSAL

Bioengineering techniques  
(permeable walls)



Phyto-purification  
systems



### CONSIDERATIONS FOR THE USER/READER

The NBS and the classification shown in this document are intended to serve as an inspiration for technical municipal staff and other agents involved in deploying the NBS. The aim is also to show the versatility and the multiple options provided by implementing this type of solutions.

We recommend consulting the descriptive sheets in Annex I of the document "Nature-based solutions for local climate adaptation in the Basque Country" or specific technical documents cited throughout the text for further information on NBS.

See table 1 on the possibilities of implementing NBS at different scales of intervention for different types of spaces using different constructive elements.



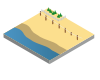
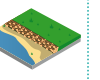
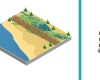
**TABLE 1.** Potential application of the different NBS depending on the scale of intervention, type of space, and constructive element

| INTERVENTION SCALE             | TYPE OF SPACE                                    | CONSTRUCTIVE ELEMENT                                                              | Renaturalisation/<br>greening and<br>TREE PLANTING                                | Green or mixed<br>roofs / vegetable<br>gardens                                    | Green / natural<br>façades                                                         | Dry toilets                                                                         | Rainwater<br>harvesting                                                             | Green /<br>sustainable<br>street furniture                                          |
|--------------------------------|--------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                |                                                  |                                                                                   |  |  |  |  |  |  |
| BUILDING                       | Public, private, industrial or commercial centre | Roofs                                                                             | ●                                                                                 | ●                                                                                 |                                                                                    |                                                                                     | ●                                                                                   |                                                                                     |
|                                |                                                  | Façades                                                                           | ●                                                                                 |                                                                                   | ●                                                                                  |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Interior                                                                          | ●                                                                                 |                                                                                   |                                                                                    | ●                                                                                   | ●                                                                                   |                                                                                     |
| OUTDOOR SPACE                  | Private/<br>community space                      | Block courtyards                                                                  | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     | ●                                                                                   | ●                                                                                   |
|                                |                                                  | Private community spaces, inter-block spaces                                      | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     | ●                                                                                   | ●                                                                                   |
|                                |                                                  | School playgrounds                                                                | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     | ●                                                                                   | ●                                                                                   |
|                                |                                                  | Car parks in commercial and industrial areas                                      | ●                                                                                 |                                                                                   |                                                                                    | ●                                                                                   | ●                                                                                   | ●                                                                                   |
|                                | Public, industrial and commercial outdoor space  | Squares, parks                                                                    | ●                                                                                 | ●                                                                                 |                                                                                    | ●                                                                                   | ●                                                                                   | ●                                                                                   |
|                                |                                                  | Opportunity spaces and/or degraded spaces                                         | ●                                                                                 |                                                                                   |                                                                                    | ●                                                                                   | ●                                                                                   | ●                                                                                   |
|                                |                                                  | Streets                                                                           | ●                                                                                 |                                                                                   |                                                                                    | ●                                                                                   | ●                                                                                   | ●                                                                                   |
|                                |                                                  | Public car parks                                                                  | ●                                                                                 | ●                                                                                 |                                                                                    | ●                                                                                   | ●                                                                                   | ●                                                                                   |
| TRANSPORT INFRASTRUCTURE       | Low capacity road                                | Roads and their elements (roundabouts, medians, embankments, road surfaces, etc.) | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   |
|                                | High capacity road                               | Under viaducts                                                                    | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   |
|                                | Railway                                          | Tramway                                                                           | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
| WATER BODIES AND WATER-COURSES |                                                  | River courses                                                                     | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Forests / controlled flood plains                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
| RURAL AND AGROFORESTRY         |                                                  | Dispersed population areas                                                        | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Agricultural areas                                                                | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Forest plantations                                                                | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
| COASTLINE                      |                                                  | Beaches                                                                           | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Estuaries                                                                         | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |
|                                |                                                  | Coastline / coastal strip including the built environment                         | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |

## Nature-Based Solutions in the Basque Country

[illegible]

[.../...]

| ESCALE                        | TYPE OF SPACE                                             | CONSTRUCTIVE ELEMENT                         | Restoration / reforestation with native species                                   | Organic/ regenerative mixed farming                                               | Diversification of sustainable agroforestry systems                               | Dune restoration                                                                  | Beach regeneration and stabilisation                                               | Renaturalisation/ stabilisation of cliffs                                           | Regeneration of marsh                                                               | Bioengineering techniques (permeable walls)                                         | Phyto-purification systems                                                          |
|-------------------------------|-----------------------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                               |                                                           |                                              |  |  |  |  |  |  |  |  |  |
| BUILDING                      | Public, private, industrial or commercial centre          | Roofs                                        |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|                               |                                                           | Façades                                      |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|                               |                                                           | Interior                                     |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| OUTDOOR SPACE                 | Private/ community space                                  | Block courtyards                             |                                                                                   | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     | ●                                                                                   |
|                               |                                                           | Private community spaces, inter-block spaces |                                                                                   | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     | ●                                                                                   |
|                               |                                                           | School playgrounds                           |                                                                                   | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     | ●                                                                                   |
|                               |                                                           | Car parks in commercial and industrial areas |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|                               | Public, industrial and commercial outdoor space           | Squares, parks                               |                                                                                   | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
|                               |                                                           | Opportunity spaces and/or degraded spaces    |                                                                                   | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
|                               |                                                           | Streets                                      |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
|                               |                                                           | Public car parks                             |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
| TRANSPORT INFRASTRUCTURE      | Low capacity road                                         | Roads and their elements                     |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     | ●                                                                                   |
|                               | High capacity road                                        | Under viaducts                               |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     | ●                                                                                   |
|                               | Railway                                                   | Tramway                                      |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| WATERBODIES AND WATER-COURSES | River courses                                             |                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   |                                                                                     |
|                               | Forests / controlled flood plains                         |                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
| RURAL AND AGROFORESTRY        | Dispersed population areas                                |                                              | ●                                                                                 | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
|                               | Agricultural areas                                        |                                              | ●                                                                                 | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
|                               | Forest plantations                                        |                                              | ●                                                                                 | ●                                                                                 | ●                                                                                 |                                                                                   |                                                                                    |                                                                                     |                                                                                     | ●                                                                                   | ●                                                                                   |
| COASTLINE                     | Beaches                                                   |                                              |                                                                                   |                                                                                   |                                                                                   | ●                                                                                 | ●                                                                                  |                                                                                     | ●                                                                                   | ●                                                                                   |                                                                                     |
|                               | Estuaries                                                 |                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                    |                                                                                     | ●                                                                                   |                                                                                     |                                                                                     |
|                               | Coastline / coastal strip including the built environment |                                              |                                                                                   |                                                                                   |                                                                                   | ●                                                                                 |                                                                                    | ●                                                                                   |                                                                                     | ●                                                                                   |                                                                                     |

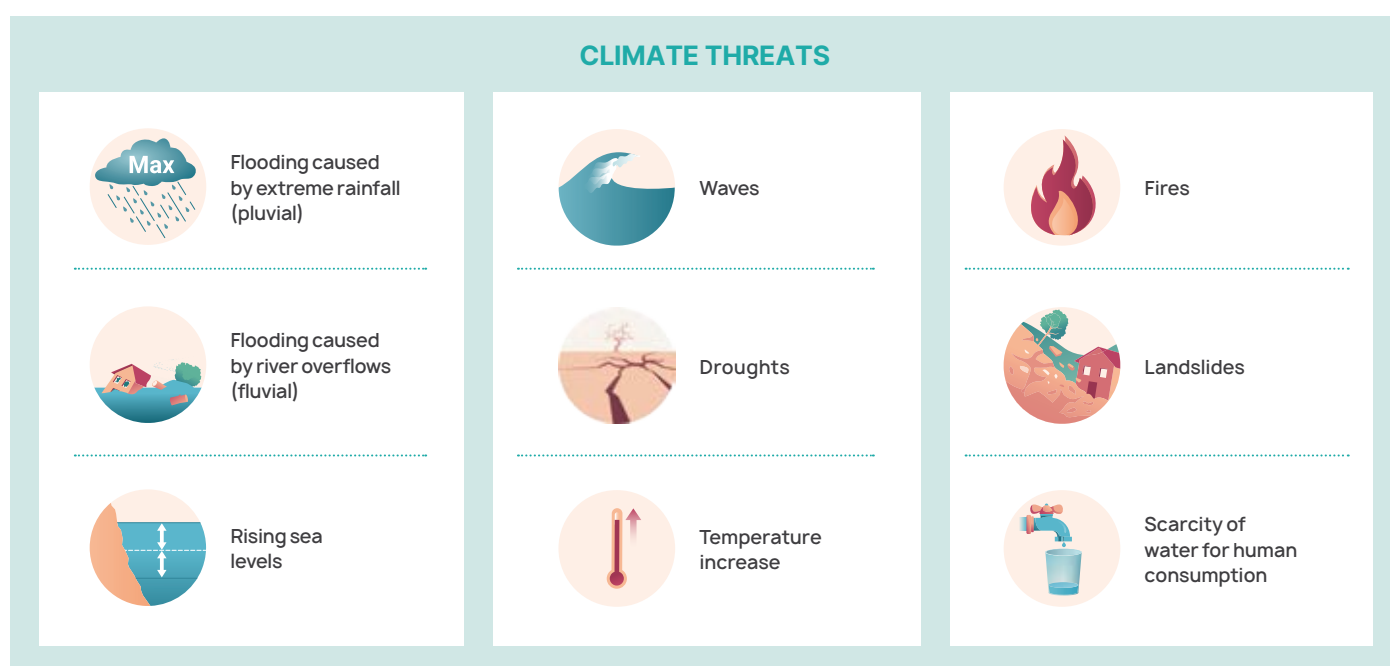
### 3.3. Characterisation of Nature-Based Solutions based on climate threats and co-benefits

NBS should be characterised in terms of the climate threats they address and the co-benefits they are expected to provide once implemented as a way to show-case their potential for climate adaptation and multi-functionality.

In the case of climate threats, they have been prioritised based on several reports on climate

in Europe<sup>31</sup>, assessed in combination with the reality of the Basque region and the different diagnoses on which Basque climate planning<sup>32</sup> has been based since 2015. As a result, two new climate threats have been added to the seven considered in the previous guide: landslides and the scarcity of water for human consumption.

**FIGURE 6 .** Climate threats based on which the NBS compiled in this catalogue are characterised



The following table (Table 2) displays the extent to which each NBS contributes to reducing the effects of the identified climate

threats. The intensity of this contribution is shown in the following scale:



<sup>31</sup> State of the climate in Europe 2022. World Meteorological Organization. [https://library.wmo.int/viewer/66206?medianame=1320\\_State\\_of\\_the\\_Climate\\_in\\_Europe\\_2022\\_en\\_%23page=1&viewer=picture&o=bookmark&n=0&q=](https://library.wmo.int/viewer/66206?medianame=1320_State_of_the_Climate_in_Europe_2022_en_%23page=1&viewer=picture&o=bookmark&n=0&q=)

European State of the Climate 2021. The Copernicus Programme. European Commission. <https://climate.copernicus.eu/esotc/2021>

<sup>32</sup> Basque Climate Change Strategy 2050. [https://www.euskadi.eus/contenidos/documentacion/klima2050/en\\_def/adjuntos/KLIMA2050\\_en.pdf](https://www.euskadi.eus/contenidos/documentacion/klima2050/en_def/adjuntos/KLIMA2050_en.pdf)

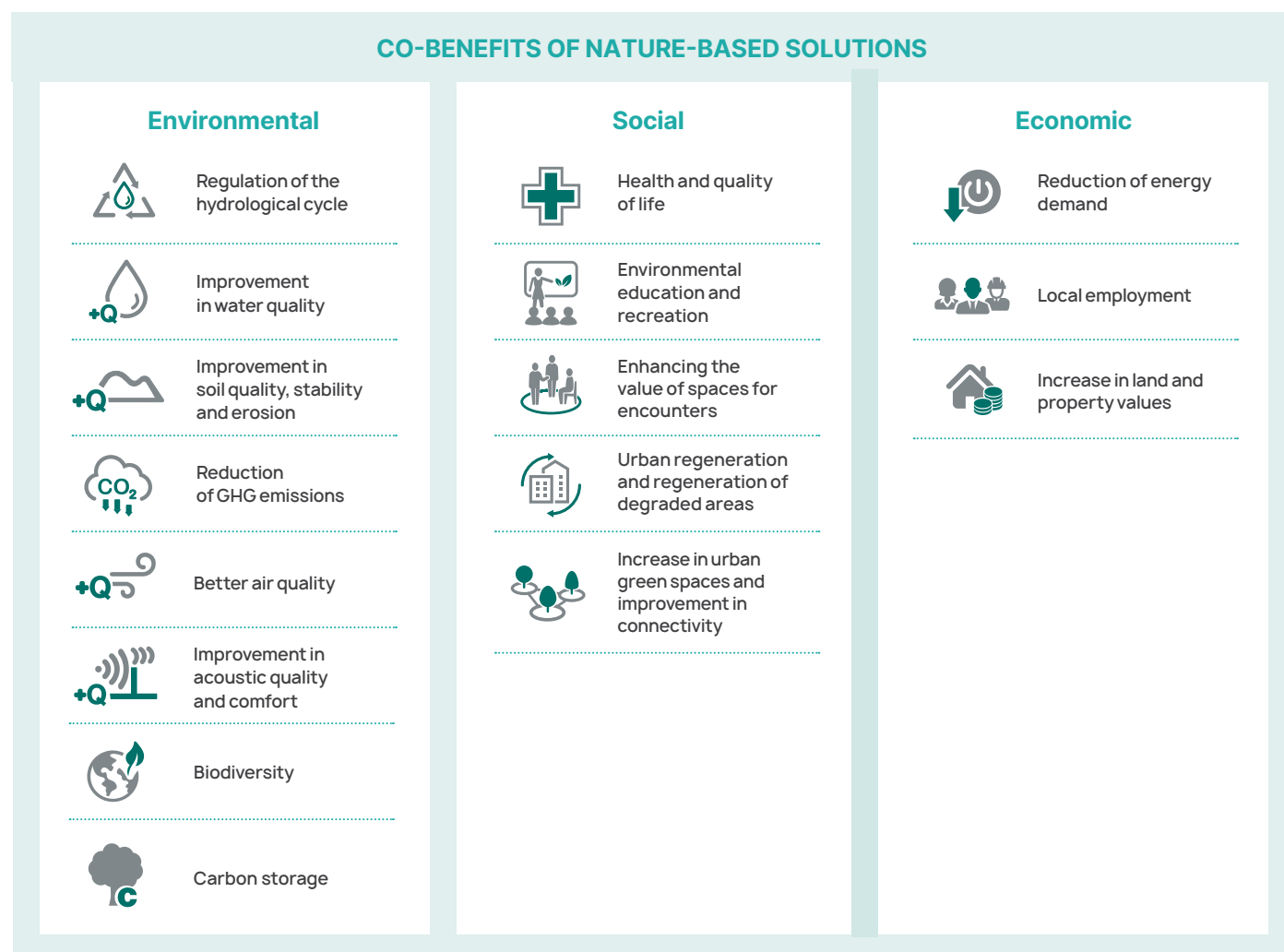
**TABLE 2.** Contribution of the NBS to reducing the effects of the different climate threats identified for the Basque Country

| CLIMATE THREATS                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                              |  |  |  |  |  |  |  |  |  |
| <b>BUILDING</b>                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Green roofs                                                  | 2                                                                                 | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Vegetable gardens                                            | 1                                                                                 | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Cool roofs                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Rainwater harvesting                                         | 2                                                                                 | 1                                                                                 |                                                                                   | 2                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     | 3                                                                                   |
| Dry toilets                                                  |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     | 3                                                                                   |
| Green/natural façades                                        | 2                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| <b>OUTDOOR SPACE</b>                                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of block courtyards                         | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of inter-block spaces                       | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of school playgrounds                       | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Comfortable squares                                          | 2                                                                                 | 1                                                                                 |                                                                                   |                                                                                   | 1                                                                                 | 3                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Renaturalisation of plots of land and opportunity spaces     | 3                                                                                 | 2                                                                                 |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Parks and urban forests                                      | 3                                                                                 | 1                                                                                 | 1                                                                                 |                                                                                   | 1                                                                                 |                                                                                     | 1                                                                                   | 1                                                                                   |                                                                                     |
| Car park permeabilisation                                    | 3                                                                                 | 1                                                                                 | 1                                                                                 |                                                                                   | 1                                                                                 | 1                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Green street furniture                                       | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Permeable pavements                                          | 3                                                                                 | 1                                                                                 | 1                                                                                 |                                                                                   | 1                                                                                 | 1                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Sustainable Urban Drainage Systems (SUDs)                    | 3                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   | 1                                                                                 |                                                                                     |                                                                                     |                                                                                     | 2                                                                                   |
| Improvement or creation of water bodies                      | 3                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   | 2                                                                                 | 2                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Water micro-climates                                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Green wall                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   |                                                                                     | 2                                                                                   |                                                                                     |
| <b>TRANSPORT INFRASTRUCTURE</b>                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of linear soft-traffic infrastructures      | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Conversion of roads into green corridors                     | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   | 1                                                                                 | 3                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| Renaturalisation of high-capacity linear infrastructures     | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Re-greening of spaces under viaducts / climate shelter       | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Green tram                                                   | 3                                                                                 |                                                                                   |                                                                                   |                                                                                   | 1                                                                                 | 1                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| <b>WATER BODIES AND WATERCOURSES</b>                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of rivers and streams (removal of barriers) | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                   | 1                                                                                 | 1                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Forests / controlled flood plains                            | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   | 1                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Wetlands                                                     | 3                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   | 1                                                                                 | 2                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |
| <b>RURAL AND AGROFORESTRY</b>                                |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Restoration / reforestation with native species              | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   | 2                                                                                 |                                                                                     | 3                                                                                   | 3                                                                                   |                                                                                     |
| Diversification of sustainable agroforestry systems          | 2                                                                                 | 2                                                                                 |                                                                                   |                                                                                   | 2                                                                                 | 1                                                                                   | 2                                                                                   |                                                                                     | 1                                                                                   |
| Organic/regenerative mixed farming                           | 2                                                                                 | 1                                                                                 |                                                                                   |                                                                                   | 2                                                                                 | 1                                                                                   | 1                                                                                   |                                                                                     |                                                                                     |
| <b>COASTLINE</b>                                             |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Dune restoration                                             |                                                                                   |                                                                                   | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Beach regeneration and stabilisation                         |                                                                                   |                                                                                   | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Regeneration of marshes and coastal wetlands                 |                                                                                   | 2                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation / stabilisation of cliffs                   |                                                                                   |                                                                                   | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   |                                                                                     |
| <b>TRANSVERSAL</b>                                           |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Bioengineering techniques (permeable walls)                  | 2                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   |                                                                                     | 3                                                                                   |                                                                                     |
| Phyto-purification systems                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     | 2                                                                                   |

With regard to co-benefits (see Figure 6), those identified in the previous guide have been taken into account and they have been updated to align them with those considered by the European Commission

in 2021<sup>33</sup> (refer to sections 1.2 and Annex I). The contribution of each type of NBS to providing environmental, social, and economic co-benefits is qualitatively described in Table 3.

**FIGURE 7.** Co-benefits based on which the NBS compiled in this catalogue are characterised



#### CONSIDERATIONS FOR THE USER/READER

The NBS have been characterised based on their contribution to responding to the identified climate threats, as well as the degree to which they provide environmental, social and economic benefits, qualitatively categorising this contribution as high, medium, or low.

This information aims to provide a simple and visual way of understanding what main climate responses and co-benefits can be achieved through each of the interventions.

<sup>33</sup> European Commission, Directorate-General for Research and Innovation, Evaluating the impact of nature-based solutions – A summary for policy makers, Publications Office, 2021, <https://data.europa.eu/doi/10.2777/521937>

TABLE 3. Environmental, social, and economic co-benefits provided by different types of NBS

| CO-BENEFITS                                                  |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                              | Environmental                                                                     |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
|                                                              |  |  |  |  |  |  |  |  |
| <b>BUILDING</b>                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Green roofs                                                  | 2                                                                                 | 3                                                                                 |                                                                                   | 2                                                                                 | 1                                                                                   | 3                                                                                   | 3                                                                                   | 1                                                                                   |
| Vegetable gardens                                            | 1                                                                                 |                                                                                   |                                                                                   | 1                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |                                                                                     |
| Cool roofs                                                   |                                                                                   |                                                                                   |                                                                                   | 3                                                                                 |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Rainwater harvesting                                         | 3                                                                                 |                                                                                   |                                                                                   | 1                                                                                 |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Dry toilets                                                  | 3                                                                                 |                                                                                   |                                                                                   | 2                                                                                 |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Green/natural façades                                        | 1                                                                                 |                                                                                   |                                                                                   | 3                                                                                 | 1                                                                                   | 2                                                                                   | 2                                                                                   |                                                                                     |
| <b>OUTDOOR SPACE</b>                                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of block courtyards                         | 3                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                   | 2                                                                                   | 1                                                                                   | 2                                                                                   | 2                                                                                   |
| Renaturalisation of inter-block spaces                       | 3                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                   | 2                                                                                   | 1                                                                                   | 2                                                                                   | 2                                                                                   |
| Renaturalisation of school playgrounds                       | 3                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                   | 2                                                                                   |                                                                                     | 2                                                                                   | 2                                                                                   |
| Comfortable squares                                          | 2                                                                                 | 1                                                                                 | 1                                                                                 |                                                                                   | 1                                                                                   | 1                                                                                   | 2                                                                                   | 1                                                                                   |
| Renaturalisation of plots of land and opportunity spaces     | 2                                                                                 | 1                                                                                 | 3                                                                                 |                                                                                   | 1                                                                                   | 1                                                                                   | 2                                                                                   | 2                                                                                   |
| Parks and urban forests                                      | 2                                                                                 | 2                                                                                 | 3                                                                                 | 1                                                                                 | 3                                                                                   | 2                                                                                   | 3                                                                                   | 3                                                                                   |
| Car park permeabilisation                                    | 2                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Green street furniture                                       |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   | 1                                                                                   | 1                                                                                   |                                                                                     |
| Permeable pavements                                          | 2                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Sustainable Urban Drainage Systems (SUDs)                    | 3                                                                                 | 3                                                                                 | 1                                                                                 |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Improvement or creation of water bodies                      | 2                                                                                 | 2                                                                                 |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   |                                                                                     |
| Water micro-climates                                         | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 1                                                                                   |                                                                                     |
| Green wall                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   | 3                                                                                   | 2                                                                                   |                                                                                     |
| <b>TRANSPORT INFRASTRUCTURE</b>                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of linear soft-traffic infrastructures      | 3                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                   | 3                                                                                   | 2                                                                                   | 3                                                                                   |
| Conversion of roads into green corridors                     | 2                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                   | 3                                                                                   | 3                                                                                   | 3                                                                                   |
| Renaturalisation of high-capacity linear infrastructures     | 3                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                   | 3                                                                                   | 2                                                                                   | 3                                                                                   |
| Re-greening of spaces under viaducts / climate shelter       | 1                                                                                 |                                                                                   |                                                                                   | 2                                                                                 | 2                                                                                   | 2                                                                                   | 3                                                                                   | 1                                                                                   |
| Green tram                                                   | 2                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   | 1                                                                                   |                                                                                     | 1                                                                                   | 1                                                                                   |
| <b>WATER BODIES AND WATERCOURSES</b>                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of rivers and streams (removal of barriers) | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   | 1                                                                                   |
| Forests / controlled flood plains                            | 3                                                                                 |                                                                                   | 1                                                                                 |                                                                                   |                                                                                     |                                                                                     | 2                                                                                   | 1                                                                                   |
| Wetlands                                                     | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   | 2                                                                                   |
| <b>RURAL AND AGROFORESTRY</b>                                |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Restoration / reforestation with native species              | 3                                                                                 | 3                                                                                 | 3                                                                                 | 1                                                                                 |                                                                                     |                                                                                     | 3                                                                                   | 3                                                                                   |
| Diversification of sustainable agroforestry systems          | 2                                                                                 | 1                                                                                 | 2                                                                                 |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   | 3                                                                                   |
| Organic/regenerative mixed farming                           | 2                                                                                 | 2                                                                                 | 3                                                                                 | 1                                                                                 | 1                                                                                   |                                                                                     | 2                                                                                   | 3                                                                                   |
| <b>COASTLINE</b>                                             |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Dune restoration                                             |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   | 1                                                                                   |
| Beach regeneration and stabilisation                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   |                                                                                     |
| Regeneration of marshes and coastal wetlands                 | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   |                                                                                     |                                                                                     | 3                                                                                   | 3                                                                                   |
| Renaturalisation / stabilisation of cliffs                   |                                                                                   |                                                                                   | 2                                                                                 |                                                                                   |                                                                                     |                                                                                     | 2                                                                                   |                                                                                     |
| <b>TRANSVERSAL</b>                                           |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |                                                                                     |
| Bioengineering techniques (permeable walls)                  | 2                                                                                 |                                                                                   | 3                                                                                 |                                                                                   |                                                                                     |                                                                                     | 2                                                                                   | 1                                                                                   |
| Phyto-purification systems                                   | 3                                                                                 | 3                                                                                 |                                                                                   | 2                                                                                 |                                                                                     |                                                                                     | 1                                                                                   | 1                                                                                   |

| CO-BENEFITS                                                  |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
|--------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                                                              | Social                                                                            |                                                                                   |                                                                                   |                                                                                   |                                                                                   | Economic                                                                            |                                                                                     |                                                                                     |
|                                                              |  |  |  |  |  |  |  |  |
| <b>BUILDING</b>                                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Green roofs                                                  | 2                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   | 2                                                                                   | 2                                                                                   |
| Vegetable gardens                                            | 2                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                   | 1                                                                                 | 1                                                                                   | 1                                                                                   | 2                                                                                   |
| Cool roofs                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   | 1                                                                                   | 2                                                                                   |
| Rainwater harvesting                                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                   | 3                                                                                   |                                                                                     |
| Dry toilets                                                  |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   | 3                                                                                   | 1                                                                                   |
| Green/natural façades                                        | 1                                                                                 | 2                                                                                 |                                                                                   | 1                                                                                 | 2                                                                                 | 3                                                                                   | 2                                                                                   | 2                                                                                   |
| <b>OUTDOOR SPACE</b>                                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of block courtyards                         | 3                                                                                 |                                                                                   |                                                                                   | 1                                                                                 | 3                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Renaturalisation of inter-block spaces                       | 3                                                                                 | 3                                                                                 | 3                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                     | 1                                                                                   | 3                                                                                   |
| Renaturalisation of school playgrounds                       | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                   | 3                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Comfortable squares                                          | 3                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Renaturalisation of plots of land and opportunity spaces     | 2                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                     |                                                                                     | 3                                                                                   |
| Parks and urban forests                                      | 3                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 | 1                                                                                   |                                                                                     | 2                                                                                   |
| Car park permeabilisation                                    |                                                                                   |                                                                                   |                                                                                   | 1                                                                                 | 1                                                                                 |                                                                                     | 3                                                                                   |                                                                                     |
| Green street furniture                                       | 1                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                   |                                                                                   |                                                                                     | 3                                                                                   | 1                                                                                   |
| Permeable pavements                                          |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     | 3                                                                                   |                                                                                     |
| Sustainable Urban Drainage Systems (SUDs)                    |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     | 3                                                                                   |                                                                                     |
| Improvement or creation of water bodies                      | 1                                                                                 | 1                                                                                 | 2                                                                                 | 1                                                                                 | 2                                                                                 |                                                                                     |                                                                                     | 1                                                                                   |
| Water micro-climates                                         | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                   |                                                                                   |                                                                                     | 1                                                                                   | 1                                                                                   |
| Green wall                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                 | 2                                                                                 |                                                                                     | 2                                                                                   | 1                                                                                   |
| <b>TRANSPORT INFRASTRUCTURE</b>                              |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of linear soft-traffic infrastructures      | 3                                                                                 | 3                                                                                 | 3                                                                                 | 2                                                                                 | 3                                                                                 |                                                                                     |                                                                                     | 3                                                                                   |
| Conversion of roads into green corridors                     | 3                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                     |                                                                                     | 3                                                                                   |
| Renaturalisation of high-capacity linear infrastructures     |                                                                                   | 1                                                                                 | 1                                                                                 | 2                                                                                 | 2                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Re-greening of spaces under viaducts / climate shelter       | 3                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Green tram                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     | 1                                                                                   |                                                                                     |
| <b>WATER BODIES AND WATERCOURSES</b>                         |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Renaturalisation of rivers and streams (removal of barriers) | 1                                                                                 | 1                                                                                 | 1                                                                                 | 1                                                                                 | 2                                                                                 |                                                                                     | 1                                                                                   | 2                                                                                   |
| Forests / controlled flood plains                            |                                                                                   | 2                                                                                 | 2                                                                                 | 1                                                                                 | 2                                                                                 |                                                                                     |                                                                                     | 2                                                                                   |
| Wetlands                                                     | 1                                                                                 | 2                                                                                 |                                                                                   |                                                                                   | 1                                                                                 |                                                                                     | 1                                                                                   |                                                                                     |
| <b>RURAL AND AGROFORESTRY</b>                                |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Restoration / reforestation with native species              | 1                                                                                 | 2                                                                                 |                                                                                   |                                                                                   | 2                                                                                 | 1                                                                                   | 1                                                                                   |                                                                                     |
| Diversification of sustainable agroforestry systems          | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   | 1                                                                                 |                                                                                     |                                                                                     |                                                                                     |
| Organic/regenerative mixed farming                           | 1                                                                                 | 1                                                                                 | 3                                                                                 | 2                                                                                 | 3                                                                                 | 1                                                                                   | 2                                                                                   | 1                                                                                   |
| <b>COASTLINE</b>                                             |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Dune restoration                                             | 2                                                                                 |                                                                                   |                                                                                   | 1                                                                                 | 2                                                                                 |                                                                                     | 2                                                                                   |                                                                                     |
| Beach regeneration and stabilisation                         | 2                                                                                 | 3                                                                                 | 3                                                                                 | 1                                                                                 | 2                                                                                 |                                                                                     | 2                                                                                   |                                                                                     |
| Regeneration of marshes and coastal wetlands                 | 2                                                                                 | 2                                                                                 | 2                                                                                 | 3                                                                                 | 3                                                                                 |                                                                                     | 2                                                                                   |                                                                                     |
| Renaturalisation / stabilisation of cliffs                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     | 2                                                                                   |                                                                                     |
| <b>TRANSVERSAL</b>                                           |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                   |                                                                                     |                                                                                     |                                                                                     |
| Bioengineering techniques (permeable walls)                  |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 1                                                                                 |                                                                                     | 3                                                                                   |                                                                                     |
| Phyto-purification systems                                   | 1                                                                                 |                                                                                   |                                                                                   |                                                                                   |                                                                                   | 2                                                                                   | 3                                                                                   |                                                                                     |



# NATURE-BASED SOLUTIONS IN THE BASQUE COUNTRY. CATALOGUE OF INTERVENTIONS 2017-2024

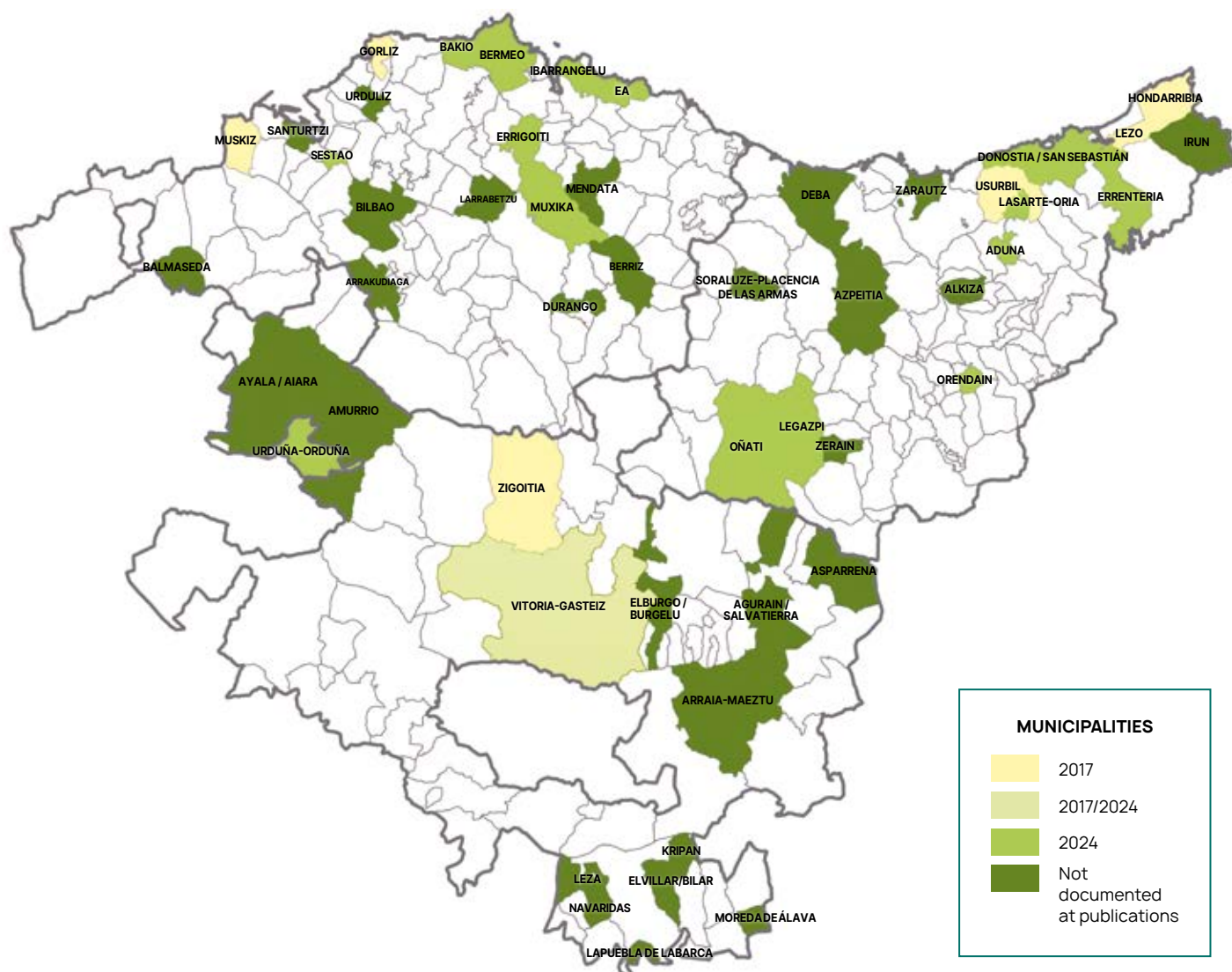
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The following is a selection of interventions promoted by several Basque municipalities in which NBS have been incorporated for climate adaptation. Most of them have been financed or at least co-financed through the instruments listed in section 2.2 and implemented after 2017, in almost all cases, when "Selection of nature based solutions. Good practices in the Basque Autonomous Community" was published. The practices documented in the good practice guide published in 2017 and those developed in this catalogue are shown in different shades in the map in Figure 7. The municipality of Vitoria-Gasteiz is the only one that has practices included in both publications, and there are other municipalities that have implemented NBS but they have not been documented to date.

A data sheet has been prepared for each of the interventions in the municipalities presented in this catalogue. These sheets have information and materials to serve as inspiration for replicating this type of solution in other parts of the region

(see Figure 8). Each sheet has an introductory section with generic data on the location, the implementation period, and the person/mode of contact, together with a brief contextualisation and motivation for carrying out the intervention, as well as a summary of the solution adopted. Details of the NBS incorporated are provided in the central part of the sheet, along with technical information to provide an idea of the technical complexity and the implementation and maintenance requirements of the adopted solutions. The contribution of each intervention to addressing the climate threats identified in the region, the co-benefits obtained from its implementation, and the contribution to the United Nations Sustainable Development Goals (SDGs) are indicated in the right-hand margin. Finally, specific practical information is provided on the financing and approximate cost of each intervention, other agents involved in addition to the developer, the barriers encountered, lessons learned, success factors, and how to reduce environmental impacts, where data is available. With this information, those interested in replicating practices will be able to

**FIGURE 8.** Basque municipalities in which NBS have been implemented and selection of interventions with NBS that are included in the catalogue



anticipate factors that are difficult to take into account using the theoretical framework.

The NBS interventions compiled below have been organised according to the intervention scales presented in section 3.2. Table 4 identifies the specific NBS implemented in each case (arranged by columns) for each of the municipal interventions selected in this catalogue (arranged in rows and grouped by scale). In addition, since renaturalisation and tree planting are the central element for the deployment of a large part of the NBS, the first column in Table 4 specifies the number of tree or shrub specimens used in the intervention and the

renaturalised area, as a way of highlighting their key role in addressing climate threats and providing environmental, social, and economic co-benefits.

As can be observed, the same intervention or project may contain more than one type of NBS classified at different scales of intervention. The project on the "Comprehensive refurbishment of the Natur Eskola School in Oñati using nature-based solutions" is a clear example of this. Although the project has been classified as a building-scale intervention, as the building is the main infrastructure on which action has been taken by implementing a green roof and dry toilets, other NBS have also been implemented

in the outdoor space, such as the permeable paving installed in the school playground and the phyto-purification system to treat wastewater.

The fact that the same project incorporates several NBS at different scales of intervention demonstrates the versatility and multi-functionality of these solutions. This demonstrates the possibility of combining multiple NBS to face different types of climate threats when taking an intervention, rehabilitation, or any type of project on, whether the project is public or private.

In addition, by providing the information on the interventions in the structure shown in the Table 4 users can easily identify in which projects the different types of NBS have been implemented

and thus appreciate the different ways different problems can be tackled with the same solution. For example, it can be observed in the table that phyto-purification systems have been implemented in various projects at different scales of intervention: on a building scale in the Natur Eskola School in Oñati to treat the grey water generated in the school; on the transport infrastructure scale with the renaturalisation of the Oiartzun river to treat the runoff water from the motorway before it is discharged into the river; and on the natural space scale, in Errigoiti o Merru, where there is no access to the municipal sewerage network.

The same NBS can adopt different implementation formulas depending on the specific needs in each case.

**FIGURE 9.** The structure of the sheet explaining each of the solutions included in this publication

 DEVELOPER
  LOCATION
  YEAR OF IMPLEMENTATION
  CONTACT

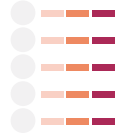
TITLE

CONTEXT

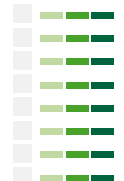

  
IMAGE

EXPLANATION OF THE NBS  
IN THE INTERVENTION  
OR  
PHASES OF  
IMPLEMENTATION  
OF THE NBS

CLIMATE THREATS



CO-BENEFITS

Environmental
 

Social
 

Economic
 

SDG



EXPLANATION OF THE NBS  
IN THE INTERVENTION  
OR  
PHASES OF  
IMPLEMENTATION  
OF THE NBS

TESTIMONY OF PERSON INVOLVED  
IN THE INTERVENTION


  
**Actors involved**  
Actors involved in the intervention,  
in addition to the developer


  
**Economic data**


  
**Barriers encountered**

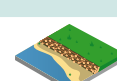

  
**Reduction of environmental impacts**  
(information available only in some interventions)


  
**Increase of green areas**


  
**Lessons learnt**

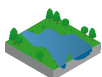
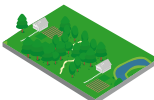
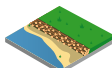

  
**Success factors**

**TABLE 4.** NBS interventions included in the catalogue, classified by intervention scale and the NBS they contain

|                                                                             |                                                                                                                                  | RENATURALISED SPACE                                                                                                      |              |                                               |                                                                                                                                 |
|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
|                                                                             |                                                                                                                                  | TYPE OF RENATURALISED SPACE OR ELEMENT TO BE ACTED UPON                                                                  | SURFACE (m²) | NUMBER OF TREES AND SHRUBS PLANTED            | Green or mixed roofs / vegetable gardens<br> |
| CLASSIFICATION OF NATURE-BASED INTERVENTIONS BY SCALE AND TYPOLOGY OF SPACE | BUILDING                                                                                                                         |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Comprehensive refurbishment of the Natur Eskola school in Oñati using NBS                                                        | Building<br>                            |              |                                               | 420 m²                                                                                                                          |
|                                                                             | Efficient construction of the Enerctic building in Donostia / San Sebastian following bioclimatic criteria                       |                                                                                                                          |              |                                               | 1.100 m²                                                                                                                        |
|                                                                             | PRIVATE OUTDOOR SPACES: SCHOOL PLAYGROUNDS                                                                                       |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Renaturalisation of the Orduña municipal public school playground                                                                | School playgrounds<br>                  | 1.736 m²     | 20 trees<br>120 shrubs<br>350 aromatic plants | 40 m²                                                                                                                           |
|                                                                             | Greening of the haurreskola Txagorritxu school playground in Vitoria-Gasteiz                                                     |                                                                                                                          | 245 m²       | 20 trees<br>57 arbustos<br>38 aromatic plants |                                                                                                                                 |
|                                                                             | PUBLIC OUTDOOR SPACES                                                                                                            |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Regeneration of an opportunity space to tackle heat through NBS in Aduna                                                         | Opportunity spaces<br>                  | 1.776 m²     | 22 trees<br>228 shrubs                        |                                                                                                                                 |
|                                                                             | Conversion of urban wasteland into fertile grassland through regenerative agro-agriculture in Sestao                             |                                                                                                                          | 14.580 m²    |                                               |                                                                                                                                 |
|                                                                             | Sustainable Urban Drainage Systems in the urban development of the Arteleku Square in Donostia / San Sebastian                   | Square<br>                              | 8.600 m²     | 52 trees                                      |                                                                                                                                 |
|                                                                             | Green roof and Sustainable Urban Drainage Systems in the Laubide children's playground in Legazpi                                |                                                                                                                          |              |                                               | 120 m²                                                                                                                          |
|                                                                             | Permeable car parks in the Ibarruri neighbourhood of Muxika                                                                      | Parking<br>                            | 1.040 m²     | 7 trees                                       |                                                                                                                                 |
|                                                                             | OUTDOOR SPACE INDUSTRIAL AREAS                                                                                                   |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Restoration of the industrial ruin of Urtubiaga into a multi-purpose area and a seasonal green parking area in Ea                | Opportunity spaces<br>                | 5.667 m²     | 48 trees                                      |                                                                                                                                 |
|                                                                             | Jundiz Park: green corridor to restore the soil and landscape surrounding the Jundiz industrial estate in Vitoria-Gasteiz        |                                                                                                                          | 430.000 m²   | 51.185 trees and shrubs                       |                                                                                                                                 |
|                                                                             | LINEAR TRANSPORT INFRASTRUCTURES                                                                                                 |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Renaturalisation of the river Oiartzun in an urban section covered by the motorway in Errenteria                                 | Opportunity spaces under viaducts<br> | 23.500 m²    | 75 trees                                      |                                                                                                                                 |
|                                                                             | Conversion of an urban traffic artery into a green corridor to improve thermal comfort along Maria Diaz de Haro street in Bilbao | Traffic roads<br>                     | 6.000 m²     | 50 trees                                      |                                                                                                                                 |
|                                                                             | WATER MASSES AND WATER COURSES                                                                                                   |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Riverside park to tackle flooding in the Txomin-Enea neighbourhood of Donostia / San Sebastian                                   | Flood plains<br>                      | 3 ha         |                                               |                                                                                                                                 |
|                                                                             | NATURAL SPACE AND RURAL ENVIRONMENT                                                                                              |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Phyto-purification system to treat wastewater in a rural environment in Errigoiti                                                | Dispersed population areas<br>        |              |                                               |                                                                                                                                 |
|                                                                             | Sub-surface flow wetland in the Merru neighbourhood of Ibarrangelu                                                               |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Reforestation using native species through land stewardship mechanisms in Bakio                                                  | Forest plantations<br>                | 5,7 ha       |                                               |                                                                                                                                 |
|                                                                             | Reforestation of the Oberan hills using native species in Donostia / San Sebastian                                               |                                                                                                                          | 19 ha        |                                               |                                                                                                                                 |
|                                                                             | Reforestation to improve the carbon sink capacity in Orendain using native species                                               |                                                                                                                          | 5,7 ha       |                                               |                                                                                                                                 |
|                                                                             | COASTLINE                                                                                                                        |                                                                                                                          |              |                                               |                                                                                                                                 |
|                                                                             | Recovery of a natural coastal space along the Tonpoi cliffs in Bermeo following climate criteria                                 | Coastline<br>                         | 1,4 ha       | 77 trees<br>1.500 shrubs                      |                                                                                                                                 |

## TYPES OF NATURE-BASED SOLUTIONS IMPLEMENTED IN EACH INTERVENTION

[illegible]

|                                                                             |                                                                                                                                  | RENATURALISED SPACE                                                                                                      |              |                                               |                                                                                                        |
|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|--------------|-----------------------------------------------|--------------------------------------------------------------------------------------------------------|
|                                                                             |                                                                                                                                  | TYPE OF RENATURALISED SPACE OR ELEMENT TO BE ACTED UPON                                                                  | SURFACE (m²) | NUMBER OF TREES AND SHRUBS PLANTED            | Ponds and lakes<br> |
| CLASSIFICATION OF NATURE-BASED INTERVENTIONS BY SCALE AND TYPOLOGY OF SPACE | BUILDING                                                                                                                         |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Comprehensive refurbishment of the Natur Eskola school in Oñati using NBS                                                        | Building<br>                            |              |                                               |                                                                                                        |
|                                                                             | Efficient construction of the Enerctic building in Donostia / San Sebastian following bioclimatic criteria                       |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | PRIVATE OUTDOOR SPACES: SCHOOL PLAYGROUNDS                                                                                       |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Renaturalisation of the Orduña municipal public school playground                                                                | School playgrounds<br>                  | 1.736 m²     | 20 trees<br>120 shrubs<br>350 aromatic plants | 15 m²                                                                                                  |
|                                                                             | Greening of the haurreskola Txagorritxu school playground in Vitoria-Gasteiz                                                     |                                                                                                                          | 245 m²       | 20 trees<br>57 arbustos<br>38 aromatic plants |                                                                                                        |
|                                                                             | PUBLIC OUTDOOR SPACES                                                                                                            |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Regeneration of an opportunity space to tackle heat through NBS in Aduna                                                         | Opportunity spaces<br>                  | 1.776 m²     | 22 trees<br>228 shrubs                        |                                                                                                        |
|                                                                             | Conversion of urban wasteland into fertile grassland through regenerative agro-agriculture in Sestao                             |                                                                                                                          | 14.580 m²    |                                               |                                                                                                        |
|                                                                             | Sustainable Urban Drainage Systems in the urban development of the Arteleku Square in Donostia / San Sebastian                   | Square<br>                              | 8.600 m²     | 52 trees                                      |                                                                                                        |
|                                                                             | Green roof and Sustainable Urban Drainage Systems in the Laubide children's playground in Legazpi                                |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Permeable car parks in the Ibarruri neighbourhood of Muxika                                                                      | Parking<br>                            | 1.040 m²     | 7 trees                                       |                                                                                                        |
|                                                                             | OUTDOOR SPACE INDUSTRIAL AREAS                                                                                                   |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Restoration of the industrial ruin of Urtubiaga into a multi-purpose area and a seasonal green parking area in Ea                | Opportunity spaces<br>                | 5.667 m²     | 48 trees                                      |                                                                                                        |
|                                                                             | Jundiz Park: green corridor to restore the soil and landscape surrounding the Jundiz industrial estate in Vitoria-Gasteiz        |                                                                                                                          | 430.000 m²   | 51.185 trees and shrubs                       | 432 m²<br>(9 ponds of 48 m²)                                                                           |
|                                                                             | LINEAR TRANSPORT INFRASTRUCTURES                                                                                                 |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Renaturalisation of the river Oiartzun in an urban section covered by the motorway in Errenteria                                 | Opportunity spaces under viaducts<br> | 23.500 m²    | 75 trees                                      |                                                                                                        |
|                                                                             | Conversion of an urban traffic artery into a green corridor to improve thermal comfort along Maria Diaz de Haro street in Bilbao | Traffic roads<br>                     | 6.000 m²     | 50 trees                                      |                                                                                                        |
|                                                                             | WATER MASSES AND WATER COURSES                                                                                                   |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Riverside park to tackle flooding in the Txomin-Enea neighbourhood of Donostia / San Sebastian                                   | Flood plains<br>                      | 3 ha         |                                               |                                                                                                        |
|                                                                             | NATURAL SPACE AND RURAL ENVIRONMENT                                                                                              |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Phyto-purification system to treat wastewater in a rural environment in Errigoiti                                                | Dispersed population areas<br>        |              |                                               |                                                                                                        |
|                                                                             | Sub-surface flow wetland in the Merru neighbourhood of Ibarrangelu                                                               |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Reforestation using native species through land stewardship mechanisms in Bakio                                                  | Forest plantations<br>                | 5,7 ha       |                                               |                                                                                                        |
|                                                                             | Reforestation of the Oberan hills using native species in Donostia / San Sebastian                                               |                                                                                                                          | 19 ha        |                                               |                                                                                                        |
|                                                                             | Reforestation to improve the carbon sink capacity in Orendain using native species                                               |                                                                                                                          | 5,7 ha       |                                               |                                                                                                        |
|                                                                             | COASTLINE                                                                                                                        |                                                                                                                          |              |                                               |                                                                                                        |
|                                                                             | Recovery of a natural coastal space along the Tonpoi cliffs in Bermeo following climate criteria                                 | Coastline<br>                         | 1,4 ha       | 77 trees<br>1.500 shrubs                      |                                                                                                        |



## TYPES OF NATURE-BASED SOLUTIONS IMPLEMENTED IN EACH INTERVENTION

[illegible]



1.

# Interventions at building scale

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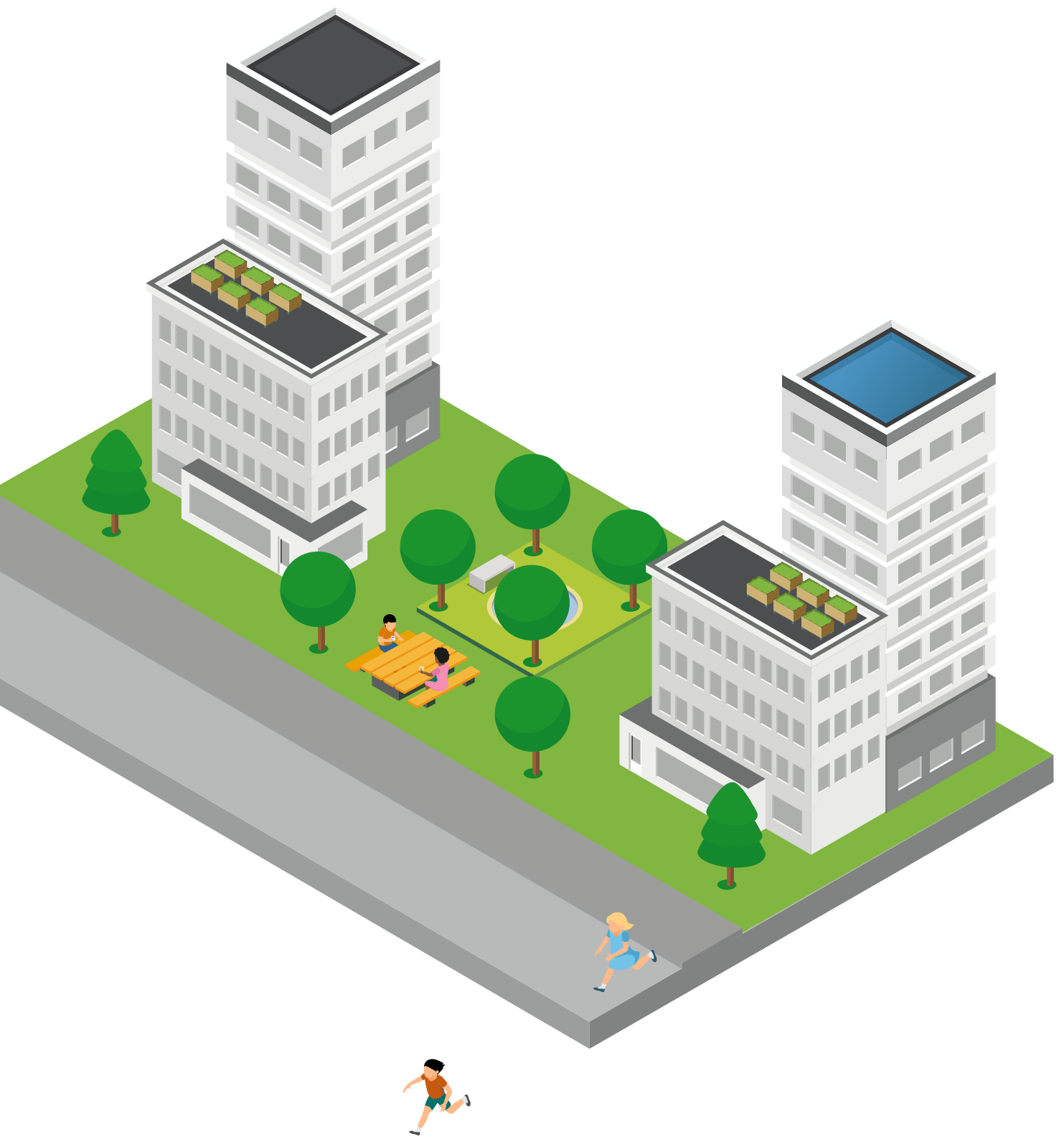


**Comprehensive refurbishment of the Natur  
Eskola school in Oñati using NBS**

---

**Efficient construction of the Enertic  
building in Donostia / San Sebastian  
following bioclimatic criteria**

---



# Comprehensive refurbishment of the Natur Eskola school in Oñati using NBS

The Natur Eskola project arose from the need to fully refurbish the municipal school. The Oñati Town Council aimed to create a space connected to nature that is also aligned with its vocation for sustainable educational. In response, its proposal was to incorporate natural solutions both in the building itself and in the surrounding outdoor space.



View of the Natur Eskola from the outside after the intervention was completed.



## Type of NBS implemented in the intervention



### Extensive green roof

Surface area of 420 m<sup>2</sup> planted with species of the genus *sedum* (succulent plants). Total thickness of 11 cm, retaining approximately 30 l/m<sup>2</sup>.



Green roof implementation process.



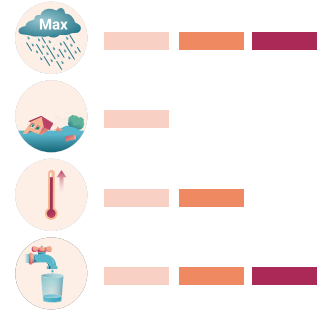
### Natural façade

Façade design using an External Thermal Insulation Composite Systems (ETICS). The main façade uses straw as the insulating material and the ventilated façade is made using larch wood. The remaining façades have cellulose and wood fibre insulation and lime rendering.



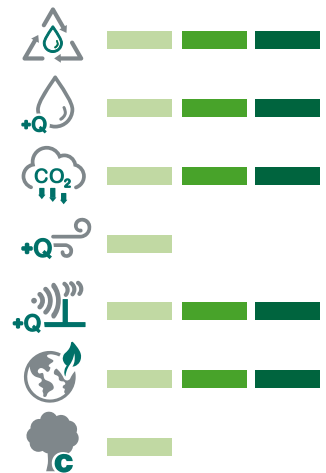
Outside of the Eskola and its natural façade

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social

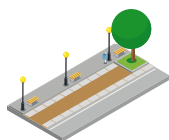


### Economic



## SDG



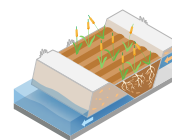


### Permeable paving

The concrete paving slab in the outdoor courtyard and perimeter pavements was replaced with draining paving over an extension of **310 m<sup>2</sup>** with French drainage underneath it.



Drainage floor installed in the outdoor area.



### Phyto-purification system

50 m<sup>2</sup> horizontal flow pond to treat grey water from the Eskola (there is no "black water" sewage as solids are separated in dry toilets) with a **treatment capacity of 20 equivalent inhabitants**.



General appearance of the artificial pond.



### Dry toilets

The services were refurbished by installing **5 dry toilets and 2 dry urinals** to manage faecal waste and urine in an environmentally friendly way.



Dry toilets installed.



Solids management system.



“The commitment was to carry out a minor intervention, meaning many elements were preserved in their existing condition. Moreover, the refurbishment work was based on NBS, bio-construction, and reusing materials from the site itself, meaning that the budget was not very high. Any other approach would have been more expensive. In short, the objectives set have been fully achieved and Oñati will have a Natur Eskola for many years to come.”

**Municipal Technical Manager of Oñati Town Council.**



### Agents involved

- Oñati Town Council
- URA - Basque Water Agency
- Natur Eskola's educational community



### Barriers encountered

- Difficulty getting companies to tender. Traditional construction companies are reluctant to get involved in such projects.
- Complexity in coordinating the work to ensure all the companies involved complied with the project requirements.



### Economic data

**Approximate cost of the intervention:**  
€1 M

**Approximate cost of green roof:**  
€12,000

**Approximate cost of façade:**  
€38,000

**Approximate cost of dry toilets and phyto-purification system:**  
€30,800

#### Funding:

- **€35,000**  
(Berringurumena Programme, 2018)
- **€532,000**  
(TMA7178/2022, Ministry of Transport, Mobility and the Urban Agenda)



### Reduction of environmental impacts

**Savings achieved with the 5 dry toilets, 2 dry urinals and the phyto-purification system:**

- 73,000 litres/year reduction in drinking water consumption.
- 73,000 litres/year reduction in wastewater generated.
- 500 kg/year reduction in sludge generated.
- 200 kg/year of bio-compost generated.



### Success factors

The project was conceived by the town council in a **comprehensive and sustainable way from the outset.**

The educational community was involved in the project: **the NBS implemented have been well received and integrated** into the educational programme.

**Refurbishment** using bio-construction and NBS criteria **has not proved to be more costly** than using conventional solutions.



**Donostia Sustapena/  
San Sebastian Ministry  
of Public Works**  
Donostia / San Sebastian  
City Council



Polígono 27,  
Paseo Ubarburu 39.  
Donostia San Sebastián,  
Gipuzkoa



**Two phases:**  
Phase 1:  
2011 and 2012  
Phase 2:  
2013 and 2014.



**Donostia Sustapena/  
Fomento San Sebastián**  
[www.fomentosansebastian.eus](http://www.fomentosansebastian.eus)  
943 482 800  
[fomentoss@donostia.eus](mailto:fomentoss@donostia.eus)

# Efficient construction of the Enertic building in Donostia / San Sebastian following bioclimatic criteria

The ENERTIC building, located on industrial estate 27 in Martutene and inaugurated in 2014, was a pioneering project that sought to maximise energy efficiency by incorporating bioclimatic and climate change adaptation design criteria.

ENERTIC is a business centre with a total built area of 9,000 m<sup>2</sup> above ground, of which approximately 6,000 m<sup>2</sup> are used for a total of 56 rental offices, common areas, an auditorium, and meeting rooms.



Exterior view of the ENERTIC building.

## Type of NBS implemented in the intervention

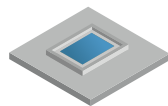


### Green roof

Surface area of **1,100 m<sup>2</sup>** vegetated with species of the genus *sedum* (succulent plants).



ENERTIC living roof.



### Rainwater harvesting

The building has a tank to store rainwater that is later used to flush the toilets.

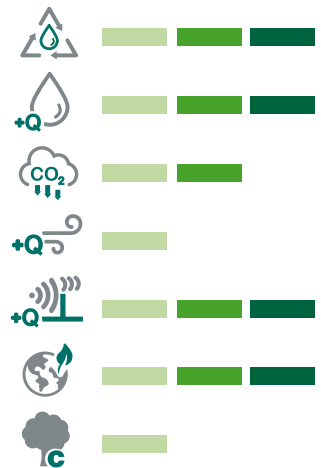
The tank has a total volume of **30 m<sup>3</sup>** and it is located in the basement, giving it a capacity of approximately **3,000 flushes**. This water reclamation system has a chlorine dosing system to treat the water before it is used.

## CLIMATE THREATS



## CO-BENEFITS

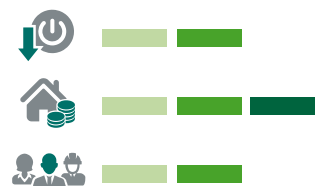
### Environmental



### Social



### Economic



## SDG





## Other solutions implemented in the ENERTIC building to adapt to climate change:

### Energy self-sufficiency with renewables

The heating and cooling demand in common areas and offices is covered by aerothermal and geothermal systems. The building's energy demand is covered by a photovoltaic installation on the building roof that is not connected to the grid.

### Bioclimatic criteria

- The compact cubic design reduces the surface the building has in contact with the outside and reduces energy losses.
- The building is north-south facing, reducing its energy demand and improving natural lighting. By facing north, the office spaces have glare-free working light, and the southern facing allows light to enter through the atrium.
- The north, east, and west façades are made of concrete with a high amount of insulation and thermal inertia. The south façade is a glazed atrium which acts as a thermal regulator for the building and also serves as a natural ventilation system.



### Agents involved

- Donostia/San Sebastian City Council
- Fomento San Sebastián



### Economic data

**Approximate cost of the intervention:**  
€ 8,6 M



### Lessons learnt

- Tanks to store **harvested rainwater** should be sized to meet the demand of the intended use. The need for space can be a constraint.
- The water needs to be pre-treated or filtered prior to use.



### Success factors

A pioneering project for the way it incorporates **energy efficiency, self-consumption, sustainability and climate change adaptation criteria** at a time when this was not so widespread in similar constructions.

# 2.

## Interventions in private outdoor spaces: school playgrounds

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Renaturalisation of the Orduña municipal  
public school playground

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Greening of the haurreskola Txagorritxu  
school playground in Vitoria-Gasteiz

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# Renaturalisation of the Orduña municipal public school playground

Orduña Town Council, as an activating agent of municipal policies for climate action, sustainability, and energy transition, has been able to transform their Infant and Primary School playground into a naturalised, healthy and resilient public space in the face of climate change and in response to the impact of heat waves and associated rainfall flooding. The project also has a clear purpose of integrating the educational community through which it aims to promote an innovative educational model that is closely linked to nature.

The project had a transformative objective to improve the adaptive capacity of the municipality, so the new space was designed so that it can be used by all citizens outside school hours, as an additional municipal green environment.



General view of the naturalised area of the school playground.

## Type of NBS implemented in the intervention



### Greening of school playground

The outdoor school space has a surface area of 3,314 m<sup>2</sup>, 25% of which was occupied by green areas and 75% by impermeable paved surface prior to the intervention. Following the work carried out, which included the creation of **176 m<sup>2</sup> of new shaded areas**, the naturalised space has **increased to 1,736 m<sup>2</sup>** (52% of the total surface area), while the **impermeable surface area is reduced to 1,578 m<sup>2</sup>** (48% of the playground).



Topsoil in depaved areas.

Over **900 m<sup>2</sup> of reinforced concrete slabs** were removed as part of the works, which consisted of:

- Creating a **75 m linear windbreak hedge** around the perimeter of the playground with **120 low-growing trees**.
- Creating an edible garden-forest using permaculture and a vegetable garden featuring perennial plants, vegetables, flowers and undergrowth with **6 large trees and 14 low-growing trees and shrubs**. Mature compost and shredded clippings were used as substrate.
- Conditioning and modification of the existing green space, defining new levels and textures, using **350 m<sup>3</sup> of topsoil**, green manure (oats, vetch and mustard), planting **350 plants of 25 aromatic species**, and a final top layer of shredded tree bark.



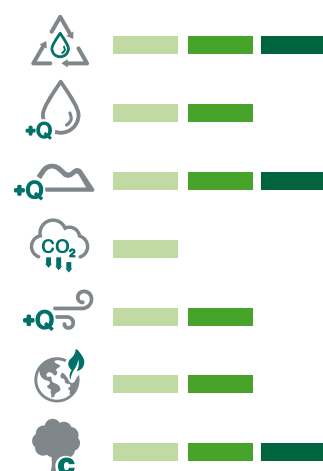
Edible forest and vegetable garden.

### CLIMATE THREATS



### CO-BENEFITS

#### Environmental



#### Social



#### Economic



### SDG





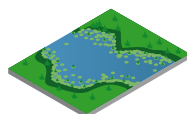


### Rainwater harvesting

Connection of the school roof to an underground tank with a **capacity to store 10,000 litres** of rainwater to be used in an automatic drip irrigation system for some of the vegetated areas.



Drip irrigation connected to the rainwater harvesting system.



### Pond

A **15 m<sup>2</sup>** wetland was created which is connected to the rainwater harvesting system. The wetland also receives water that overflows from the drinking water fountain next to it.



Pond and system to collect excess water from the drinking water fountain in the playground.



### Green urban furniture

Construction of a **40 m<sup>2</sup>** roofed classroom with a wooden structure and green roof; an agora and stage with natural elements (wood and soil); and a play and workshop area with acacia and larch wood elements to ensure durability.



Agora, stage and roofed classroom in the background.



Play area with acacia and larch wood.

*“ The project implementation process has brought about social learning. The participatory process carried out among all stakeholders to agree on the strategic objectives of the project has led to the new playground being recognised as an attractive place to gather and socialise both inside and outside school hours. ”*

**Municipal Technical Manager of Orduña Town Council.**



### Agents involved

- **Orduña Town Council:**
  - Mayor's office
  - Urban Planning Department
  - Department of Agricultural Development, Administration and Municipal Brigade
- **Basque Government Department of Education**
- **Basque Government Natural Heritage and Climate Change Department**
- **URA - Basque Water Agency**
- **Educational community**
- **Municipal Community Service Group**
- **Cultural Association of Architects**



### Economic data

**Approximate cost of the intervention:**  
**€ 235,000**

**Funding:**

**€ 162,000**

(Local Climate Eco-Innovation Grant Programme, 2021; Inclusive Playground Grant Programme, 2022)



### Lessons learnt

- The new space generated requires specific technical maintenance and an understanding of permaculture, a perspective from which the vegetated areas have been designed.
- It is important to ensure training and support for teachers to guarantee the educational use of the space in a way that looks after it correctly.



### Success factors

A preliminary **diagnosis and analysis** phase was carried out to introduce the initial design proposal, **adapting it to the local context and to the needs of the educational community.**

**All agents were involved** from the outset through a participatory and collaborative process.

**A Works Committee was created to coordinate and supervise the works**, in which all the agents involved are represented.

**Students were involved in conservation work** for the various interventions, always from a pedagogical point of view based on education in nature and sustainability.

**Entities with experience in initiatives of the same nature** formed part of the project.



# Greening of the haurreskola Txagorritxu school playground in Vitoria-Gasteiz

The naturalisation of the Txagorritxu school playground is the pilot project to expand the naturalisation strategy across school playgrounds in Vitoria-Gasteiz. The school's own educational community were the driving force behind this project which aims to improve the quality and environmental comfort of the space, increase the permeability of the soil, and increase biodiversity and the set of associated ecosystem services.

It forms part of the shared *construction of urban green infrastructure* programme and also aims to involve citizens and social agents in the greening of public and private spaces. Furthermore, it provides ecological reinforcement that adds new spaces to the Vitoria-Gasteiz Urban Green Infrastructure System.



General view of the playground after the work was completed.

## Type of NBS implemented in the intervention

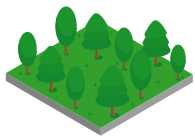


### Removing school playground paving

The **permeable green surface area** was increased from the initial 30 m<sup>2</sup> to **275m<sup>2</sup>**, an increase of 245 m<sup>2</sup>.



Initial condition of the playground and works to remove the paving.



### Planting and sowing

A total of **20 trees**, **57 shrubs** and **38 aromatic plants** of different species were planted, all adapted to the environment. Previously there were only 6 trees, 2 medium and 4 small ones.



Final condition of the playground and appearance of the newly planted vegetation.

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social



### Economic



## SDG







## Street furniture

Installation of play containers with natural elements. Three containers were provided with water, soil, stones and wood, to encourage children's contact with nature.



Details of the wooden games and soil containers.



The playground as a new learning space.



Girls in the naturalised playground.

“ This project has meant the beginning of the School Playground Naturalisation Strategy in the city in response to the demands of the educational community. ”

Technician of the Environmental Studies Centre at Vitoria-Gasteiz.



### Agents involved

- **Vitoria-Gasteiz City Council:**
  - Environmental Studies Centre
  - Public Space and Natural Environment Service (Landscape Unit)
  - Maintenance Dept.
  - Education Service (Infant Schools).
- **Educational community:** haurreskola Txagorritxu directors, parents' association, team of educators, caretaker, Haurreskolak committee.



### Economic data

**Approximate cost of the intervention:**  
€ 27,000

**Funding:**  
€ 25,000

(Ihobe ecoinnovation projects, 2020)



### Barriers encountered

- Initial reluctance by cleaning staff to shrubs being planted, as they assumed an increased workload.
- Initial reluctance by parents as they assumed that the children would get muddy when playing on a renaturalised surface.



### Lessons learnt

- There were several heat waves in the first summer following the project that dried out some of the vegetation. In anticipation of increasingly hot summers, it is important that high temperature resistant species are planted and that efficient irrigation systems are provided for later summer months.
- It is important that risk aspects are considered: choosing bushes without thorns, containers without corners to avoid accidents, allergenic species, etc.



### Success factors

Pioneer project of the Vitoria-Gasteiz City Council **school playground naturalisation strategy** ([web page](#))

All agents involved were identified and involved in the project from the outset by raising awareness of the benefits of the intervention.

Low implementation and maintenance costs.



# Interventions in public space

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Regeneration of an opportunity space to tackle heat through NBS in Aduna

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Conversion of urban wasteland into fertile grassland through regenerative agro-agriculture in Sestao

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Sustainable Urban Drainage Systems in the urban development of the Arteleku Square in Donostia / San Sebastian

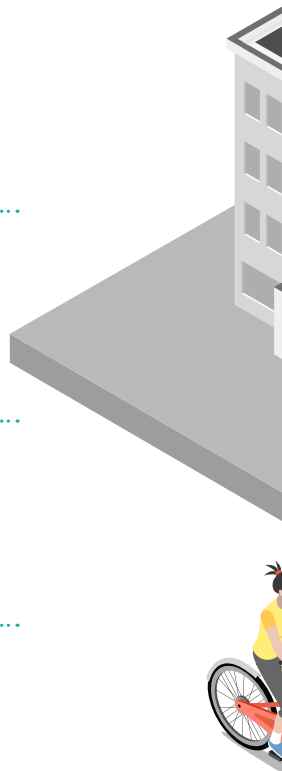
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Green roof and Sustainable Urban Drainage Systems in the Laubide children's playground in Legazpi

---

Permeable car parks in the Ibarruri neighbourhood of Muxika

---







# Regeneration of an opportunity space to tackle heat through NBS in Aduna

Before the intervention, the town centre of Aduna did not have an urban park or leisure area with vegetation that would provide shade and act as a climate haven on hot summer days. Through this project, the Aduna Town Council responds to this need and provides a multi-purpose recreational space by incorporating climate criteria in an existing unused site. It created a meeting space that caters to different audiences and helps to tackle the increasingly frequent and intense heat waves.



General view of the park after the intervention was completed.

## Type of NBS implemented in the intervention



### Renaturalisation of an opportunity space

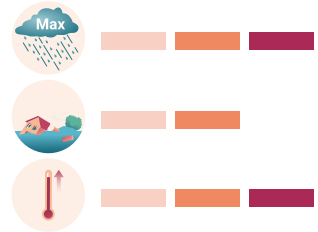
Use of an unused urban space of **1,776 m<sup>2</sup>** to create a multi-purpose recreational park and provide a haven during heat waves.

The area is acclimatised using vegetation, specifically by planting **22 trees (1.2 trees per 100 m<sup>2</sup>)** and **228 shrubs (almost 13 specimens per 100 m<sup>2</sup>)**, including native species such as *Acer campestre*, *Betula alba*, *Quercus robur* and *Fraxinus excelsior*. The aim of this vegetation is to improve the thermal comfort of the space.



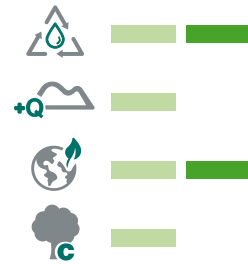
Trees and shrubs planted in the area.

### CLIMATE THREATS

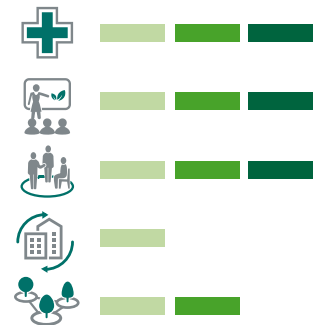


### CO-BENEFITS

#### Environmental



#### Social



#### Economic



### SDG

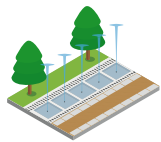




In addition, the multi-purpose park has other elements such as shaded sitting areas, picnic area with tables and exercise machines for the elderly.



Exercise machines for the elderly.



### Water microclimates

Part of the park developed through the intervention is intended as a water play area for children.



Water play area.

*“ We have managed to incorporate climate change adaptation in the park design. It came at a cost, but in the end the public has seen the benefit. In addition, the project has served as a showcase on how to include environmental and climate change adaptation in municipal policy. ”*

**Municipal technician from Aduna Town Council.**



### Agents involved

Aduna Town Council



### Economic data

**Approximate cost of the intervention:**  
**€ 265,000**

**Funding: € 74,000**  
(aid programme for local authorities carrying out actions to promote sustainable development, 2020)



### Barriers encountered

- Small changes needed to be made to how construction companies work to include the climate component in the designs.
- Difficulty of reusing water due to legionella regulations.



### Success factors

The project is **well received** by the population as a new recreational space that promotes intergenerational cohesion.

**It is an alternative solution to the absence of municipal swimming pools** and therefore reduces the need to travel to other towns.

The park provides a **safe pedestrian connection between the Aduna urban centre and the residential area**, which has contributed to local sustainable mobility.

**It provides a new teaching resource for the municipal school** (urban biodiversity, climate change, etc.).

**The project raises awareness among policy makers** on the need for climate change adaptation.

# Conversion of urban wasteland into fertile grassland through regenerative agro-agriculture in Sestao

This initiative to recover wasteland and degraded space in the municipality of Sestao has been promoted by the Town Council and the public company Sestao Berri.

The test plot, which was in a highly degraded state, is located next to the Sestao Blast Furnace and the former Arcelor Mittal facilities. The aim of the intervention was to test the effectiveness of innovative and low-cost soil reclamation, composting and seeding techniques, and regenerative livestock principles for grassland management. To this end, the different solutions implemented have been analysed in terms of their capacity to convert wasteland into productive grassland with good soil quality, and their potential to maximise climatic ecosystem services such as carbon sequestration and improved permeability.

The intervention also tested urban grassland management solutions such as regenerative grazing, which produces significantly less emissions than conventional park maintenance and guarantees better soil quality.

Location of the plot to be recovered next to the Sestao Blast Furnace (Basque Cultural Heritage).





## Phases of the work to RENATURALISE THE OPPORTUNITY SPACE

### PHASE 1: Site preparation

Clearing and levelling work on a vacant plot of land of **14,580 m<sup>2</sup>**. The surface was almost devoid of soil, aside from sparse material that has settled over the years on an old concrete slab. Work was carried out to adapt the texture and relief of the plot, re-profiling the land, adapting the slopes to improve drainage, and providing 30 cm of fill material (nutrient free) of suitable grain size.



Appearance of the plot before the intervention.



Appearance of the plot after clearing and levelling the land.

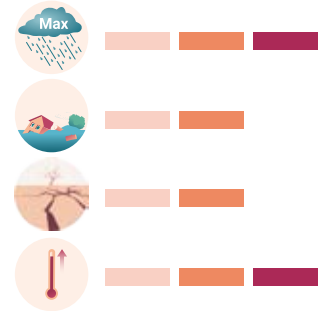
### PHASE 2: Conditioning of the physical and chemical properties of the soil

Work was performed to amend the organic nature of the soil using compost from the organic fraction of MSW treated at the Artigas landfill to improve soil quality and develop fertile grassland. Mycorrhizal treatment was also applied.



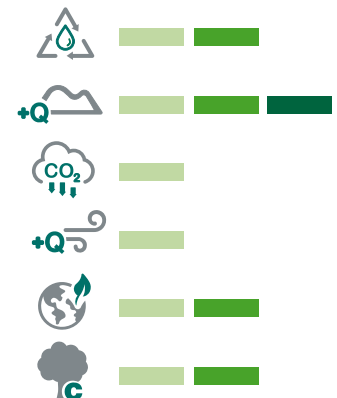
Compost heaps before and after application.

#### CLIMATE THREATS



#### CO-BENEFITS

##### Environmental



##### Social



##### Economic



#### SDG





## PHASE 3:

**Vegetation conditioning and weed control**

Seeds were sown to recover the native grasslands and develop biodiversity. The plot was divided into 8 tesserae, differentiated by the amount of compost used, whether mycorrhizae was applied or not, and whether conventional commercial grassland or native honey meadow were sowed, using seeds of **40 types of flowers** and **4 types of grasses** at a **proportion of 60% and 30%**, respectively. The overall aim is to provide the lowest possible cost and maximum ecosystem services.



Evolution of grassland growth after planting.



## PHASE 4:

**Grazing of the plot using regenerative livestock to maintain urban parks**

A flock of **11 sheep** was used for **14 days** who effectively grazed the plot (to the extent equivalent to conventional urban park maintenance) while fertilising it through their droppings and urine.



Appearance of the plot after sheep grazing.

“Through this intervention, a degraded wasteland has been converted into native grassland that will become part of the museum facilities related to the Sestao Blast Furnace, part of our cultural heritage, in a municipality with a high population density and very few green spaces.”

Managing Director of Sestao Berri Public Company.



### Agents involved

- Sestao City Council/Sestao Berri - Project developers
- Soil microbiology consulting company
- Garbiker (waste manager) - Compost supplier
- Herder
- Neiker - Laboratory Services



### Economic data

#### Cost of the intervention:

€ 55,794.15

#### Funding:

€ 50,214.74

(Local Eco-innovation, 2021)



### Lessons learnt

- It is important to use a suitable dosage of mature compost, as it has been proven that high doses of compost do not result in higher grassland productivity.
- The plots need to be provided with shade and water to ensure the welfare of the animals.
- The grassland should be consolidated before livestock are introduced.
- The soil quality declaration must be taken into account if there are contaminated or potentially contaminated plots, and a soil investigation may be required to ensure the safe keeping of livestock.



### Barriers encountered

- The impossibility of applying compost from sewage sludge from the Galindo treatment plant (as foreseen in the design phase) due to the possible presence of pollutants and administrative issues related to transferring the sludge to a non-accredited entity.
- Difficulty in finding sheep flocks close to the pilot site.
- The concrete slab (cracked) hampers water infiltration.



### Reduction of environmental impacts

- Annual cost of fertilising and mowing 1 m<sup>2</sup> of lawn: **€ 0.5 with machinery VS € 0.03 with sheep.**
- CO<sub>2</sub> emissions per hectare: **1,200 Kg CO<sub>2</sub> equivalent with machinery VS - 70 Kg CO<sub>2</sub> equivalent with sheep.**



### Success factors

A pioneering project that uses sheep to maintain urban green space.

The sheep **effectively remove invasive species** and weeds on the plot.

Mutual benefit generated by **regenerative grazing** for the herders and **maintenance for the plots.**

**Positive impact on citizen perception** of urban environments by using sheep.



# Sustainable Urban Drainage Systems in the urban development of the Arteleku Square in Donostia / San Sebastian

In 2007, the City Council of Donostia/San Sebastian approved the final version of the Special Urban Development Plan for the Txomin-Enea neighbourhood, which envisaged the development of Arteleku Square, planned for the former site of the demolished building from which it takes its name. Arteleku Square is located next to the Txomin Enea river park (an intervention included in this catalogue) and which also formed part of the aforementioned Special Urban Development Plan.

The Arteleku Square is the main point of connection between the river and the neighbourhood and is designed to be an extension of the river park.

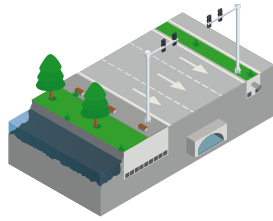
The square was designed by taking into account climate adaptation criteria, incorporating various NBS (mainly SUDS) and taking into account the uses prioritised by the citizens in an ideas competition.



General view of Arteleku square

Argazkia: El Diario Vasco

## Type of NBS implemented in the intervention



### Urban Sustainable Drainage System (SUDS)

The solution adopted in Arteleku Square combines sustainable drainage systems with conventional drainage systems using grate sewers.

The SUDS has surface rainwater collection elements formed by drainage strips and rain gardens. In addition, due to the low permeability of the soil, gravel wells or columns have been built at different points in the square to help rain infiltrate into the ground. Water is directed from the catchment points to the gravel columns through a rainwater channelling system.

The elements that make up the SUDS for the square are detailed below.



- Infiltration columns
- Rainwater conveyance system with HDPE pipe
- 40 cm wide and 1 m deep drainage strips filled with gravel

#### Rain gardens

##### Type (a):

Lawn with a mixture of festuca, matricaria and ryegrass, mowing length 40 mm

##### Type (b):

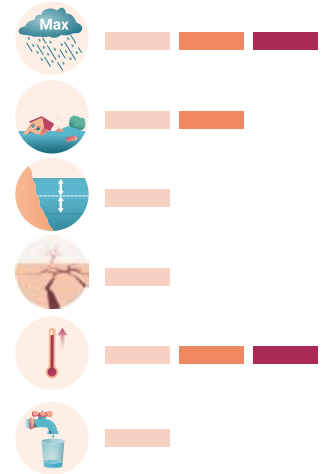
Lawn with a mixture of festuca, matricaria and ryegrass, mowing length 80 mm

*Anemathele lessoniana* (main), *Pennisetum thunberg* "Red Buttons"

*Miscanthus sinensis* 'Purpurascens'

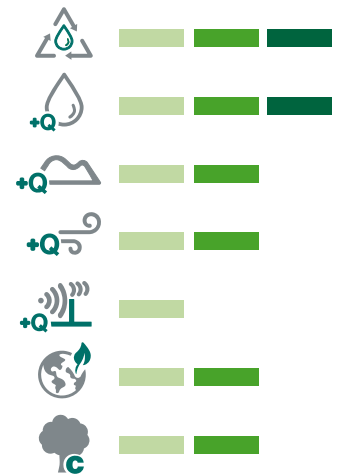
Layout and distribution of the different elements that make up the Arteleku Square SUDS.

### CLIMATE THREATS



### CO-BENEFITS

#### Environmental



#### Social



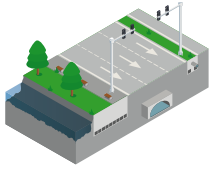
#### Economic



### SDG







## Infiltration columns

Based on the results of the geotechnical study of the soil and the fill placed in the area to raise the ground level by 7 metres and thus prevent flooding (refer to the intervention in the Txomin Enea river park), 6-metre-deep gravel columns were placed at 4 strategic points in the square to ensure water correctly infiltrates into the ground, while the gravel acts as a filter to remove possible impurities.

The rainwater is collected through a channelling system that sends it to the infiltration columns. An access chamber has been provided for each gravel column to allow maintenance staff to check that the drain is working correctly and to analyse whether the gravel system is clogging.



6 m deep gravel infiltration column to ensure drainage.



Rainwater channelling system using HDPE pipes that discharge into the gravel column.



Access chamber under construction.



Access chamber upon completion of the work.



## Drainage strips

The strips are **40 cm wide and 1 m deep**, filled with gravel and covered with vegetation. In total, **12 drainage strips** have been placed in different parts of the square, 7 of which are located in the low permeability part, and are therefore connected to the rainwater channelling system that drains into the infiltration columns. The rest of the strips are located in the north-eastern part of the square and, in this case, they infiltrate directly into the ground. The square's rainwater collection system combines drainage strips with conventional drains that capture rainwater that is not able to be absorbed by the sustainable drainage system. In the image below you can see how a drainage strip and a sewer grate connected to the conventional sewerage system complement each other.



Drainage strip construction process.



Drainage strip (left) after completion of the work and conventional rainwater collection pit (right).

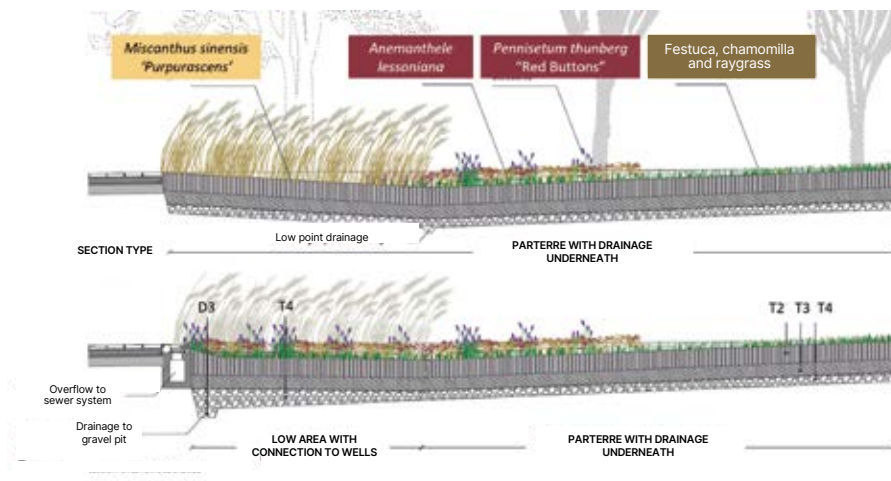
## Rain gardens

Rain gardens help to reduce turbulent flow, filter impurities from the water, and help it to infiltrate into the ground, favouring aquifer recharge with quality water. **Two types of rain gardens** have been developed: (a) solely composed of grass, specifically a mixture of *festuca*, *matricaria* and *ryegrass*, with a mowing length of 40 mm, requiring 10 mows/year, and a planting density of 30-40 g/m<sup>2</sup>; (b) composed of grass species that tolerate humidity well, but cannot handle waterlogging (not desired for the project), as a drainage pipe is placed in the bottom gravel sub-base of the planters to channel the water towards the infiltration wells. In this second type, three different garden heights are created with the following vegetation and soil composition:



— Vegetation in the rain garden (b):

- Ornamental grass with a mixture of *festuca*, *matricaria* and *ryegrass*. Mowing length 80mm (6 mows/year). Planting density 30-40 g/m<sup>2</sup>. Highest area of the flower bed, giving a uniform semi-treadable surface.
- *Stipa arundinacea* (main species) for the middle section with a height of 45 cm and a planting density of 4 pcs/m<sup>2</sup>. *Pennisetum thunberg* "Red Buttons" (secondary species) with a height of 60 cm and a planting density of 2 pcs/m<sup>2</sup>.
- *Miscanthus sinensis* 'Purpurascens' in the lowest part of the flower bed with a height of 160 cm and a planting density of 4 pcs/m<sup>2</sup>.



Vegetation profile and soil composition in rain gardens (b).



Rain garden construction process.

— Soil composition in the rain garden (b):

- T2: High-quality garden topsoil, with an electrical conductivity of less than 0.8 dS/m
- T3: sandy textured soil
- T4: drainage gravel with geotextile
- D3: drainage pipe for flowerbeds and planters

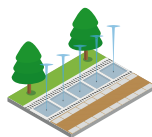


Type (a) rain gardens: grass with a mixture of *festuca*, *matricaria* and *ryegrass*, with a mowing length of 40 mm.



Type (b) rain gardens with a combination of grass species.

inally, the rain gardens are completed by planting **52 oak** (*Quercus robur*), maple (*Acer palmatum* and *Acer freemani*), poplar (*Populus nigra*) and ash (*Fraxinus excelsior*) trees. The species have been selected by considering the biodiversity and vegetation of the surrounding environment. Tree specimens are given a minimum volume of useful land for their development that does not contain any type of service pipes or channels (either public or private), with the exception of the irrigation network. The minimum soil volume to meet the agronomic conditions for root development is 3 m<sup>3</sup> for small trees (*Acer palmatum*), 8 m<sup>3</sup> for medium trees (*Acer freemani*) and 15 m<sup>3</sup> for large trees (oak, poplar and ash).



## Water microclimates

Part of the square developed through the intervention is used for a children's water play area with nozzles on the ground that have a playful and refreshing function for the summer months.

*“Combining SUDS with conventional rainwater collection systems has allowed all the City Council departments involved to test new systems and learn in the process, with the assurance that there will be no failures.”*

**Project and Site Manager** Donostia/San Sebastian City Council Projects and Works Department



### Innovative aspects

- A citizen participation process and an ideas competition was launched in 2017 to define the design of Arteleku square.
- Naturalisation of an urbanised environment by incorporating SUDS to infiltrate rainwater, permeabilising the land.
- Infiltration columns. The initial poor infiltration capacity of the soil can be overcome using water conveyance systems to channel the water to infiltration areas such as the gravel columns, where impermeable substrates are connected to permeable substrates.
- Incorporation of rain gardens to reduce turbulent water flow.



### Agents involved

- **Donostia/San Sebastian City Council:**
  - Project and Works Management
  - Maintenance and Urban Services Department
  - Sustainable Urban Planning



### Economic data

**Approximate cost of the intervention:**  
**€ 1.2 M**



### Barriers encountered

There were conflicting criteria between naturalisation through SUDS and Maintenance Services. The long-term performance of the SUDS and the type of maintenance to be carried out are not known. Therefore, drainage systems have been duplicated with SUDS and conventional systems.



### Success factors

**A detailed geological and geotechnical study was available.** Having this information beforehand is important to assess the feasibility of the SUDS, and to know relevant information for their design such as soil composition and permeability, water table, etc.

**Combining SUDS with conventional rainwater collection systems has allowed** all the City Council departments involved **to test new systems with the assurance that there will be no failures.** It is a way of learning and breaking down reluctance to change.



# Green roof and Sustainable Urban Drainage Systems in the Laubide children's playground in Legazpi

The Laubide playground in Legazpi did not have a roof that would allow it to be used and enjoyed in times of rain or intense heat.

Faced with this need, Legazpi Town Council, as part of the deployment of its *Klima 2030* municipal strategy, proposed to improve the space using NBS. The project had the dual purpose of improving the use of the playground and adapting it to the local impacts of climate change. The town council identified improving thermal comfort and controlling the hydrological cycle as the climate challenges to be solved in this public urban area. The project had participatory and communicative processes aimed at involving citizens.



Laubide playground after the intervention was completed.



## Type of NBS implemented in the intervention



### Green roof

**120 m<sup>2</sup>** of local larch wood flat roof on a steel structure, revegetated with **12 varieties of sedum** (succulent plants) adapted to the local climate as well as to the specific orientation of the roof.

The vegetated roof retains rainwater before it is channelled into a drainage ditch under the playground paving. The roof has a **2% slope in a west-east direction** to ensure that the playground has the greatest possible shade in the summer season and the greatest possible lighting in autumn and winter, improving the thermal comfort of everyone enjoying the space.



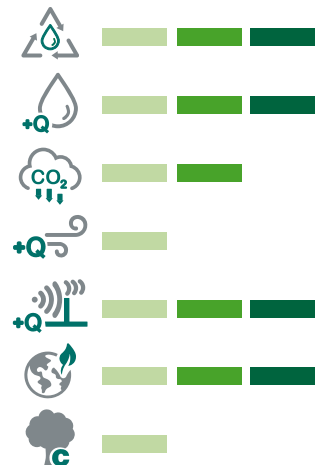
Images showing the Laubide green roof installation process.

### CLIMATE THREATS



### CO-BENEFITS

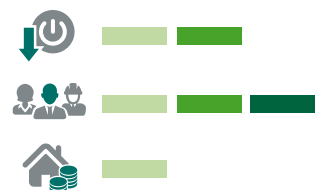
#### Environmental



#### Social

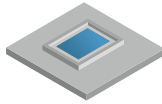


#### Economic



### SDG





### Rainwater harvesting

A **1,000 litre tank** was installed in the lowest part of the roofed area (east side of the playground) as a preliminary step to the sustainable drainage system. The tank retains the runoff water captured both on the green roof and on the ground of the playground. The retained water is used to irrigate the roof vegetation in the dry season.



Water retention tank.



### Sustainable Drainage System (SUDS)

SUDS with drainage cells that have a high storage capacity and control how the rainwater infiltrates, located in the eastern part of the park. When the tank overflows, the water is evacuated towards the SUDS. The cellular drainage structure is covered in gravel and finished in wood help the water to infiltrate into the ground. As a result, the volume of water reaching the Urola river through the municipal rainwater network is reduced.



Excavation and laying of geotextile.



Backfill with drainage cells and gravel.



Wood finish.

“ The Town Council’s technical team believes the outcome is satisfactory, as in addition to achieving a new sheltered space that can be used at different times of the year with certain independence to weather conditions, the plants located on top of the roof help to adapt to climate change. ”

Legazpi Town Hall.



### Agents involved

- Legazpi Town Hall
- URA - Basque Water Agency
- Citizenship



### Economic data

**Approximate cost of the intervention:**

**€ 142,000**

**Funding: € 97,876**

(Aid programme for local authorities carrying out actions to promote sustainable development, 2019)



### Lessons learnt

- The maintenance and upkeep requirements of the roof vegetation should be anticipated.
- It is important to ensure accessibility to the roof for maintenance purposes and to avoid the use of a lifting platform.



### Reduction of environmental impacts

- Reduction of the temperature of the space under the roof: [1°C-4.5°C].
- Reduction of reflection coefficient: >17%.
- Absorption of ambient noise: [5-20] dB (estimate).
- Environmental dust retention: 54 kg/year (estimate).
- Management of 340 m<sup>3</sup> of rainwater (for an average annual rainfall of 1,575 m<sup>3</sup>), 70% of which is retained or evapotranspires, and 30% is treated and channelled in the SUDS.



### Success factors

Citizens were involved in the decision-making process, fostering a quality participatory culture.

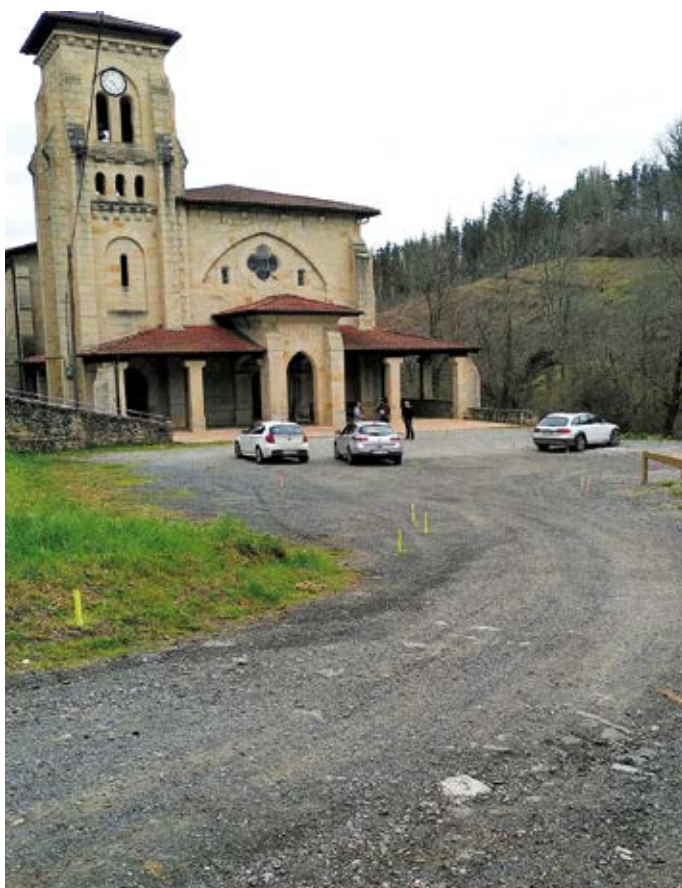
Governance model and participatory process which also integrates political offices and municipal technical staff, as a way to ensure innovative, cross-disciplinary, and efficient municipal management.



# Permeable car parks in the Ibarruri neighbourhood of Muxika

The car park next to the Andra Mari church in the Ibarruri district in Muxika has a quarry-run base, with no pedestrian access, no landscaping, and it becomes waterlogged when it rains.

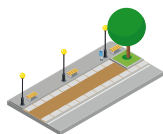
A citizen participation process was carried out with the residents of the municipality, which came up with the proposal to work on the car park landscaping while maintaining its permeability using NBS and SUDS. This proposal included a car park area, pedestrian pavements leading to the church, and a park area with children's playgrounds.



Car park condition before and after the intervention.



## Type of NBS implemented in the intervention



### Permeable paving

Different types of permeable paving have been used for the road, parking spaces, and pedestrian pavement. The permeable paving covers an approximate area of **1,040 m<sup>2</sup>**.

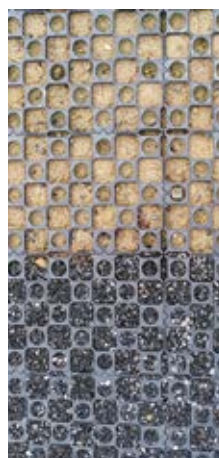
- **Parking spaces:** recycled polypropylene cells filled with different shades of gravel.
- **Pedestrian pavements and access to the church:** Continuous porous concrete flag stones in the church entrance area and continuous porous concrete for the pedestrian access pavement on the right side of the area of action.
- **Children's play area:** wood bark.
- **Roads for vehicular traffic:** reinforced and perforated concrete slab poured on site that allows for vegetation growth between the gaps. As the concrete was poured on low-strength plastic bases, the workers had to walk on panels, in this case polystyrene thermal insulation panels, to avoid breaking the bases.



Recycled polypropylene cells filled with different shades of gravel for parking spaces.



Continuous porous concrete flag stones for pedestrian pavements.



Continuous porous concrete for pedestrian pavements.



Perforated concrete slabs used for traffic road bases.



### CLIMATE THREATS



### CO-BENEFITS

#### Environmental



#### Social



#### Economic



### SDG



Once the concrete had set, the plastic in the holes was broken to allow water to pass through and vegetation to grow. This process was carried out manually by the operators using a blowtorch. Finally, the holes in the cells were filled with plant and seed substrate to grow grass.



Perforated concrete slabs used for traffic road bases.



Concrete cells for traffic road bases.

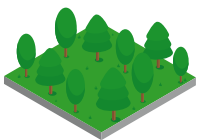


## Sustainable Drainage System (SUDS)

A drainage ditch was installed in the area that used to get waterlogged. A **200 mm drainage pipe** was placed on a layer of sand in the base of the trench which was covered with two geotextile fabric layers and around 60 cm of gravel. Finally, it was covered with topsoil to plant grasses. The drainage pipe connects to the existing rainwater drainage system.



Construction of the drainage ditch (photo on the left) . Drainage ditch with vegetation after completion of the work (photo on the right).



## Trees

**7 new species** are added in the car park to increase shade.



Tree on landscaped area.



## Other solutions implemented to adapt to climate change

### Sustainable street furniture

The urban furniture installed in the space is made of ecological wood: children's swings, litter bins, edging, fencing, benches and picnic tables.



Street furniture made from sustainable materials.



#### Agents involved

Muxika Town Council



#### Economic data

**Approximate cost of the intervention:**

**€172,000**

**Funding: €75,000**

(Local Eco-innovation 2021 calls for grants)



#### Lessons learnt

- Difficulties installing the recycled polypropylene cells in the parking area. The irregular shape of the car park made it difficult to follow the star-shaped lines of the drill holes. Adjustments were made to the thickness of the solid edge to facilitate installation.
- Difficulty in laying the perforated concrete pavement for the roads; the plastic trays are fragile and the process to manually burn the holes in the plastic was labour-intensive.



#### Success factors

Acceptance of the intervention by locals as it was proposed through a **citizen participation process**.

The **drainage ditch** is easy to install and **effectively solves the waterlogging problems**.

# 4.

## Industrial-type interventions in outdoor space

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Restoration of the industrial ruin of Urtubiaga into a multi-purpose area and a seasonal green parking area in Ea

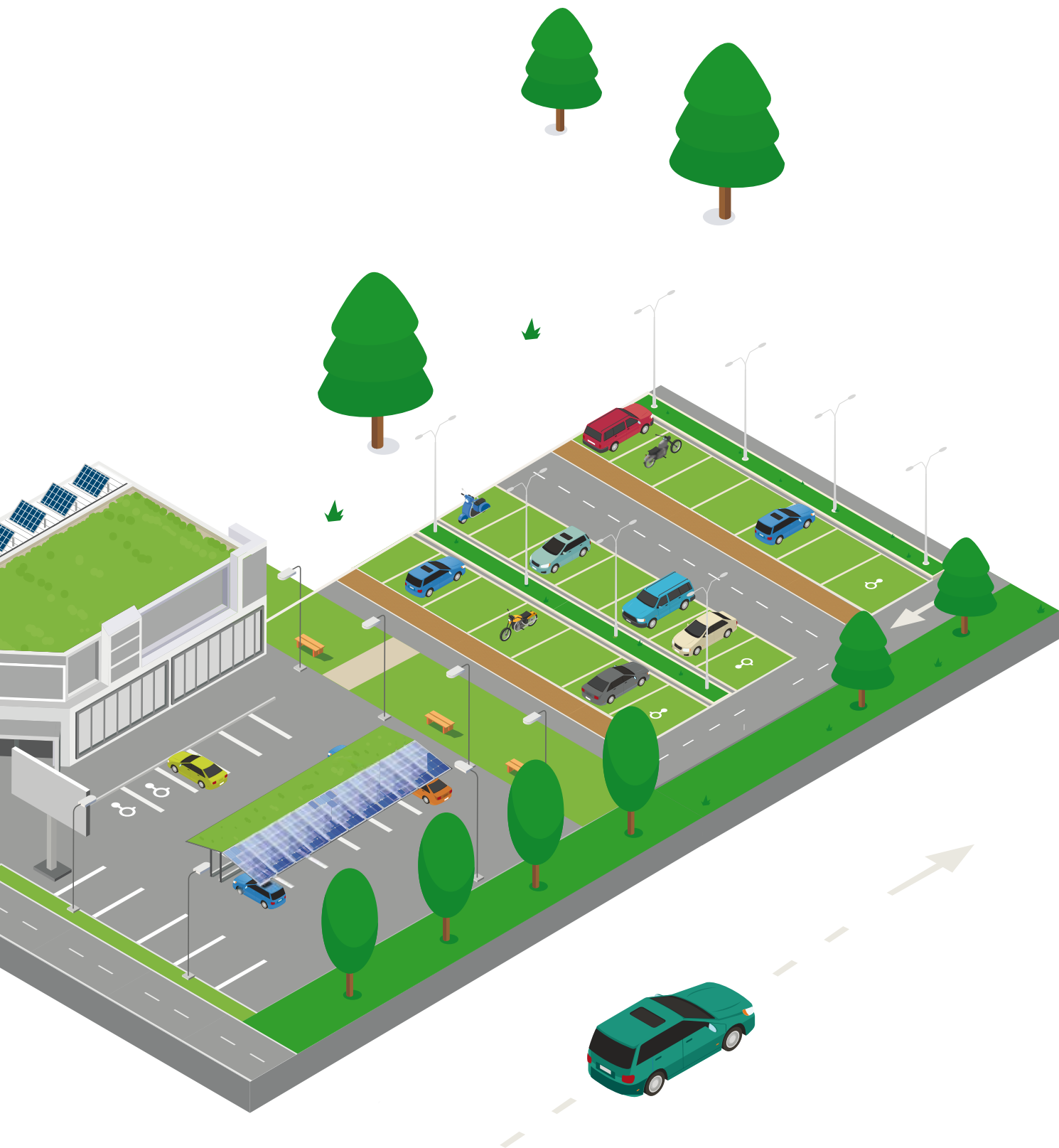
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Jundiz Park: green corridor to restore the soil and landscape surrounding the Jundiz industrial estate in Vitoria-Gasteiz

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# Restoration of the industrial ruin of Urtubiaga into a multi-purpose area and a seasonal green parking area in Ea

The municipality of Ea has a limited number of parking spaces due to its geographical layout and urban morphology. As a result, a significant amount of traffic is caused by vehicles looking for parking, with the negative impact that this entails. Furthermore, the situation is aggravated in summer when the population grows from 800 inhabitants to around 3,000.

The intervention arises as an opportunity to recover an area after the industrial area in Urtubiaga occupied by the old paper mill had been demolished. In response, the proposal is to create a low-impact car park using NBS and recycled materials from the demolition work. There is a permanent parking area and a reversible one to be used during the summer and weekends, and as a recreational area at off-peak times. This intervention is part of a comprehensive rehabilitation process for the plot that combines its environmental and recreational use with that of a new area for economic activities and a multi-purpose space.

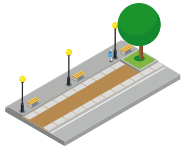
The reclaimed area is 5,667 m<sup>2</sup> in total (1,384 m<sup>2</sup> for the access ramp, 2,568 m<sup>2</sup> for the permanent car park and 1,715 m<sup>2</sup> for the reversible car park). It provides 130 parking spaces, 73 in the permanent car park with 5 spaces for motorhomes, and 52 temporary spaces in the reversible section.



Condition of the area before the intervention.







## Permeable paving

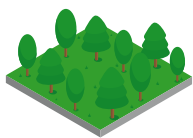
Drainage cells made of polypropylene and reinforced turf have been used for the parking spaces. Various mixtures of sand and topsoil were tested to achieve optimal filtration; the mixture used consists of 60 % granular material (sand (2-5mm) and fine gravel (4mm)) and 40 % screened topsoil that is enriched with compost. The permeable paving covers an approximate area of **3,000 m<sup>2</sup>**.



Installation of polypropylene cells.



Parking area six months after installation.



## Planting of native species

48 specimens mainly in the picnic area and flowerbeds. The species used are:

- *Salicaceae (S. alba)*: 12 pcs.
- *Corylus avellana*: 24 pcs.
- *Quercus robur*: 4 pcs.
- *Castanea sativa*: 4 pcs.
- *Fraxinus excelsior*: 4 pcs.

The slopes are staked with *Salix alba* and *Salix purpurea*.



Tree planting in the picnic area.





## Sustainable Drainage System (SUDS)

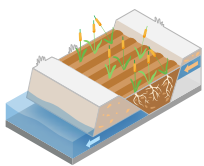
A network of French drains and a green ditch are used to collect rainwater and transport it to the phyto-purification system. A layer of draining gravel was spread over the sub-base to allow rainwater to infiltrate the ditch, and a sheet of recycled polypropylene geotextile was laid on top of the gravel to retain sediment. A mixture of sand and recycled compost from Garbiker is spread over the top for the grass.



Green ditch construction process.



Green ditch six months after completing the work.



## Phyto-purification system

The sustainable drainage system is connected to a phyto-purification system to remove grease and hydrocarbons that may be carried by runoff water from the parking area. The system has a grease separator tank and a **56 m<sup>2</sup>** filtration basin.



Phyto-purification system and grease separation tank.

## Sustainable street furniture

All the urban furniture placed on the site has been made from local acacia and manufactured by local craftsmen: fences, bollards, gates, tables, benches and fountains.



Bench area, wooden stakes, and gate in the reversible parking area.



### Barriers encountered

- The green drainage pavement did not filter as intended because the soil mix was over-compacted and contained excessive clay which made the layer too impermeable. An already installed area had to be removed and new soil mixtures had to be made, while limiting compaction as much as possible.
- It was difficult to find a mixture of sand and topsoil suitable for the reinforced turf roots. Several mixtures were created and tested in different sections of the intervention.
- Aripaq type agglomerated terrazzo pavement suffers from surface erosion and premature degradation.



### Agents involved

- Ea Town Council
- Bizkaia Provincial Council
- URA - Basque Water Agency



### Economic data

**Approximate cost of the intervention:**

**€348,000**

**Funding: €228,000**

(from various local eco-innovation programmes and a series of subsidies to promote sustainable development, calls for proposals in 2020 and 2021)



### Success factors

**Reversibility of a seasonal facility** (summer parking area) with little visual impact.



### Lessons learnt

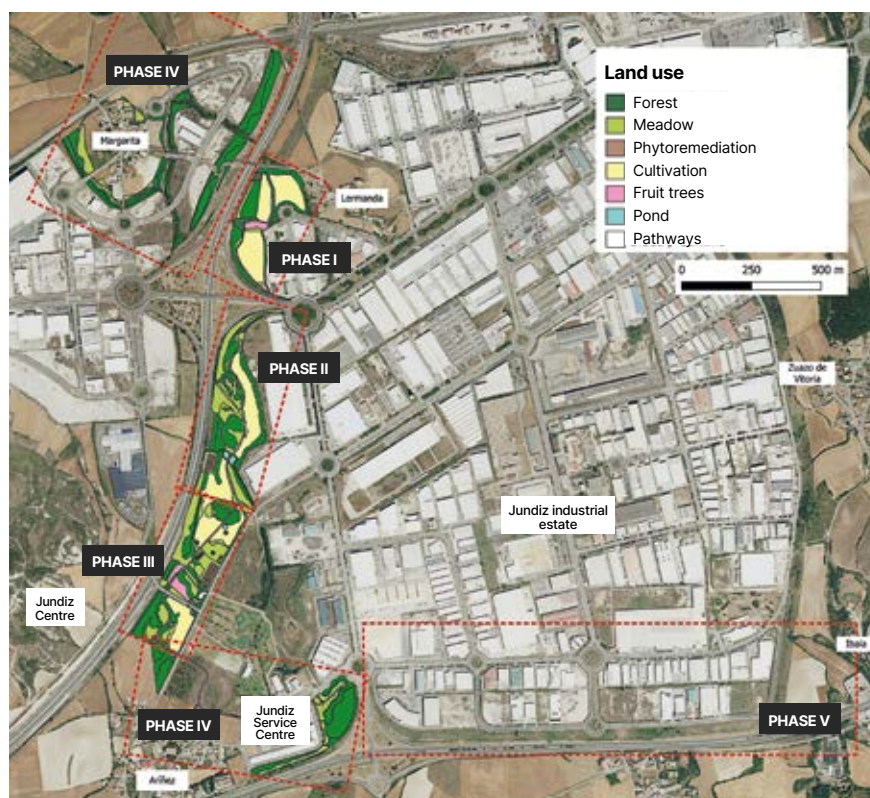
- Green drainage pavements are delicate, as care should be taken to avoid excessive compaction and to control the proportions of the sand, gravel and fertilised topsoil mixture.
- This type of bioengineered construction requires more maintenance, particularly gardening work, than a hard asphalt or concrete car park. Otherwise there is a risk that it will deteriorate.



# Jundiz Park: green corridor to restore the soil and landscape surrounding the Jundiz industrial estate in Vitoria-Gasteiz

The Mendebalde Project is designed to create a large green corridor between the Jundiz industrial estate and the A1 motorway (Jundiz Park). The aim is to improve the environmental quality of the currently degraded soil and landscape, recover ecological connectivity, continue agricultural activities, and mitigate the effects of climate change. The corridor also connects the surrounding rural areas (Lermanda, Margarita, Aríñez and Zuazo) and links them to the existing network of green walkways and cycle paths. The extensive area of action covers more than 43 hectares, so the project will be carried out in successive phases, each one of approximately 10 ha: phase I Lermanda in 2016-17, phase II Mendigurrentxo in 2018-19, phase III Aríñez in 2020-21, phase IV Aríñez-Margarita in 2022-23, and phase V Ibaia-Zuazo in 2023-24.

General criteria were established during the design of phase I (Lermanda) that have been maintained for all subsequent phases: installing visual and sound protection dykes in front of the roads; soil restoration using crops and forests to create carbon sinks; saving fertile soil for agriculture; and recovering riverbanks

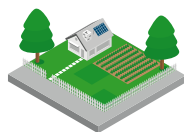


and creating ponds for biodiversity, creating a new area for public use. The next phases continue with the same philosophy, and also incorporate a large number of recycled materials in their construction: soil from excavation works, compost from selective organic waste collection, and wood waste from municipal plants. Phase III involved action on potentially contaminated soils, and therefore required exploratory and detailed investigations into the contamination, risk assessments and remediation proposals. Following this work, phyto-remediation and phyto-management techniques were used to clean up the soils.

General outline of the Mendebalde Project phases.



## Type of NBS implemented in the intervention



### Diversification of sustainable agroforestry systems

The work to restore the soil in the area in question follows the same order of events, and it has already been completed in 5 of the phases.

**Step 1: site preparation** by manually cleaning the land and selectively removing waste that is sent to an authorised waste manager. If the soil has been marked as potentially contaminated (phase III), investigations, risk assessments, and a remediation proposal must be carried out before work can continue, which are reviewed and authorised by the competent environmental body.

**Step 2: earthworks** and construction of dykes to provide an acoustic and visual barrier. Inert materials from the area can be recycled and used to form the dyke core, using higher quality soils on the surface. Any soil from areas with potentially contaminated soils (phase III) must be analytically characterised before they can be used in accordance with current legislation.



Loose waste found on the ground is temporarily stockpiled, and stones are removed from the area which is also levelled.

**Step 3: construction of paths** for pedestrians, cyclists, and farmers or managers of the green corridor. Organic correction is essential in this area to improve the soil and provide nutrients to the plants. This was done using compost from selective waste collection at an initial single dose of 75 t/ha, which can be reinforced after 5 years or lower doses can be applied annually. It must be verified that the right amount of N is provided.



Construction of earth dykes next to the motorway.



Works to create paths with recycled material.

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social

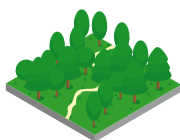


### Economic



## SDG





## Restoration / reforestation with native species

**Phase I: 5,026 forest plants** to create a carbon sink forest and riverside vegetation to improve the river network and restore the ecological corridor.

**Phase II: 9,392 trees and shrubs** on the perimeter dykes that provide visual and acoustic protection from the motorway in ridges (known as Hugelkultur) formed on the perimeter of the industrial estate. The ridges contain large piles of wood from the city's felling operations, and include the *Pinus pinea* species as a way of hiding the industrial warehouses. Vegetation typical of ash-elm forests is used in areas with higher edaphic humidity, and trees and shrubs typical of transitional Iberian oak groves are used in the lower-lying areas. In addition, 68 lines of shrub hedges (of holm oak, Iberian oak, and pine trees) are created to reinforce the above solutions with 904 specimens in mulch on the perimeter of the forest.

**Phase III: 6,718 specimens** of forest plants with large areas of restorative crops (meadows of rustic species such as alfalfa) to improve the physical and biological characteristics of the soil, as well as shrub and aromatic hedges to mark out the different areas.

In this phase, several phyto-remediation experimental plots are set up to deal with soil contamination within the framework of the European PhytoSudoe and Phy2Sudoe projects. Contamination levels are reduced using organic compounds, inoculation of mycorrhizae, and combining agricultural crops (rapeseed, wheat, alfalfa) with forestry plants (poplars, willows and others). This also means that risks can be controlled in the medium term to allow these plots to be used as a "public park", which are then fully incorporated into the park. Key partners in this process were Neiker, the University of the Basque Country, and Ihobe/Basque Government.

**Phase IV: 18,949 plants**, used to establish permanent forests with climate-adapted species, and 37 fruit trees are planted in the Margarita area.



Development of riverside vegetation planted on plastic mulch.



Linear planting of aromatic hedges in staggered rows.



Revegetated slopes.



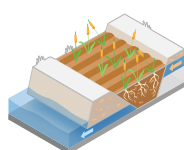
Experimental phyto-remediation plot: poplar and alfalfa.

**Phase V** (under implementation at the time this document is drafted): **11,100 trees and shrubs** will be planted to naturalise the area surrounding the industrial estate and contribute to the fight against climate change.

In addition, **304 elm trees** from the "LIFE Olmos Vivos project" that are resistant to Dutch elm disease will be planted along the walkways in collaboration with the Ministry of Agriculture and Fisheries, Food and Environment.



Elm trees resistant to Dutch elm disease planted in a linear fashion.

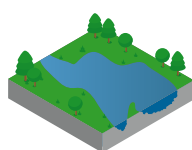


### Phyto-purification system

Consisting of a gravel bed that is around **30 cm deep** with an approximate surface area of **300 m<sup>2</sup>**. The system incorporates **160 aquatic plants** of 3 species commonly used in water purification (*Scirpus holoschoenus*, *Carex pendula* and *Typha latifolia*) that help water to infiltrate into the ground while filtering the water coming from the A-1 dual carriageway gutters.



Green filter with gravel bed and aquatic vegetation.



### Pond

Construction of **9 artificial ponds** within the scope of the project to promote biodiversity. This creates small aquatic ecosystems of a temporary nature (they fill and empty according to the rainfall) that are essential for the conservation of amphibian and reptile species, some of which are of great interest such as the Iberian parsley frog or the natterjack toad. The ponds are approximately **8 m x 6 m** and some of them are fitted with a waterproofing sheet. Plants will be placed in the surrounding area to integrate the ponds into the landscape.



Development of one of the ponds for this intervention.



“ This project is achieving several objectives. In addition to recovering the soil, green itineraries are being created that connect several green walkways in the municipality. With these actions, steps are being taken to incorporate this land as peri-urban parks on the outskirts of Vitoria-Gasteiz, protected from the noise of the motorway by the earth ridges. Planting vegetation is a fundamental part of all the work carried out. ”

**Head of the Public Space and Natural Environment Service  
of the Vitoria-Gasteiz City Council.**



### Agents involved

- **Vitoria-Gasteiz City Council:**
  - Environmental Studies Centre
  - Economic Promotion Area
- **Councils or Small Local Entities**
- **Basque Seed Network**
- **Gardelegi CDW recycling plant**
- **Ministry of Ecological Transition and the Demographic Challenge**



### Economic data

**Approximate cost of the intervention: € 709,000**

#### Funding:

**Phase I: € 40,000** (aid programme for local authorities carrying out actions to promote sustainable development, 2015).

**Phase II: € 49,000** (aid programme for local authorities carrying out actions to promote sustainable development, 2017).

**Phase III: € 80,000** (aid programme for local authorities carrying out actions to promote sustainable development, 2019).

**Phase IV: € 63,000** (aid programme for local entities that carry out actions that promote sustainable development, 2021); **€ 35,000** (Rural Kutxa-Caja Rural de Navarra social action programme).

**Phase V: € 89,000** (aid programme for local entities that carry out actions that promote sustainable development, 2022); **45.000 €** (LIFE Programme, LIFE IP URBAN KLIMA 2050 project).



### Barriers encountered

Provincial Road Regulations create an administrative barrier to plantations, which is particularly relevant in the current context of climate crisis. The planning permissions issued through the Road Service require a distance of 25 metres to be left between the roadside and the plantations. This intervention runs parallel to the road network, and as a result of these regulations, approximately 50% of the public land next to the road cannot be used for plantations, reducing the efficiency of the nature-based solution in terms of reducing air pollution and mitigating GHGs from road traffic.



### Success factors

**Reuse of inert materials** found on the site itself and materials from municipal management plants, **reducing the GHG emissions associated** with these materials and **reducing the environmental impact**.

**Collaboration with the Economic Promotion Area** to **promote social-labour insertion programmes** in the pond creation work and some maintenance work.

**Public collaboration with phyto-remediation research centres** to monitor soil and vegetation with the new techniques.

**Use of mostly local plant material** and acclimatisation of some specimens in municipal nurseries.

**More intense maintenance and vegetation support work** (clearing, summer watering, replanting) during the first years of growth (especially for experimental phyto-remediation plantations).

**Project communication:** diversification of communication actions according to the type of target audience.



# 5.

## Linear transport infrastructure interventions

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Renaturalisation of the river Oiartzun  
in an urban section covered by the motorway  
in Errenteria

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Conversion of an urban traffic artery into a  
green corridor to improve thermal comfort  
along Maria Diaz de Haro street in Bilbao

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# Renaturalisation of the river Oiartzun in an urban section covered by the motorway in Errenteria

Errenteria Town Council identified the need to intervene on the Oiartzun River as it passes through the municipality as one of its priorities in the Strategic Plan 2025.

The degraded space was located under a complex network of transport roads (the A8 viaduct, its entry and exit lanes, and the Euskotren tracks); however, this space has significant natural value due to the presence of emblematic species such as the Atlantic salmon, heritage value due to the Fanderia mill canal, and recreational and communication value due to the important Arditurri Green path that runs through it.

A surface area of 23,500 m<sup>2</sup> of urban river environment has been renaturalised along 330 metres of the course of the river through this intervention.



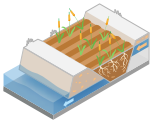
Viaduct where some of the interventions are located.



- 1 Phyto-purification system
- 2 Naturalisation of linear transport infrastructure
- 3 Green wall with cabling on pillars and recreation of the old Fanderia dam
- 4 Sustainable urban drainage system (SUDS)
- 5 Geological Garden

Location of the different interventions along the course of the river.

## Type of NBS implemented in the intervention



### Phyto-purification system

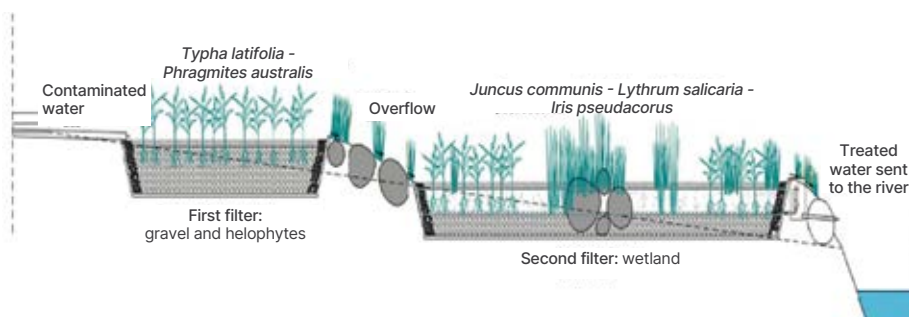
Runoff water from the A8 motorway is collected by a side ditch that descends to the underside of the viaduct and is directed to the purification basins.



Side ditch to collect runoff water from the A8 motorway.

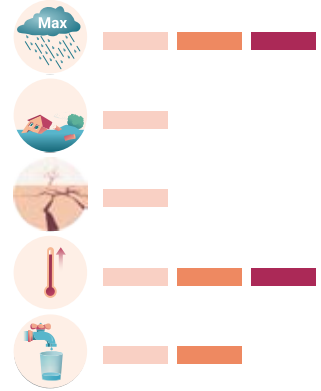


Connected phyto-purification basins (gravel and helophyte filter basin on the left, wetland basin on the right).



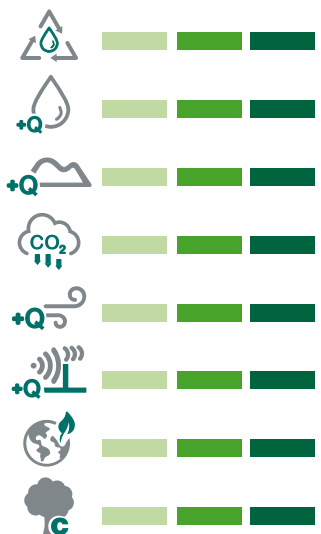
Schematic diagram of the connected phyto-purification basins.

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social



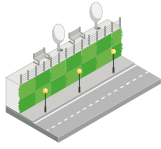
### Economic



## SDG



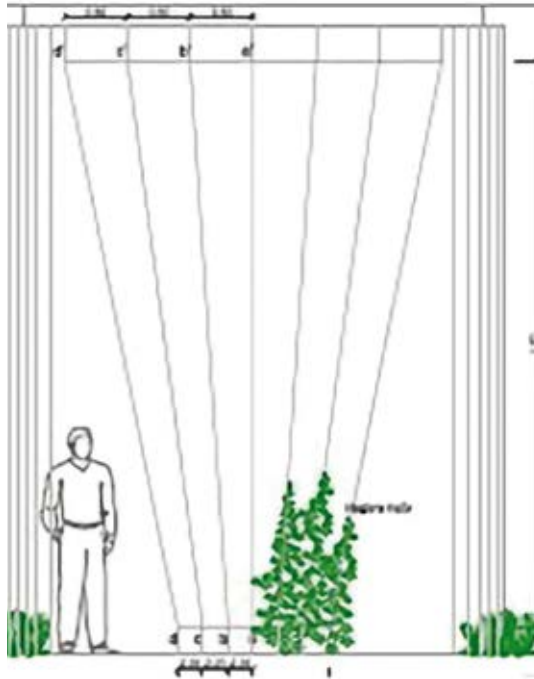




## Green wall with cabling on pillars

7 fan-shaped steel cables were placed longitudinally along the viaduct pillars so that vegetation could be developed. The cables are anchored to the pillar with sufficient clearance so as not to interfere with maintenance work.

A drainage system with gravel and geotextile has been installed on the ground to direct rainwater runoff from the viaduct onto the vegetation on the pillars, thus ensuring the viability of the vegetation. This is the only water supply for the vegetation.



Design layout of the cabling system.

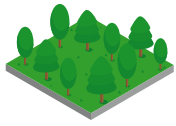


Cables anchored to the pillars, providing separation.



Gravel and pipe drainage system that directs rainwater to the vegetation.





## Naturalisation of linear transport infrastructures

Tree species were planted in the area adjacent to the space under the A8 roadbed. **75 trees** have been planted to regenerate the native riverside vegetation typical of the Atlantic alder grove, which features alders, ash, and hazelnut trees.



Riverside vegetation planted in the intervention area.



## Sustainable Urban Drainage System (SUDS)

Drainage ditches that allow water from the motorway viaduct to drain, creating a wetland and vegetation under the viaduct.



Runoff from the motorway viaduct is sent to the naturalised ditch below.



## Other interventions that contribute to enhancing the surrounding heritage

### Recreation of the old Fanderia dam

Upstream of the intervention area, the structure of the old Fanderia dam has been recreated using the original wooden framework, taking advantage of the protection offered by the viaduct. The dam was demolished in 2011 following a flood and was completely dismantled in 2014 and replaced by a permeable ramp for wildlife.



Recreation of the old Fanderia dam.

### Geological Garden

A recreational area located among the trees where the rocks of the Oiartzun river basin can be appreciated, characterised by having 8 Places of Geological Interest.



Arrangement of the rocks from the Oiartzun river basin in the Geological Garden.

“ The disappearance of the Oiartzun river dam and the renaturalisation of the Fanderia area have allowed Atlantic salmon to be connected with the Natura 2000 Network in Aiako Harria, while improving the quality of urban life and comfort. ”

Environmental technician of Erreterria Town Council.



### Agents involved

- Erreterria Town Hall
- Basque Government Department of Tourism, Trade and Consumer Affairs
- Bidegi



### Economic data

**Approximate cost of the intervention:**  
€ 360,000

**Funding:**  
€ 290,000  
(Berpiztu Programme 2022)

€ 15,000  
(Berringurumena Programme 2019)

€ 10,095  
(Local Agendas 2021, Gipuzkoa Provincial Council)

€ 25,000  
(Grants to develop Landscape Action Plans 2014)



### Lessons learnt

- The longitudinal vegetation on the viaduct pillars that receive more water is more developed and in a better condition. The irrigation therefore needs to be reinforced or the viaduct drainage increased so that the pillars receive more water.
- An upstream screen may need to be built to reduce clogging in the basins and to help to remove solids.



### Success factors

**Political interest in regenerating** the intervention area.

**Actions were defined in a staggered, participatory, and consensual way, and they were planned by integrating different sectors.** This helped resolve common difficulties in this type of spaces where different administrative competencies coincide.

**The intervention was divided into small projects,** making it possible to obtain different lines of funding.

**Support from the proposals set out** in the landscape determinations of the Partial Territorial Plan of Donostialdea, approved in September 2020.



# Conversion of an urban traffic artery into a green corridor to improve thermal comfort along Maria Diaz de Haro street in Bilbao

The Bilbao City Council proposed to fully transform María Díaz de Haro Street, converting two of its three traffic lanes into a green corridor connecting two existing urban green areas - Doña Casilda Park and Ametzola Park. The entire road design has been completed, and at the date this document is published the first phase of the work, the section from Simón Bolívar to Autonomía Street, has also been finished.

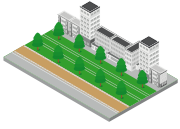
The intervention aims to renaturalise a road that is almost 1 km long and 25 metres wide. The first phase of the project covers an area of around 9,000 m<sup>2</sup>, a large part of which will be used for new pedestrian and green areas. Motorised traffic lanes are therefore removed, widening the pavements and creating a large central space in the form of a green corridor where a children's play area is also installed. The project has been able to completely revitalise this important urban artery of the city from the pedestrian, recreational, and commercial point of view.



María Díaz de Haro green corridor after the intervention was completed.



## Type of NBS implemented in the intervention



### Renaturalisation of linear infrastructure for soft traffic

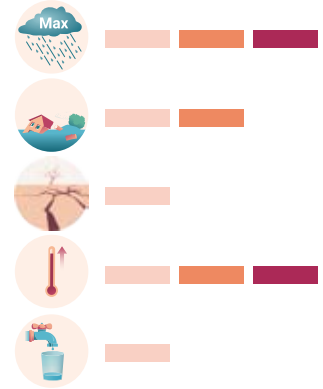
The first phase of the project covers a surface area of nearly 9,000 m<sup>2</sup>, of which more than **6,000 m<sup>2</sup> are destined for new pedestrian and green areas**. To this end, two of the three motorised traffic lanes are removed, widening the **pavements to 4.5 metres** and creating a large central space as a green corridor.

Approximately **50 trees** of four different medium-large size species, as well as shrubs and grass (approximately 10 different species) are planted to create the linear space along the green corridor, forming different plant strata.



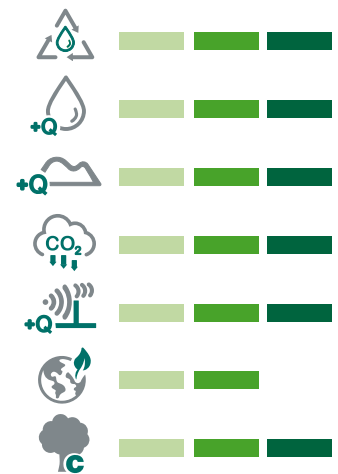
Photographs with the interventions described (in the middle and at the bottom).

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social



### Economic



## SDG





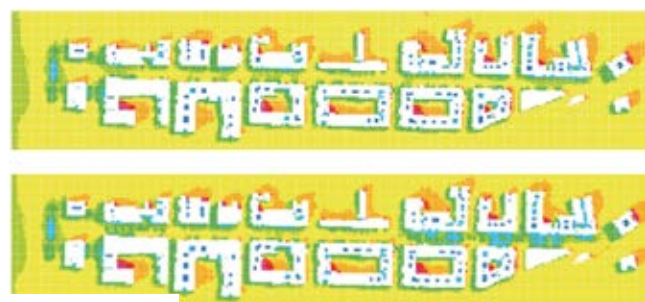
## Urban Sustainable Drainage System (SUDS)

Storage cells are arranged at the lowest points of each street section to allow water to infiltrate into the ground and reduce the risk of rainwater flooding. This system also helps to reduce the impact of heavy rainfall events on the stormwater network, as only the excess water overflowing from the cells is discharged into the network.

Structural soil has been incorporated in the tree surrounds, based on granular material specially treated with gels and other materials. The soil favours the optimal development of the tree roots, helping to ensure the availability of water, air, organic matter and nutrients. This avoids damage to street furniture and paving when the root system of the planted specimens grows. At the same time, the designed structure can temporarily store surface runoff.

## Micro-scale thermal modelling

Thermal modelling at micro-scale level has been used to analyse the effectiveness of the solutions adopted. The improvement in thermal comfort experienced in the street is analysed by comparing the situation before and after the works were carried out and all the elements of shading, green areas, etc. were incorporated. The study also took into account the climatic variable, analysing the results under different climate scenarios.



| PET               |                   |                   |                |
|-------------------|-------------------|-------------------|----------------|
| below 23.17 °C    | 31.87 to 36.23 °C | 44.93 to 49.28 °C | above 57.98 °C |
| 23.17 to 27.52 °C | 36.23 to 40.58 °C | 49.28 to 53.63 °C | Min: 18.82 °C  |
| 27.52 to 31.87 °C | 40.58 to 44.93 °C | 53.63 to 57.98 °C | Max: 62.33 °C  |

Effect of vegetation and materials used in the intervention on the thermal comfort indicator PET (Physiological Equivalent Temperature).

“The street will become a green corridor and a natural extension of the Doña Casilda Park up to where it meets the Ametzola Park. It will be an entirely harmonious, sustainable place, with wide spaces to take a walk, well-looked after vegetation, and children’s playgrounds.”

**Juan Mari Aburto, Mayor of the City of Bilbao.**



### Agents involved

#### Bilbao City Council:

- Mobility and Sustainability Department
- Works, Urban Planning and Strategic Projects Department
- Services and Quality of Life Department



### Economic data

**Approximate cost of the intervention:**  
**€ 3 M**

**Funding: € 16,200**

(Local Climate Eco-innovation, 2021) for micro-scale thermal modelling.



### Success factors

**Collaborative and interdisciplinary work flow** between the different **city council departments and the agents involved**.



### Lessons learnt

- The ability of NBS to provide shade is one of the elements that determines their potential to provide thermal comfort. How the shade behaves on the street must be considered when designing NBS, trying to ensure that the shadow is cast on the areas intended to be used and walked through.
- Wind is another key element in thermal comfort. The prevailing wind channels should be identified and NBS should not be placed in areas that would obstruct the wind flow and prevent aeration.
- The following should be taken into account when selecting tree and shrub species: their potential to provide thermal comfort, their native character, their contribution to urban biodiversity, and their maintenance requirements (pruning, water consumption, etc.).

**Consultation and assessment of available information** on the vulnerability and risk of Basque municipalities to climate change, and **thermal analysis of the city** to address the challenge of thermal adaptation on a city scale from a general urban planning point of view.



### Increase in green areas

- Increase in estimated CO<sub>2</sub> **absorption capacity by 39%.**
- **80% of the surface** of the action area **improves the adaptability to heat stress:** following the intervention, more than 40% of the surface is in a low range of moderate heat stress for the hours of the day most exposed to discomfort (from 9h to 14h) in typical summer days with hot weather.
- Thermal improvement ranging between **0 and 2 °C**, with 13% of the area improving by more than 2 °C.



# Interventions on water bodies and watercourses

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Riverside park to tackle flooding  
in the Txomin-Enea neighbourhood of  
Donostia / San Sebastian

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Donostia / San Sebastian  
City Council



Txomin-Enea district,  
Donostia/San Sebastian  
(Gipuzkoa)



2015-2020



Joseba Rodriguez Bayon,  
Project and Site Manager (Civil  
Works and Infrastructures)

# Riverside park to tackle flooding in the Txomin-Enea neighbourhood of Donostia / San Sebastian

The Txomin Enea river park intervention was carried out alongside the urban development project for the neighbourhood. It is a comprehensive urban regeneration project for a degraded area subject to recurrent flooding events.

The aim of this flood park is to minimise the risk of the River Urumea flooding. This is done using a flood plain intended for leisure and recreation purposes and of high natural value, given the environment in which it is located next to the banks of the River Urumea.

The creation of the Txomin Enea flood park is part of a series of interventions undertaken between 2015 and 2020 as part of the Urumea Flood Plan. These interventions include the replacement of the Espartxo bridge, the construction of the new Txomin neighbourhood at a higher level, as well as the demolition of several buildings such as the Goicoenea farmhouse, a series of greenhouses, part of the Franciscan Conceptionist convent building (which is located on the Kristobaldegi pass), and the former Tintoreria de París and Mayoz y Goenaga company facilities.



Current aerial view (year 2022) of the River Park next to the urban development of Txomin Enea.  
Source: El Diario Vasco.

All these changes can be seen in aerial images of the area:

The demolition of several industrial buildings and the removal of gardens and other buildings in the centre of the Txomin-Enea neighbourhood can be observed by comparing the images from 2010 and 2015.

Between 2015 and 2018 it can be observed how part of the vegetation and trees located near the Urumea River have been removed to improve the hydraulic capacity of the area in the event of a flood. It was during this period that the scope of the River Park was defined and differentiated from the urban development of Txomin Enea.



Aerial view of the area in 2010.



Aerial view of the area in 2015.



Aerial view of the area in 2018.

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social



### Economic



## SDG





## Type of NBS implemented in the intervention



### Controlled flood plain

The Txomin Enea river park is a flood plain with a surface area of approximately 3 ha that runs for 800 m along the Urumea river. The area serves as a recreational space for the leisure and enjoyment of the public in normal periods, and to absorb the excess flow of the Urumea River during periods of flooding.

As part of the comprehensive urban regeneration project for the area, the new neighbourhood of Txomin Enea is situated at a topographical elevation of 7 metres, 4 metres above its original elevation. At the same time, the neighbourhood is protected by a 3:1 earth embankment and rockfill wall that creates a gentle and naturalised transition from the residential area to the natural environment represented by the river park.

The river park has the minimum urban equipment such as benches, litter bins, etc. so as not to hinder water flow in the event of a flood.



Aerial view of the area in 2022.



Pedestrian access to the riverside park.



“ Good communication and the eagerness of public administrations involved has been key to the successful development of the intervention. The Basque Water Agency, the Coastal Authority, and the City Council have used all their powers to reach an understanding. ”

**Project and Site Manager** Donostia/San Sebastian City Council  
Projects and Works Department.



### Agents involved

- Donostia/San Sebastian City Council:
  - Project and Works Management
  - Sustainable Urban Planning
- Basque Country Coastal Authority
- URA - Basque Water Agency



### Economic data

Approximate  
cost of the  
intervention:  
**€ 3 M**



### Barriers encountered

- Long process, more than a decade of complex negotiations.
- Difficulty in signing expropriation files.
- Difficulty in managing some relocations, especially sports entities closely linked to the river such as the rowing club, as a place close to the river needed to be found so that they could continue with their activities.
- Competing criteria between hydraulics and environment; removal of all obstacles versus the need to plant more trees. The initial project envisaged the provision of tree and shrub plant species in the riverside park to turn the area into an urban forest. The need to keep the area free of obstacles to the passage of water meant that the initial proposal was not feasible, and a balance had to be struck between hydraulic and environmental criteria.



### Success factors

#### Naturalisation of the slopes for the urban development.

The river park, on its border with the Txomin urban development, was initially designed with rockfill walls that broke with the spirit of the natural recovery of the river bank. To avoid this, they were redesigned to have a better and more natural fit with the environment. This new transition takes up more space, but it is undoubtedly much more appropriate and natural, and **the park-urban transition is more harmonious.**

**Rainwater** collected in the new development is **treated in a hydrodynamic separator** before being discharged into the receiving medium.

# 7.

## Interventions in natural areas and the rural environment

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Phyto-purification system to treat wastewater in a rural environment in Errigoiti

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Sub-surface flow wetland in the Merru neighbourhood of Ibarrangelu

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Reforestation using native species through land stewardship mechanisms in Bakio

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Reforestation of the Oberan hills using native species in Donostia / San Sebastian

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Reforestation to improve the carbon sink capacity in Orendain using native species

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# Phyto-purification system to treat wastewater in a rural environment in Errigoiti

The Errekalde district of Errigoiti, a rural area of scattered farmhouses, had a sewage and wastewater management problem. The septic tank in the neighbourhood, buried in a sloping area and not connected to the municipal sewage system, was deteriorated as ground settlement had caused several cracks in the septic tank.

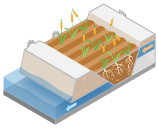
Faced with this scenario, Errigoiti Town Council decided to tackle the problem by combining different NBS and applying circularity criteria. In the civil works part of the intervention, bioengineering techniques were used to stabilise the land, and the cracked septic tank was reused to set up a phyto-purification and mechanical-biological filtration system for wastewater and faecal water from the district. Following the intervention, the effluent generated can be discharged into a nearby stream, complying with all the legal parameters for discharge into the public water domain.



General appearance of the phyto-purification and mechanical-biological filtration system upon completion of the intervention.



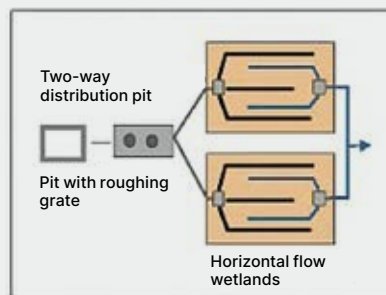
## Type of NBS implemented in the intervention



### Phyto-purification system

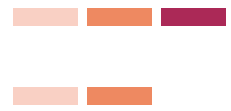
A vertical flow wetland reinforced with a phyto-purification system and mechanical-biological filtration with a **surface area of 29 m<sup>2</sup>**, using the pre-existing septic tank. The system receives **328,500 litres/year of wastewater** from the single-family homes in the neighbourhood (the equivalent of 6 inhabitants) and is designed to **serve the equivalent of 18 inhabitants**, foreseeing a possible scenario with an increase in the number of users during the system's useful life of at least 30 years.

Diagram of the vertical flow wetland reinforced with a phyto-purification system



Excavation next to the pre-existing septic tank.

### CLIMATE THREATS



### CO-BENEFITS

#### Environmental



#### Social



#### Economic



### SDG



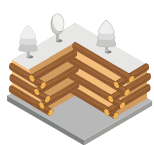
The system has been optimised by adding activated carbon as well as efficient micro-organisms and red worms, improving the absorption of the system and shortening water treatment transit times. As the system is based on aerobic processes, no sludge or odours are generated, which is important when these treatment systems are located in inhabited areas. The maintenance requirements involve checking the screen every 2-3 months, pruning the vegetation, and loosening the sand once a year. This represents an approximate **annual dedication of 16 hours of operating personnel.**



Placement of the two halves of the septic tank to install the purification system, after it was emptied and cut into two.



Installation of equipment and backfilling of wetlands once the two parts of the septic tank were sealed.



### Bioengineering techniques to stabilise the slope

Geomorphological profiling of berms and implementation of a permeable living wall (local larch trunks, biotechnical plants, and soil left over from the excavation carried out on site) as a stabilising solution that contributes to reducing the risk of landslides in the event of an increase in heavy rainfall.



Construction of a permeable wall to stabilise the slope.



“ We have created a new treatment plant from waste and reused all the materials generated on site. ”

Agent involved in carrying out the works in Errigoiti.



### Agents involved

- Errigoiti City Council
- URA - Basque Water Agency
- Citizenship: residents of the Errekalde district



### Economic data

**Approximate cost of the intervention:**

**€ 29,000**

**Funding: € 25,000**

(Berringurumena Programme 2019).



### Barriers encountered

- Difficulty in finding companies to bid for the tender as the project involves the use of NBS.
- Obstruction in the roughing screen due to the non-responsible use of the sewage system by citizens (non-degradable material being dumped in the sewer).



### Success factors

**Proactive involvement and participation of the municipality** throughout all phases of the project.

**Citizen involvement and high acceptance** of the solution adopted.

**Campaigns to raise public awareness** on the potential contamination of surface and groundwater distributed across different discharge points. As a **result** of this project, neighbourhood groups are proposing that the council **review other septic tanks in similar conditions** to identify possible actions.

**Zero waste generated** on site.

**Economic savings** of € 1,200/year to manage the sludge generated in the septic tank.

**Positive assessment from the municipal brigade** in charge of cleaning and maintaining the system, due to the fact that **it does not imply a high workload**.

# Sub-surface flow wetland in the Merru neighbourhood of Ibarrangelu

The Merru district (within the municipality of Ibarrangelu) had an issue, as the wastewater generated by the scattered farmhouses frequently caused diffuse and uncontrolled dumping on the land. Faced with this situation, Ibarrangelu Town Council proposed to implement an ecological phyto-purification system as a solution.

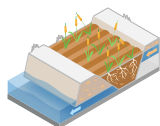
The system implemented collects the wastewater flows from the farmhouses in the Merru district into a new separate sewage network. The wastewater is then treated in an artificial wetland with sub-surface horizontal flow macrophytes. This type of solution is highly efficient, does not generate odours or noise, has a long service life, does not consume energy, and can generate an effluent that is suitable for reuse.



General view of the artificial sub-surface horizontal flow wetland using macrophytes in the Merru district.

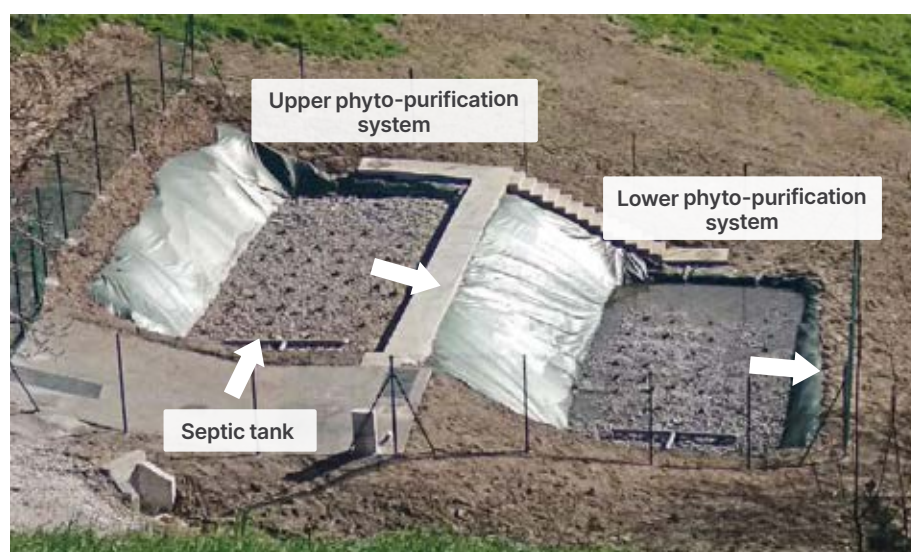


## Type of NBS implemented in the intervention



### Phyto-purification system

Consisting of a septic tank for pre-treatment and a sub-surface horizontal flow wetland, sized for the **equivalent of 40 inhabitants**. Waterproofing is provided between the ground and the two wetlands with a high density polyethylene (HDPE) sheet that is more than 2 mm thick to prevent it from being perforated by plant roots and rhizomes, protected both below and above by a 300g/cm<sup>2</sup> geotextile sheet. A layer of sand has also been spread over the base of the basin to create an even surface and protect it. The HDPE sheet is anchored to the ground at the gravel level to prevent root systems from affecting the geotextile slopes. The anchoring trench is 1 m wide where the waterproof sheet is inserted and filled with soil to bury the sheet.



**Phase I. Pre-treatment in a septic tank** for roughing, desanding, and degreasing the wastewater, as well as providing primary treatment.

**Phase II. Phyto-purification.** Sub-surface horizontal flow wetland formed by two basins with a **surface area of 40 m<sup>2</sup>** (each measuring 4 m wide x 10 m long), with a 60 cm thick bed of coarse gravel (>100 mm grain size) and medium gravel (20-40 mm grain size), and reed plantations (4-6 plants of *Phragmites australis*/m<sup>2</sup>) found in the local area. This sizing is included within the range established for this type of treatment system (2-5 m<sup>2</sup> per inhabitant equivalent), taking into account the present scenario and future potential.

## CLIMATE THREATS



## CO-BENEFITS

### Environmental



### Social



### Economic



## SDG



**Phase III. Discharge of treated effluent to the land:** A manifold has been designed with three outlets at different heights, which allows the level of the pond to be maintained according to the wastewater requirements. This also allows the retention times and level of waterlogging to be controlled, which is usually kept about 10 cm below the level of the aggregates, preventing the water from being visible.

The treated effluent complies with the conditions to be discharged into the natural terrain in accordance with Royal Decree 509/1996 of 15 March, implementing Royal Decree-Law 11/1995 of 28 December, which establishes the rules applicable to urban wastewater treatment and the discharge limits to be complied with taking into account the characteristics of the municipality.

Filter trenches have been installed to discharge the effluent into the ground in a controlled and regular way. These ditches are outside the fenced area to allow them to be used as grazing areas.



Lower basin of the constructed wetland, showing the gravel filtering substrate with different grain sizes and a thickness of 60 cm, in which the aquatic vegetation is planted.

The wetland maintenance operations consist of cleaning the water distribution and collection structures, and controlling the vegetation in the basins which involves regularly removing reeds exposed above the water level. With regards to the septic tank, sludge collection is required on a 2-yearly basis.

The expected effluent yield (%) obtained from the implemented treatment system has the following general parameters:

| BOD <sub>5</sub> (mg/l) | COD (mg/l) | SS (mg/l) |
|-------------------------|------------|-----------|
| 70-90                   | 75         | 90        |

**BOD<sub>5</sub>:** Biological oxygen demand  
**COD:** Chemical oxygen demand  
**SS:** Suspended solids



### Agents involved

- Albarrangelu Town Council
- URA - Basque Water Agency
- Bizkaia Provincial Council
- Busturialdea Water Consortium



### Economic data

#### Approximate cost of the intervention:

€ 240,000

#### Funding:

€ 25,000 (Berringurumena Programme, 2018), € 135,300 (grant from the Basque Government Department of Economic Development and Infrastructures, 2018) and € 80,000 (grant from the Busturialdea Water Consortium)



### Success factors

The use of *Phragmites australis*, with a **high nutrient removal capacity** (such as nitrogen and phosphorus), as a suitable species for domestic wastewater treatment.

The **reeds were planted** in such a way as to allow a **uniform distribution of the discharge** over the entire width of each basin, in order to enhance pre-treatment and to facilitate future maintenance in the event of clogging. **No reeds were planted in the first metre of each basin**, as this is the area where the water is most polluted and least diluted.

The importance of **planning a initial rooting and stabilisation stage** to complete the development of reed roots and rhizomes, and to extend the vegetation throughout the wetland. This period lasts from several months to 1 full cycle.

**Uniform inflow is improved by placing larger gravel** (10-15 cm) in the first 30 cm of the wetland, occupying the entire depth of the bed. In anticipation of facilitating maintenance and even occasionally operating the system without primary treatment, it would be appropriate to extend this area to 1 m.



# Reforestation using native species through land stewardship mechanisms in Bakio

The climate change adaptation plan for the municipality of Bakio establishes the need to adapt the territory and its productive management to forecast climate scenarios as one of its main lines of intervention. In the area of forestry, the plan proposes identifying the risks and vulnerabilities of the Bakio forests and adapting how they are managed in response to the foreseeable increase in temperatures and decrease in rainfall.

In this context, Bakio Town Council sought to recover municipal forest land that has historically been used for forestry plantations, and to restore them using native tree and shrub species. The initiative sought to restore the ecological functionality of the forest, minimise soil erosion processes, and enhance carbon absorption by plant biomass and soil.

Bakio Town Council signed a land stewardship agreement with a land stewardship organisation to carry out this intervention. The organisation provides technical advice on forest restoration and facilitation, guaranteeing the sustainable use of the land under stewardship at all times.

The reforestation was carried out on a total area of 5.7 hectares divided into two plots previously used for eucalyptus (*Eucalyptus globulus*) that had already been harvested.



Location of the plots of land subject to intervention.



## Type of NBS implemented in the intervention



### Restoration / reforestation with native species

#### PHASE 1: Land stewardship agreement

A land stewardship agreement was reached between Bakio Town Council and the Lurgaia Fundazioa Foundation, through which the Foundation provides technical advice and shares their accumulated experience in forest restoration and facilitation to achieve the objectives pursued. The agreement also guarantees that the plots of land to be reforested will be permanently maintained as forests (this requirement being one of the Foundation's by-laws), so that there will be no alterations that could divert the project to other purposes, ensuring long-term carbon capture in both the soil and aerial biomass.

#### PHASE 2:

#### Characterisation and preparation of the two municipal forest plots selected for action

The lithology, topography, hydrology, access, and erosion processes of the plots are analysed, in addition to detecting the presence of invasive alien species. Before the reforestation work began, the resprouted specimens in both plots were controlled manually by cutting and girdling the specimens.



State of the plots subject to intervention prior to the action.

#### PHASE 3: Repopulation with native species

Due to the proximity to the sea and the orientation of the plots, species and densities typical of a mixed oak forest were selected, as well as Cantabrian holm oak species.

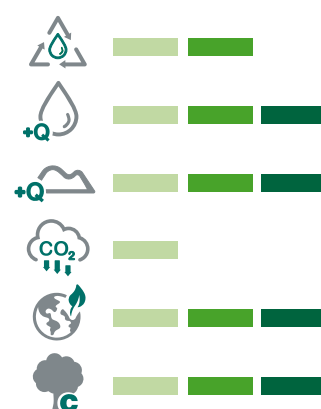
Pioneer species such as birch, ash, alder buckthorn, blackthorn and common hawthorn are specifically selected to accelerate vegetation cover, soil formation, and fruit development for wildlife.

#### CLIMATE THREATS



#### CO-BENEFITS

##### Environmental



##### Social



##### Economic



#### SDG



On the other hand, along the banks of the stream, species typical of this type of ecosystem such as alder, ash, hazel, etc., were encouraged.

In total, **3,563 specimens** were used including trees and shrubs, which is equivalent to a **planting density of approximately 625 specimens per hectare**. The replanting was completed by placing nursery stakes and protections, and some forest trodden paths were removed in areas where accessibility is not required.



Repopulation carried out in the area of action.

#### PHASE 4:

#### Campaigns to control new shoots and invasive species

The regrowth of any specimens in the plots are controlled by manually cutting and girdling them, as a continuation of the preparatory work and prior to repopulating the area. This work will also continue for three more seasons. The non-reproductive parts of this regrowth are spread on the ground to allow them to decompose, providing organic carbon to the soil, improving soil health, and enhancing the absorption capacity of the forest land.

An existing outbreak of Australian blackwood (*Acacia melanoxylon*) was also controlled, uprooting numerous young specimens both on the forest paths and in the areas being restored. As was done with the eucalyptus regrowth, the non-reproductive parts are added to the soil to retain the maximum possible biomass in the plot.



Work to control the regrowth of eucalyptus trees in the area of action.

#### PHASE 5:

#### Monitoring and maintenance plan

A monitoring plan is implemented until 2026. The condition of the fallen trees and eucalyptus regrowth is checked annually. During maintenance work, the non-reproductive parts of exotic species being treated (eucalyptus, mimosas, etc.) will be left on the ground to decompose, improving the amount of organic carbon in the soil.



## Other transversal actions that contribute to the correct development of the intervention

### Environmental volunteering campaign

Four environmental volunteering days were organised where an explanation of the project was given to provide context and raise awareness on climate change and biodiversity. In this sense, the recovery of native forests is presented as a tool to mitigate the effects of climate change and as a mechanism for sequestering CO<sub>2</sub>. The workshops were attended by a total of 106 people and were practical in nature. Activities were carried out on the plot to control the regrowth of eucalyptus and blackwood, and 375 native trees of selected species were planted.



People participating in environmental volunteering campaigns.

*“ This initiative is a good example of collaboration between a land stewardship organisation and two public entities (Bakio Town Council, as the owner of the land and promoter of the intervention, and the Basque Government, as the economic facilitator) for the common good of the natural environment. ”*

Land Stewardship Organisation Representative.



#### Agents involved

- Bakio Town Council
- Bizkaia Provincial Council
- URA - Basque Water Agency
- Land Stewardship Organisation
- Citizenship



#### Economic data

**Approximate cost of the intervention:**  
**€ 25,000**

**Funding: € 23,290**  
(aid programme for local authorities carrying out actions to promote sustainable development, 2020).



#### Barriers encountered

Presence of invasive exotic species that hinder the conservation and development of native species



#### Reduction of environmental impacts

With the actions carried out, **498 tn of CO<sub>2</sub>** is expected to be captured over **30 years** (estimate made using the Basque Country CO<sub>2</sub> ex ante absorption calculator).



#### Success factors

**Land stewardship agreement** between an accredited **entity and the municipal council** as the landowner.

**Mobilisation of citizens** through **environmental volunteering campaigns**.

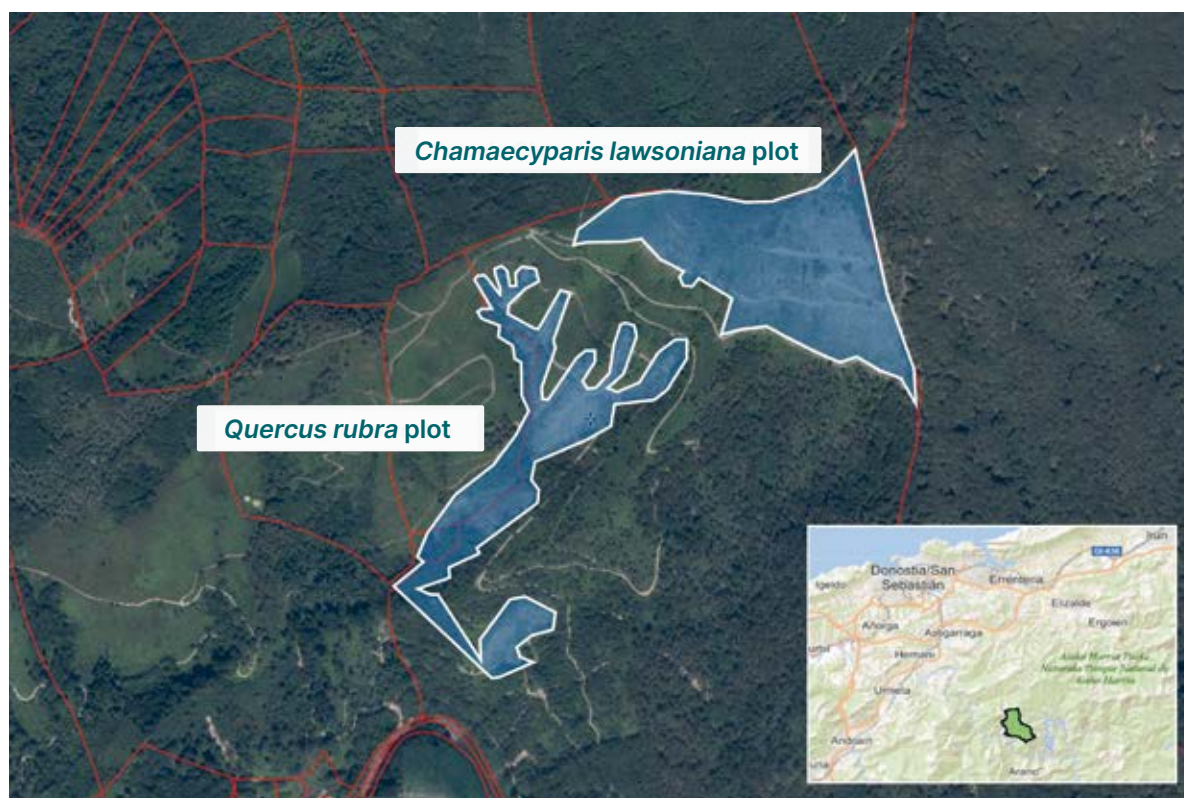
Implementation of a **monitoring plan up to 2026**.

# Reforestation of the Oberan hills using native species in Donostia / San Sebastian

The Donostia/San Sebastian City Council, through different agreements and municipal programmes such as Local Agenda 21 and the Plan to Combat Climate Change, has made a commitment to recover and conserve potential forest habitats on municipally owned land, promoting biodiversity and native species as opposed to non-native species.

Against this backdrop, the city council wanted to establish a potential native woodland on the Oberan hills, a municipal enclave located in the Aiako Harria Natural Park and Special Area of Conservation. Before this intervention, the area had been used for forestry using non-native species.

The reforestation is carried out on a total area of 19 hectares divided into two plots: one of 11 ha with Lawson cypress (*Chamaecyparis lawsoniana*), and the other of 8 ha with a Northern red oak plantation (*Quercus rubra*).



Location of the plots of land subject to intervention.



## Type of NBS implemented in the intervention



### Restoration / reforestation with native species

#### PHASE 1: Site preparation

The first phase began by felling the forest plantations on both plots, Lawson cypress and Northern red oak.

To avoid provoking erosion in the bare ground after felling, the forest residues were piled up in lanes. The clippings were also kept on the ground and arranged in such a way as to facilitate the subsequent work of hollowing out and preparing the planting lines. The hollowing out was done by hand and in staggered rows with an approximate density of **725 holes/ha** in both plots.



Image of the 11 ha plot after felling the Lawson cypress (*Chamaecyparis lawsoniana*).



Image of the 8 ha plot after felling the Northern red oak (*Quercus rubra*).

#### PHASE 2: Repopulation with native species

The choice of species was made by observing the native vegetation spontaneously present in the area, i.e. common oak (*Quercus robur*) over most of the surface, and alder (*Alnus glutinosa*) in the watercourses with irrigation channels.

Other secondary species were chosen to guarantee a greater number of species and greater biodiversity, as well as the continuity of the adjacent Añarbe-Errekabeltz oak-beech forest and the consequent improvement of the surrounding landscape.

#### CLIMATE THREATS



#### CO-BENEFITS

##### Environmental



##### Social



##### Economic



#### SDG



A total of **8,534 specimens** were planted on the 11 ha plot, of which 5,800 were common oak and the rest sessile oak (*Quercus petraea*). A total of **5,940 specimens** were planted on the 8 ha plot, the majority of which were common oak. The plants used in both plots were of certified origin.



A *Quercus robur* specimen planted for the Oberan hills reforestation project.

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### PHASE 3:

#### Campaigns to control new shoots and invasive species

Six to eight months after the plots had been repopulated, the shoots from the old Lawson cypress and Northern red oak plantations were removed. The invasive species *Phytolacca* (*Phytolacca americana*) that had grown in the area was also removed.

Given the resprouting capacity of the cypresses and the difficulty of eradicating the *Phytolacca* species, control work will need to continue for at least 5 years following the intervention. It should be noted that after the first resprouting control campaign, a greater abundance and surface area affected by the invasive plant *Phytolacca* was detected, and so the specimens were removed at the roots to prevent further spread.



Northern red oak shoot from stump.



### Agents involved

- Donostia/San Sebastian City Council
- Gipuzkoa Provincial Council
- URA - Basque Water Agency



### Barriers encountered

Absence of mycorrhiza seedlings on the market, initially planned as a pilot project. The project envisaged introducing mycorrhizae in part of the trees in order to encourage greater CO<sub>2</sub> uptake. It was not possible because such plants were not available on the market.



### Economic data

#### Approximate cost of the intervention:

€ 126,840

#### Funding:

- € 65,314

(aid programme for local authorities carrying out actions to promote sustainable development, 2020)

- € 48,749

(LIFE Programme, LIFE IP URBAN KLIMA 2050 project)



### Success factors

Commitment by the **Donostia/San Sebastian City Council** to recover municipal land destined for **forestry use** to promote native forests, establishing it **as a priority action in its environmental policies**.

**Planning** from the beginning of the project **to monitor and maintain the reforestation**.

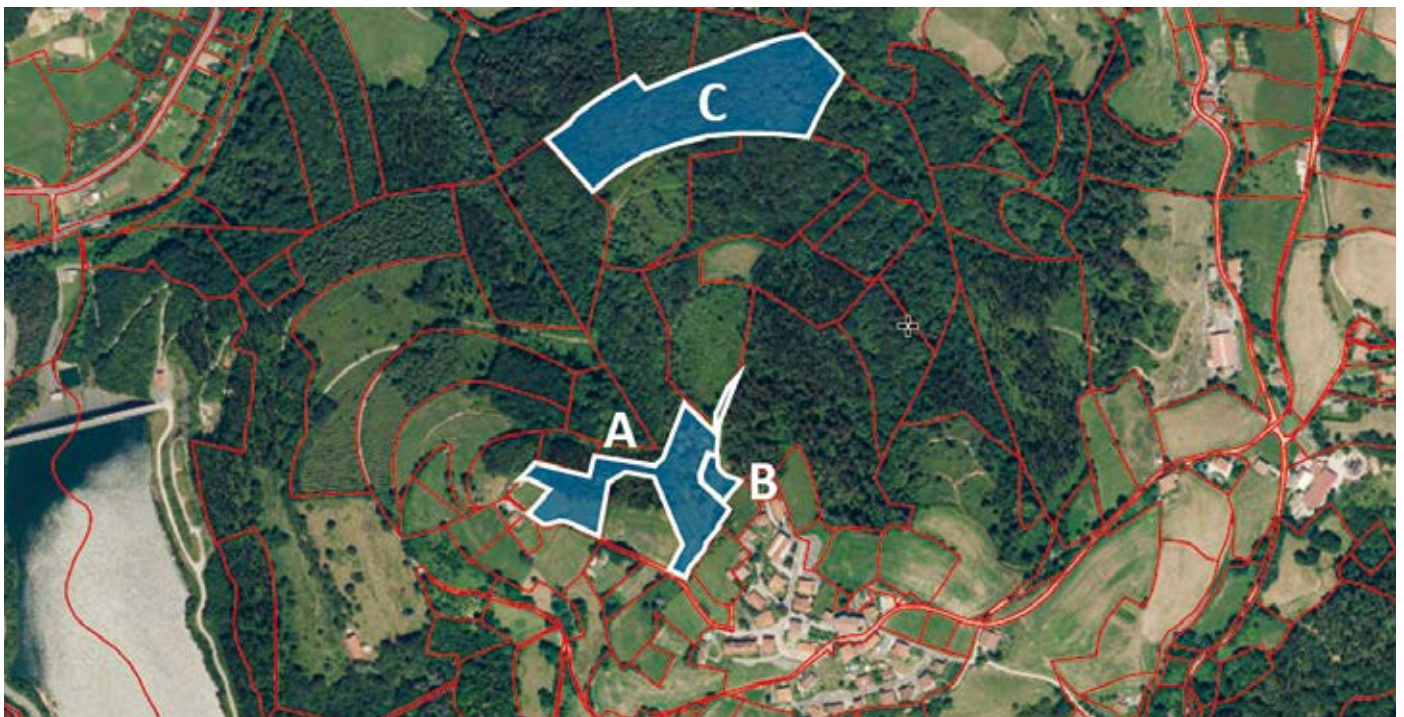
Development of a 10-year **monitoring plan**.



# Reforestation to improve the carbon sink capacity in Orendain using native species

Orendain Town Council has reforested three forest plots with native species, replacing plantations of *Pinus radiata* that had existed until 2019 and were affected by brown spot needle blight. The work carried out aims to recover the area's native forest and contribute to the fight against the climate crisis by increasing the absorption of carbon in aerial, underground, and soil biomass. All of this, without endangering local biodiversity or soil conservation, and preventing logging activities in the forest area that is close to the town centre.

The reforestation was carried out on a total of 5.7 hectares divided into three plots (plot A of 1.99 ha; plot B of 0.17 ha; and plot C of 3.53 ha) following climate change mitigation and adaptation criteria. Native species typical of oak groves and mixed forests were selected, and the soil was protected against erosion and compaction.



Location of the plots of land subject to intervention.



## Type of NBS implemented in the intervention



### Restoration / reforestation with native species

#### PHASE 1: Management Plan

Prior to the reforestation work itself, and in order to ensure that the carbon sink capacity of the reforested plots is improved over the coming decades, a management plan was developed at the end of 2020. This plan provides guidelines that will ensure the plots are properly managed for at least 30 years.

#### PHASE 2: Preparation work in deforested areas

The second phase began by **removing invasive alien species** present on the selected plots. The land was previously deforested in 2019, and had specimens of black locust (*Robinia pseudoacacia*) and above all, butterfly bush (*buddleja davidii*), species that needed to be cleared and controlled. The remains of the extracted plants were collected and given the corresponding specific treatment to ensure the effectiveness of the work carried out. This procedure is repeated annually until 2024, after which it will be done every 10 years until 2050 according to the specific Management Plan.

Monitoring work is carried out on both species in the first annual review in 2022, detecting fewer and smaller specimens, and the extraction work was repeated.

The native plants present in the plots (ash, cherry, maple or eutrophic oak species) are **marked** to prevent the invasive species control and vegetation clearing work from damaging them.



*Buddleja davidii* extraction work.



Clearing and preparation of plots.

#### CLIMATE THREATS



#### CO-BENEFITS

##### Environmental



##### Social



##### Economic



#### SDG



### PHASE 3: Repopulation with native species

Native species with a greater adaptive capacity typical of oak and mixed forests are selected, with oak (*Quercus robur*) being the predominant species used. This species has a **carbon sink capacity of 349.2 t C/ha**, much higher than the 103.2 t of carbon captured per hectare characteristic of *Pinus radiata*, the species previously planted on the plots. In terms of soil protection, only hand tools were used to carry out the work to reduce the impact on soil quality.

A total of **3,420 trees** were used, equivalent to a **planting density of 600 trees per hectare**. Each tree is fitted with a protective tube to provide shelter for the first few years after reforestation.

Most of the planting was carried out by professional technical staff, and in the area closest to Orendain town centre, tree planting activities were carried out with local citizens, specifically with families. The aim of this event, which is part of Tree Day, is to have a social impact, conveying the importance of the intervention, presenting the project as a tool to mitigate the effects of climate change and as a mechanism to sequester CO<sub>2</sub>, and encouraging participants to get involved.



Plot after reforestation and oak tree that had already emerged from the protective tube in October 2022.



Tree Day: volunteer day to reforest one of the selected plots.

“The works to improve Orendain's natural heritage were implemented to tackle the threats of climate change, and they demonstrate that smaller municipalities can also contribute and be relevant agents in climate action.”

Environmental technician .



### Agents involved

- Orendain Town Council
- Environment conservation association
- Citizenship



### Economic data

**Approximate cost of the intervention:**

**€ 32,000**

**Funding: € 25,705**

(aid programme for local authorities carrying out actions to promote sustainable development, 2020).



### Barriers encountered

Presence of invasive exotic species that hinder the conservation and development of native species



### Reduction of environmental impacts

Total carbon absorption of **1,450 t CO<sub>2</sub> (50 years)**



## Success factors

**Development of a Management Plan prior to implementation.**

Exclusive use of hand tools that have **minimised soil erosion and compaction problems.**

**Specific management of invasive alien species** to ensure the effectiveness of the work.

**Monitoring of the planted specimens** during the first 5 years in order to understand their development and health status.

**Maintaining the plots without clearing and pruning** to ensure the structural complexity in the plots.



# Coastal interventions

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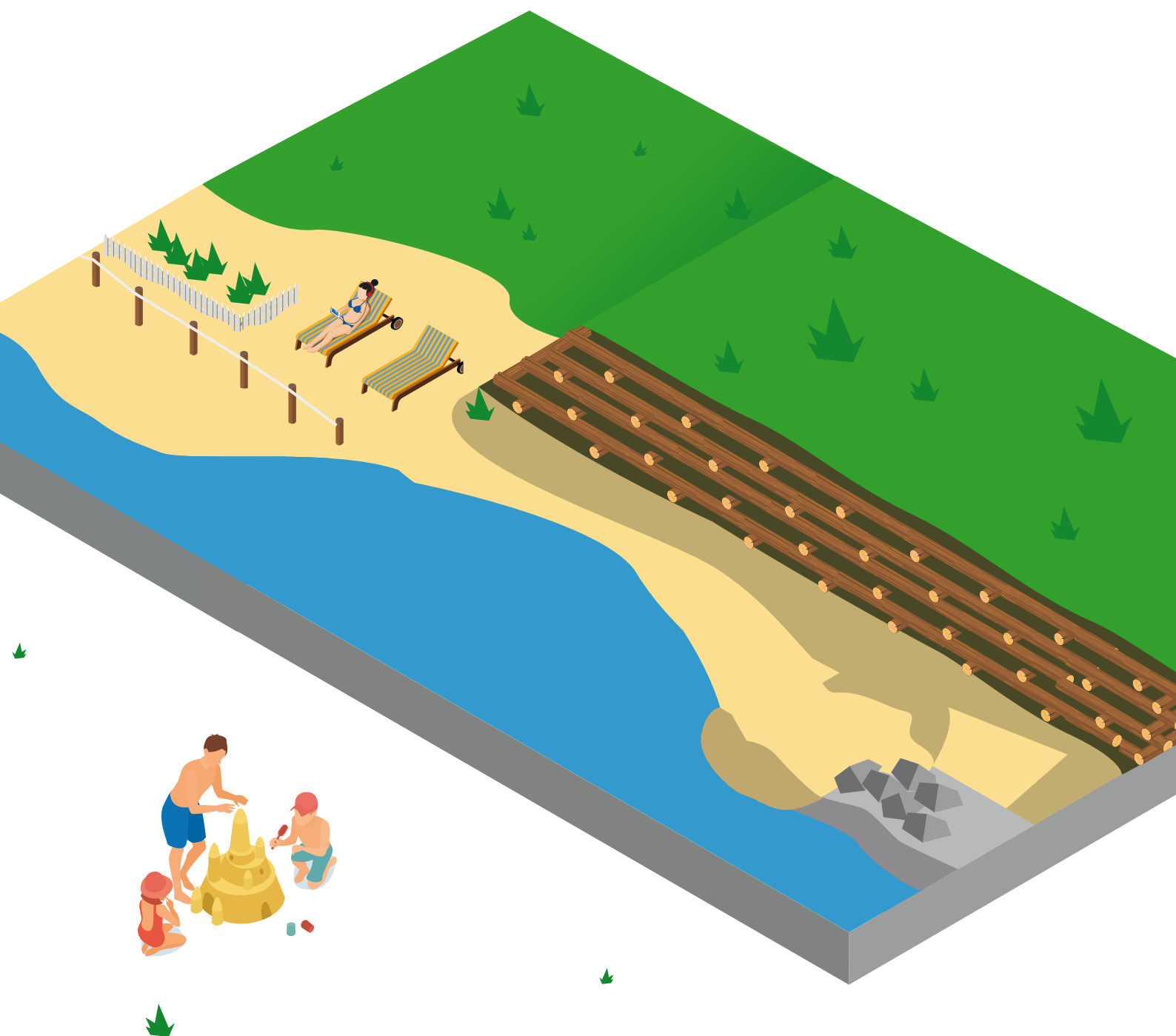


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**Recovery of a natural coastal space  
along the Tonpoi cliffs in Bermeo following  
climate criteria.**

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# Recovery of a natural coastal space along the Tonpoi cliffs in Bermeo following climate criteria

The natural area of Tonpoi is an area of high natural and scenic value as it is located next to the Talape and Tonpoi cliffs, in the vicinity of the San Juan de Gaztelugatxe protected biotope and within the Urdaibai Biosphere Reserve.

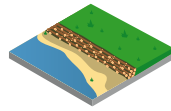
Before its recovery, the area was degraded and there was no public access. It was occupied by vegetable gardens and irregular temporary settlements such as shacks, temporary enclosures, fences, invasive vegetation, and even small uncontrolled waste dumps. Given its proximity to the sea and the steepness of the terrain, the area is vulnerable to landslides due to the combined effect of heavy rainfall and extreme wave events, which are becoming more and more frequent, putting users of the plots at risk.

The aim of the intervention was to create a public park through the environmental and social recovery of a degraded coastal environment by applying climate change adaptation criteria. To achieve this, peri-urban green infrastructure was created that occupies an area of 1.4 hectares close to the town centre, providing shaded areas and connecting Aritzatxu beach with the town centre through the Tonpoi cliffs.



General view of the park after the intervention was completed.

## Type of NBS implemented in the intervention



### Renaturalisation / stabilisation of cliffs

#### PHASE 1

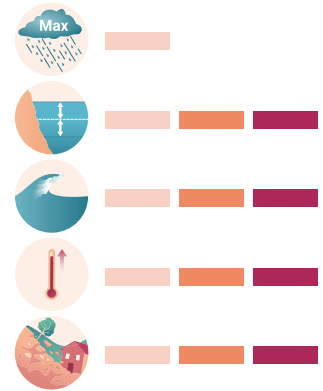
#### Acquisition of plots of land and site preparation

The first phase consisted of land expropriation, demolition of illegal constructions, and site preparation.



Preparation of land and execution of the work.

#### CLIMATE THREATS



#### CO-BENEFITS

##### Environmental



##### Social



##### Economic



#### SDG





## PHASE 2

### Vegetation planting

Planting of native tree and shrub species, provision of **3 km of footpath** that connects the urban centre with the natural coastal environment, and creation of an area to relax and enjoy the views. A total of **77 trees (0.5 trees per 100 m<sup>2</sup>)**, mainly holm oaks, have been planted to restore the original Cantabrian holm oak ecosystem of the area: 58 holm oak trees, 6 cork oak trees, 6 Pyrenean oak trees, 3 laurels, 2 pear trees, and 2 medlars. Around **1,500 shrubs (11 specimens per 100 m<sup>2</sup>)** have also been planted, of different species such as arbutus, blackthorn, buckthorn, privet, dogwood, alder buckthorn, bitter dock and common spindle. In addition, the existing fruit trees and native trees have been respected.



Final state of the area after the vegetation has been planted.



“ With this intervention, beyond environmental recovery, we have created a pedestrian itinerary where the people of Bermeo can exercise in a natural environment that is adapted to climate change and close to the town centre, but away from noise and pollution. ”

**Municipal technician of Bermeo Town Council.**



### Agents involved

- Bermeo Town Hall
- Basque Country Coastal Authority
- Neiker, Basque Institute for Agricultural Research and Development
- Citizens: owners and users of the Tonpoi plots.



### Economic data

**Approximate cost of the intervention: € 360,000**

#### Funding:

- **€ 50,000** (aid programme for local entities that carry out actions that promote sustainable development, 2018).
- **€ 290,000** (LIFE Programme, LIFE IP URBAN KLIMA 2050 project)



### Barriers encountered

- Acquisition of the land by Bermeo Town Council. The area was divided into multiple privately owned plots, many of which were unregistered. Identifying and contacting land owners was costly, lengthening the project's procedures and timeframe. In addition, after the owners and users of the plots were made public to provide information on the de-registration process to pass the land to the municipality, several allegations were received and had to be processed before the plot expropriation and eviction process could continue.
- Presence of numerous small uncontrolled landfills in the area.



### Success factors

**Recovery of the original ecosystem** with minimal actions and respecting the landscape.

**Reuse of natural materials** present on site or use of **locally sourced materials**.

**Creation of several microhabitat areas** (dead wood, pond, etc.) to enhance biodiversity.

**Measurements (pre and post action) of soil organic carbon** to analyse how the intervention improves soil quality and contributes to improving soil structure, reducing erosion, and making it more resilient to climate change.

**Street furniture and street lighting** is not used to restore the original natural state of the Tonpoi area.

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# ANNEX I.

# CO-BENEFITS

# OF NBS FOR CLIMATE

# ADAPTATION

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This annex summarises the co-benefits that NBS for climate change adaptation can provide from an environmental, social and economic perspective. It therefore builds on the progress made in section 1.2 and details the co-benefits analysed in each of the projects included in this publication.

The **environmental** co-benefits that can be achieved by implementing NBS are described below:



## Greenhouse gas emission reductions and carbon storage

NBS can contribute to climate mitigation through:

- Carbon absorption and sequestration through storage in vegetation and/or soil.
- Energy savings using passive cooling solutions to reduce emissions.



## Regulation of the hydrological cycle and water quality improvement

NBS can be an effective measure to improve both water quantity and water quality in terms of flood and drought management. Examples include:

- Reduction in the volume and flow rate of surface runoff water entering the sewerage system, causing flooding, contamination and erosion. This is achieved by increasing the uptake through vegetation and systems that permeabilise roofs and surfaces (such as permeable paving and sustainable drainage systems), a solution that can be implemented at different scales in the urban environment, such as roofs, public spaces, transport infrastructures, etc.
- Increased storage of surface or groundwater runoff through retention systems such as sustainable drainage systems with storage reservoirs. The

flow of runoff water is therefore reduced and its infiltration into the ground is improved.

- Improvement of water quality by reducing its pollutant load (organic matter, nutrients, metals and emerging contaminants) through natural infiltration and treatment solutions, among others.
- Promoting the circular use of water, moving away from linear models.



### Improvement in biodiversity

The role of biodiversity is key to ensuring the resilience of ecosystems, as well as to guaranteeing their capacity to provide us with multiple ecosystem services. The implementation of NBS contributes to increasing biodiversity and ecosystem health as it promotes, among others:

- Less habitat fragmentation, improving connectivity at different scales.
- Greater functional diversity and productivity of flora and fauna in the environments in which action is taken.
- The promotion of native species.



### Improvement of soil quality

Land and soil degradation is one of the impacts that most contribute to the severe effects of climate change. In addition, climate change itself may exacerbate the consequences of land degradation and reduce the feasibility of solutions designed to prevent, reduce, or reverse degradation.<sup>34</sup> Indeed, the impact of most of the pressures causing land degradation will be exacerbated by climate change. These include, among others: accelerated soil erosion due to increased extreme weather events; increased risk of forest fires;

changes in the distribution of invasive species, pests and pathogens; and loss of soil moisture due to changes in rainfall patterns and their expected decline over extended periods of time. The development and use of NBS for adaptation that involve sustainable soil management, with a focus on healthy and resilient soils, will directly result in the soil ecosystem providing vital ecosystem services to humans.



### Better air quality

NBS play an important role in removing atmospheric pollutants and increasing the concentration of atmospheric oxygen in anthropised environments, with vegetation being a key part of these solutions. NBS have a positive impact both on human health, which is exposed to respiratory diseases and premature deaths, and on ecosystems, which are exposed to acidification and eutrophication, among other phenomena.



### Improvement in acoustic quality and comfort

Some NBS can be particularly useful to dampening noise pollution due to their ability to reflect and absorb noise, particularly in urban and peri-urban environments. In this sense, including urban trees can reduce noise levels by 4 decibels (db), while building-scale interventions such as the implementation of vertical gardens can reduce the noise level of the environment by 9.8 db<sup>35</sup>. However, green roofs are the solution with the greatest reduction, as they are capable of reducing noise levels by 46 db in the case of intensive roofs (substrate >150 mm deep)<sup>35</sup>.

In terms of co-benefits that contribute to addressing various kinds of **social** challenges, the following should be noted:

<sup>34</sup> IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental SciencePolicy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemsen (eds.). IPBES secretariat, Bonn, Germany.

<sup>35</sup> Winch R., Hartley S. & Labe J. 2020. The IGNITION Project. Nature-based solutions to the climate emergency. The benefits to business and society. <https://ukgbc.org/wp-content/uploads/2020/08/Nature-based-solutions-to-the-climate-emergency.pdf>





## Increase in urban and peri-urban green-blue spaces and improvement in connectivity

NBS can improve the conservation status of green and blue public spaces, as well as their quantity and accessibility. In this way, the NBS help to achieve healthy green urban and peri-urban environments, as promoted by numerous initiatives such as the European Urban Initiative.<sup>36</sup>



## Health and quality of life

As the World Health Organisation<sup>37</sup>, points out, climate change directly affects people's health through heat waves, accelerated sea level rise, increasingly intense and frequent river or tidal flooding, extreme rainfall, and increasingly recurrent droughts. As a result, tens of thousands of people are affected each year. In addition, the indirect effects of climate change should not be forgotten: food and water insecurity; increased transmission of vector- and water-borne diseases; disruption of the health care system, water supplies, and sanitation; increased health inequality; and displacement/migration of communities. Various agencies, such as the United Nations Economic Commission for Europe (UNECE/UN), associate multiple benefits

to the existence of vegetation in urban areas<sup>38</sup>. In this sense, the widely-accepted "3-30-300"<sup>39, 40</sup>, rule shows that the quality of life of people in urban environments, in terms of physical and mental health, improves with people's proximity to trees and green spaces. Therefore, NBS can contribute to multiple benefits, not only physiological but also psychological, as they reduce risk factors affecting human health, contribute to encouraging physical activity, and ultimately improve health and social well-being.



## Environmental education

Major EU policies, such as the European Green Pact<sup>41</sup>, the EU Biodiversity Strategy 2030<sup>42</sup>, the EU Skills Agenda<sup>43</sup> and the Council Resolution on the European Education Area<sup>44</sup>, point to the role of education and training in empowering and engaging people for the environment and sustainability, boosting the skills and competences needed for the green and just transition. Raising awareness and provoking action is becoming more and more urgent in today's globalised and changing society. NBS are a fundamental tool to promoting knowledge about the interaction between nature and society, to developing resilient and inclusive territories, and to informing and empowering citizens<sup>45</sup>.

<sup>36</sup> European Urban Initiative (EUI). <https://www.urban-initiative.eu/>

<sup>37</sup> Climate change. In: Compendium of WHO and other UN guidance on health and environment. Geneva: World Health Organization; 2021 (WHO/HEP/ECH/EHD/21.02); <https://www.who.int/publications/i/item/WHO-HEP-ECH-EHD-21.02>

<sup>38</sup> UNECE (2022) Advancing sustainable urban and peri-urban forestry - a green approach to resilience, health, and green recovery. Policy brief. United Nations Economic Commission for Europe, Forests program, Geneva.

<sup>39</sup> Konijnendijk, C., 2021. Promoting health and wellbeing through urban forests: Introducing the 3-30-300 rule. IUCN. Urban Alliance news blog. Gland. <https://iucnurbanalliance.org/promoting-health-and-wellbeing-through-urban-forests-introducing-the-3-30-300-rule/>

<sup>40</sup> UNECE/ONU, 2021 "Sustainable Urban and Peri-urban Forestry: An Integrative and Inclusive Nature-Based Solution for Green Recovery and Sustainable, Healthy and Resilient Cities" [https://unece.org/sites/default/files/2023-03/Urban%20forest%20policy%20brief\\_final\\_0.pdf](https://unece.org/sites/default/files/2023-03/Urban%20forest%20policy%20brief_final_0.pdf)

<sup>41</sup> COM(2019) 640 final [https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal\\_en](https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en)

<sup>42</sup> COM(2020) 380 final [https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC_1&format=PDF); [https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC\\_2&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0007.02/DOC_2&format=PDF)

<sup>43</sup> COM(2020) 274 final. <https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX%3A52020DC0274>

<sup>44</sup> 2021/C 66/01 of 26.2.2021. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32021G0226%2801%29>

<sup>45</sup> Gras-Velázquez, Á., Mulvik, I. B., Campodonio, A., Nada, C. & Pocze, B. (2020) Nature-Based Solutions in education - Validation report, European Commission, August 2020. [http://storage.eun.org/resources/upload/873/20210617\\_125131844\\_873\\_NBS-pilot-validation-report-final.pdf](http://storage.eun.org/resources/upload/873/20210617_125131844_873_NBS-pilot-validation-report-final.pdf)



### Urban regeneration and regeneration of degraded areas

In the face of increasingly artificial environments, the implementation of NBS that restore degraded urban areas or limit their peri-urban growth by establishing green-blue belts is an opportunity that unequivocally contributes to increasing the quantity and quality of green spaces, and to favouring the connection between people and nature. Furthermore, urban regeneration through NBS allows us to reduce our environmental footprint, minimise inputs (water, energy, fuels, materials, food, etc.), and decrease emissions and waste associated with urban activity.

### Social justice and cohesion

In line with the previous co-benefit, the implementation of NBS can contribute to social justice and promote social cohesion between generations and between social groups, both of which play a key role in sustainable development. Examples include:

- Inclusion of socially excluded or marginalised groups in processes to design and plan NBS.
- Promoting tolerance within the community.
- Improving the quality of intra- and inter-group social and generational interactions.

### Participatory governance

NBS require an approach that, within the framework of strategic planning, prioritises collaborative governance. The effectiveness of NBS depends very closely on how their deployment is approached from the perspective of identifying and prioritising the challenges and objectives to be achieved. The effectiveness also depends on how potential solutions, along with their barriers and possibilities, are defined. In the same way, open and constant dialogue

between scientific knowledge creators and socio-economic and political agents, within the framework of this strategic planning activity, means a shared governance model can be created. Therefore, comprehensive understanding of the impact and the multi-sectoral benefits of the NBS will be achieved through such a model. Implementing this type of natural solution therefore favours, among other issues:

- Greater confidence in administrative procedures and political decisions.
- Consolidation of participatory processes and increased citizen involvement in these processes.
- Greater citizen empowerment.
- Promoting and strengthening education and awareness-raising for sustainability throughout society as a whole.

Finally, NBS for climate resilience can also contribute to solving **economic** issues such as the following:



### Reduction of energy demand

NBS not only have the capacity to capture and store carbon, thus contributing to climate change mitigation. There is evidence that some of these solutions also reduce GHG emissions directly at source, due to reduced energy consumption thanks to insulation and temperature control. Green roofs, green façades, and vertical gardens provide insulation for buildings, which means that less energy is required to regulate building temperature. Similarly, planting trees and creating parks and green spaces in urban areas reduce the surrounding air temperature and can reduce the cooling requirements of adjacent buildings. Studies<sup>46</sup> have shown that green façades can provide energy savings of 15% in the space immediately adjacent to them, and that green roofs can achieve savings of around 7%, thus achieving a reduction in energy demand that contributes to the inevitable energy transition.

<sup>46</sup> Winch R., Hartley S. & Labe J. 2020. The IGNITION Project. Nature-based solutions to the climate emergency. The benefits to business and society. <https://ukgbc.org/wp-content/uploads/2020/08/Nature-based-solutions-to-the-climate-emergency.pdf>



### New economic opportunities, as well as local and blue-green job

Climate change is causing a wide range of negative economic impacts on a global scale. It is therefore imperative to adopt changes and new development models that are more sustainable and resilient. Investing in properly planned and designed NBS brings a significant economic return on investment due to their multi-functionality, thus generating new economic and employment opportunities in the green and blue sector. Furthermore, the implementation of NBS has the potential to emit low carbon emissions, use resources efficiently, and generate socially inclusive economic growth.<sup>47</sup> Benefits may include:

- Increased productivity and average profitability of land by improving natural capital.
- Increased commercial activity in the environments in which they are implemented.
- Direct and indirect creation of green and blue jobs, both during design and implementation, as well as during subsequent maintenance.



### Increase in land and property values

The sustainable regeneration of urban environments by implementing NBS influences the price of housing and establishments in the intervention area. The magnitude of this effect decreases as the distance between the properties and nature increases, and depends on the type of intervention<sup>48</sup>. For example, residents are likely to pay more for housing in a "green neighbourhood", which supports the idea of developers including urban NBS as part of their real estate business case, and the idea of municipalities including them in urban (re)development plans.<sup>49</sup>

The co-benefits associated with NBS are often difficult to monetise, leading to the need for public bodies to rethink how to assess the benefits, economic effectiveness, and impacts associated with these types of interventions in decision-making.<sup>50</sup> It is important to recall that the co-benefits of NBS can help other sectoral policies, e.g. public health, biodiversity promotion, education, etc., to achieve their objectives<sup>51</sup>.

<sup>47</sup> New Strategy for Renaturing Cities through Nature-Based Solutions – URBAN GreenUP. D1.2: Societal Challenge Catalogue. 2019. <https://www.urbangreenup.eu/resources/deliverables/>

<sup>48</sup> M. Bockarjova, W. J.W. Botzen, M.H. van Schie, M.J. Koetse. 2020. Property price effects of green interventions in cities: A meta-analysis and implications for gentrification. *Environmental Science & Policy*. Volume 112, Pages 293-304 <https://doi.org/10.1016/j.envsci.2020.06.024>

<sup>49</sup> Marija Bockarjova, W. J. Wouter Botzen, Harriet A. Bulkeley & Helen Toxopeus. 2022. Estimating the social value of nature-based solutions in European cities. *Scientific Reports* volume 12, Article number: 19833.

<sup>50</sup> Núñez Rodríguez, M.; Sheikholeslami, D.; Moncorps, L.; Gionfra, S. (2023). Financing NbS in municipalities: Exploring opportunities from municipal funding. Factsheet drafted by IUCN for NetworkNature (H2020 project No. 887396).

<sup>51</sup> Kauark-Fontes, B., L. Marchetti, and F. Salbitano. 2023. Integration of nature-based solutions (NBS) in local policy and planning toward transformative change. *Evidence from Barcelona, Lisbon, and Turin. Ecology and Society* 28(2):25. <https://doi.org/10.5751/ES-14182-280225>

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# ANNEX II. INTERNATIONAL AND EUROPEAN CONTEXT OF THE NBS

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The following is a brief overview of the most relevant agreements, instruments, and policies in which the NBS are framed at international and European level.

## 1. International framework: NBS in international agreements

NBS for climate adaptation have been promoted by international agreements on the subject such as the Sendai Framework for Disaster Risk Reduction<sup>52</sup> signed in 2015; the Sustainable Development Goals<sup>53</sup>

also approved in 2015 by the United Nations General Assembly; and the New Urban Agenda<sup>54</sup> approved by the United Nations in 2016.

In addition to the recognition of NBS in international agreements, other instruments such as the Nationally Determined Contributions (NDC) allow the evolution of NBS implementation to be recorded in a non-binding way. NDC are a core element of the Paris agreement, that is binding for the Signatory Parties. Through this agreement, Parties commit to prepare, communicate, and maintain their national targets for reducing greenhouse gas emissions (NDC registry)<sup>55</sup>. While the NDC were defined to commit Parties to mitigating climate impacts, more than

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<sup>52</sup> UNDRR, 2015, Sendai Framework for Disaster Risk Reduction 2015-2030, United Nations Office for Disaster Risk Reduction, Geneva ([https://www.preventionweb.net/files/43291\\_sendaiframeworkfordrren.pdf](https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf)) accessed 23 November 2017.

<sup>53</sup> UN, 2015, Transforming our world: the 2030 Agenda for Sustainable Development. Resolution adopted by the General Assembly on 25 September 2015 (A/RES/70/1).

<sup>54</sup> UN, 2017, New Urban Agenda. Resolution adopted by the General Assembly on 25 September 2015 (A/RES/71/256).

<sup>55</sup> <https://unfccc.int/NDCREG>



66% of signatories to the Paris agreement have voluntarily included nature-based adaptation challenges in their NDC.<sup>56</sup> According to the report published by the World Resources Institute in October 2022 on the latest update of the NDC<sup>57</sup>, the number of NBS actions included in the NDC has doubled compared to the previous version, amounting to more than 600 actions. Although this increase has not been uniform across countries, it demonstrates the commitment of countries to improving their resilience to climate change impacts by implementing NBS and following the iterative cycle of improvement proposed by the NDC.

Furthermore, NBS were considered to be a priority for the first time at the COP 27 held in Egypt in November 2022, where NBS were conceived as a key part in mitigating emissions and protecting people. In this regard, Egypt, as host country of COP 27 together with Germany, is committed to promoting such solutions, and the United States has presented its \$25 billion roadmap for nature-based climate action.<sup>58</sup>

## 2. European framework: NBS in European policy and planning

In line with the international context, in Europe there is a clear commitment to NBS, understood as cost-effective solutions that help society to

address environmental, social, and economic problems; and that are inspired by and based on nature. Proof of this is that in recent years the European Commission has funded 46 NBS-related projects through its Horizon 2020 and Horizon Europe programmes, with an investment of approximately EUR 441 million and the participation of 923 partners from 66 countries<sup>59</sup>.

Europe also shows clear support for these types of interventions through its policies and planning instruments. NBS are at the heart of the European Green Deal<sup>60</sup>, as well as of recently adopted major European policies: the new EU Climate Change Adaptation Strategy<sup>61</sup>, the EU Biodiversity Strategy for 2030<sup>62</sup>, and the EU Soil Protection Strategy for 2030<sup>63</sup>.

It should also be noted that the European Commission has been publishing collections of guides for those who wish to learn more about NBS. The first of these, *"Handbook for practitioners"*<sup>64</sup>, presents several of the NBS-related projects that have been funded through European programmes. It also provides a synthesis of the results focused on indicators to measure the effectiveness of the NBS and a series of case studies in which this type of solutions have been applied, mainly focused on disaster reduction. The second guide in this collection, *"Appendix of methods"*<sup>65</sup>, is an extensive and comprehensive publication that details possible indicators to measure the performance of each type of NBS, as well as setting out methods to do so. In the third guide, *"A summary for policy*

<sup>56</sup> [potential-for-nature-based-solutions-initiatives.pdf \(wri.org\)](https://www.wri.org/publications/potential-for-nature-based-solutions-initiatives.pdf)

<sup>57</sup> Fransen T., C. Henderson, R. O'Connor, N. Alayza, M. Caldwell, S. Chakrabarty, A. Dixit, M. Finch, A. Kustar, P. Langer, F. Stolle, G. Walls, and B. Welle. 2022. "The State of Nationally Determined Contributions: 2022." Report. Washington, DC: World Resources Institute. Available online at [doi.org/10.46830/wripr.22.00043](https://doi.org/10.46830/wripr.22.00043).

<sup>58</sup> [La solución se encuentra en la naturaleza \(poreclima.org\)](https://poreclima.org/)

<sup>59</sup> European Commission, European Research Executive Agency, Nature-based solutions: Horizon 2020 research projects tackle the climate and biodiversity crisis, Publications Office of the European Union, 2021, <https://data.europa.eu/doi/10.2848/501354>

<sup>60</sup> EC, 2019c, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — The European Green Deal (COM(2019) 640 final).

<sup>61</sup> Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Forging a climate-resilient Europe — the new EU strategy on adaptation to climate change' (COM(2021) 82 final).

<sup>62</sup> EC, 2020e, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'EU Biodiversity Strategy for 2030 — Bringing nature back into our lives' (COM(2020) 380 final).

<sup>63</sup> La Estrategia de la UE para la protección del suelo. [https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12634-Suelos-sanos-nueva-estrategia-de-la-UE-para-la-proteccion-del-suelo\\_es](https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12634-Suelos-sanos-nueva-estrategia-de-la-UE-para-la-proteccion-del-suelo_es)

<sup>64</sup> European Commission, Directorate-General for Research and Innovation, Evaluating the impact of nature-based solutions: a handbook for practitioners, Publications Office of the European Union, 2021, <https://data.europa.eu/doi/10.2777/244577>

<sup>65</sup> European Commission, Directorate-General for Research and Innovation, Evaluating the impact of nature-based solutions: appendix of methSDG, Dumitru, A.(editor), Wendling, L.(editor), Publications Office of the European Union, 2021, <https://data.europa.eu/doi/10.2777/11361>

<sup>66</sup> European Commission, Directorate-General for Research and Innovation, Evaluating the impact of nature-based solutions: a summary for policy makers, Publications Office, 2021, <https://data.europa.eu/doi/10.2777/521937>

makers"<sup>66</sup>, NBS are presented as solutions to address different problems facing society. It should be noted that this paper focuses on NBS from a climate adaptation perspective, and also outlines the co-benefits of NBS as discussed in the introductory part.

A compilation of several policies and instruments at international and European level, as well as the degree to which NBS are incorporated in them<sup>67</sup>, is presented in a summary table below to illustrate the role of NBS in sectoral policies in addition to those related to climate change (Table 2).

**TABLE 2.** Degree to which NBS for climate adaptation and natural disaster management are incorporated into different policies at international and European level (adapted from EEA, 2021)

| THEMATIC AREA                              | TERRITORIAL FRAMEWORK | REGULATORY INSTRUMENTS                                                   | YEAR APPROVED / UPDATED | DEGREE OF INCORPORATION OF NBS |
|--------------------------------------------|-----------------------|--------------------------------------------------------------------------|-------------------------|--------------------------------|
| TRANSVERSAL                                | INTERNATIONAL         | Agenda for Sustainable Development 2030                                  | 2015                    | Medium                         |
|                                            |                       | United Nations Convention to Combat Desertification                      | 1996                    | Medium                         |
|                                            | EUROPEAN              | European Green Deal                                                      | 2019                    | High                           |
|                                            |                       | Bioeconomy Strategy                                                      | 2012/2018               | Medium                         |
|                                            |                       | European Zero Pollution Action Plan for air, water and soil              | 2021                    | Medium                         |
| CLIMATE                                    | INTERNATIONAL         | Sendai Framework for Disaster Risk Reduction                             | 2015                    | High                           |
|                                            |                       | United Nations Framework Convention on Climate Change                    | 1994                    | High                           |
|                                            |                       | Paris Agreement                                                          | 2015                    | High                           |
|                                            | EUROPEAN              | Action Plan on the Sendai Framework for Disaster Risk Reduction          | 2016                    | High                           |
|                                            |                       | Climate Change Adaptation Strategy                                       | 2013/2021               | High                           |
| BIODIVERSITY<br>(including forestry scope) | INTERNATIONAL         | UN Convention on Biological Diversity                                    | 1993                    | High                           |
|                                            |                       | Ramsar Convention                                                        | 1975                    | Medium                         |
|                                            | EUROPEAN              | Proposal for a regulation on nature restoration (Nature Restoration Law) | 2023                    | High                           |
|                                            |                       | Biodiversity Strategy for 2030                                           | 2020                    | High                           |
|                                            |                       | Habitats Directive                                                       | 1992                    | —                              |
| WATER                                      | INTERNATIONAL         | Birds Directive                                                          | 1979/2009               | —                              |
|                                            |                       | —                                                                        | —                       | —                              |
|                                            | EUROPEAN              | Water Framework Directive                                                | 2000                    | Medium                         |
| SOIL PROTECTION<br>(including agriculture) | INTERNATIONAL         | Flood Risk Assessment and Management Directive                           | 2007                    | High                           |
|                                            |                       | —                                                                        | —                       | —                              |
|                                            | EUROPEAN              | Proposal for a Directive on soil monitoring and resilience               | 2023                    | Low                            |
|                                            |                       | Soil Protection Strategy 2030                                            | 2021                    | Medium                         |
|                                            |                       | EU Forestry Strategy for 2030                                            | 2013/2021               | Medium                         |
|                                            |                       | Land use, land-use change, and forestry regulations (LULUCF)             | 2018                    | Medium                         |
|                                            |                       | Farm-to-table strategy                                                   | 2020                    | Medium                         |
| URBAN                                      | INTERNATIONAL         | Common Agricultural Policy (CAP)                                         | 2013                    | Medium                         |
|                                            |                       | —                                                                        | —                       | —                              |
|                                            | EUROPEAN              | New Urban Agenda-Habitat III                                             | 2016                    | High                           |
|                                            | EUROPEAN              | Green Infrastructure Strategy                                            | 2013                    | High                           |
|                                            |                       | The European Union's Urban Agenda                                        | 2016                    | Medium                         |

<sup>67</sup> Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction. European Environment Agency 2021.









Herri-baltzua

Sociedad Pública del

**EUSKO JAURLARITZA**



**GOBIERNO VASCO**

INDUSTRIA, TRANTSIZIO  
ENERGETIKO ETA  
JASANGARRITASUN SAILA

DEPARTAMENTO DE INDUSTRIA,  
TRANSICIÓN ENERGÉTICA Y  
SOSTENIBILIDAD