multiclimact

D8.1 - DEVELOPING ADAPTATION POLICIES AND MEASURES FOR ENABLING A CLIMATE-PROOF BUILT ENVIRONMENT

Application to a real demo

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MULTICLIMACT
D8.1 – DEVELOPING ADAPTATION POLICIES AND MEASURES FOR ENABLING A CLIMATE-PROOF BUILT ENVIRONMENT - APPLICATION TO A REAL DEMO

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Lead beneficiary	CMCC Foundation – Euro-Mediterranean Center on Climate Change
Main Authors	Carmela Apreda (CMCC), Davide Dansero (CMCC), Guglielmo Ricciardi (CMCC), Alfredo Reder (CMCC)
Main contributors	Erika Palmieri (ICLEI), Telmo Jiménez Irizar (ICLEI), Rania Christoforou (UKA), Mina Moayyadi (UKA), Maria Gavrouzou (NCSRD), Margarita Golemi (NCSRD), Diamando Vlachogiannis (NCSRD), Athanasios Sfetsos (NCSRD), Juan Manuel Gonzalez Alvarez (BCN)
Reviewers	Erika Palmieri (ICLEI), Selene Angelone (ICLEI), Telmo Jiménez Irizar (ICLEI), Mina Moayyadi (UKA), Cristina Attanasio (RINA-C), Celina Solari (RINA-C)
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REVISION TABLE

VERSION	DATE	WHAT
v1.0	13/11/2024	Table of Content (1st version)
v1.1	27/02/2025	First draft of D8.1
v1.2	30/04/2025	Second draft of D8.1
v1.3	31/07/2025	Third draft of D8.1
v1.4	01/09/2025	Fourth draft of D8.1 ready for quality check by coordinator
v1.5	20/09/2025	Final version ready for submission

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ABBREVIATIONS AND ACRONYMS

ACRONYM	DESCRIPTION
BCN	Barcelona City Council
CINEA	European Climate, Infrastructure and Environment Executive Agency
CMCC	Euro-Mediterranean Center on Climate Change
CREMA	MULTICLIMACT Climate REsilience Maturity Assessment
EEA	European Environment Agency
EO	Expected Outcome
ICLEI-EURO	ICLEI Europe
KC-M	Key Criteria for evaluating adaptation measures
KC-P	Key Criteria for evaluating adaptation policies
KPIs	Key Performance Indicators
KTMs	Key Type Measures
MULTICLIMACT	MULTI-faceted CLIMate adaptation ACTions to improve resilience, preparedness and responsiveness of the built environment against multiple hazards at multiple scales
NAPs	National Adaptation Plans
NCSRD	National Center for Scientific Research "Demokritos"
RCPs	Representative Concentration Pathways
SO	Specific Objectives
STO	Scientific and Technological Objective
UKA	Universitaetsklinikum Aachen
WP	Work Package

Executive Summary

The deliverable represents the main output of Task 8.1 "*Adaptation policies and measures for enabling a climate-proof built environment at different scales – development for the application to a real demo case*", within Work Package 8 of the MULTICLIMACT project. Task 8.1 aims to deepen the understanding of how existing adaptation policies and planned measures within the Spanish demo case can facilitate the transition to a climate-proof built environment. The task was led by the Euro-Mediterranean Centre on Climate Change (CMCC) in collaboration with the following project partners: ICLEI Europe (ICLEI), Universitaetsklinikum Aachen (UKA), National Centre for Scientific Research "Demokritos" (NCSRD), and Barcelona City Council (BCN). T8.1 is one of the six tasks under Work Package 8 included in the 2nd phase of the project, "*Develop and test*". The collaboration among partners with heterogeneous knowledge and expertise has ensured a comprehensive and multidisciplinary approach to the task's activities.

The primary objective of T8.1 is to apply and operationalize the methodologies developed in T2.1 to the real context of the Spanish demo case. A climate-proofing assessment was conducted to evaluate the capacity of policies and measures to enhance the resilience of the built environment under current and projected climate conditions. Moreover, relevant adaptation options were further identified to expand the T2.1 catalogue with additional measures. Finally, KPIs from T1.2 were integrated to support the quantitative resilience assessment of local adaptation measures to be implemented in the demo case.

The task also aims to provide practical support by collecting and synthesizing existing local adaptation policies and measures for a climate-proof built environment into a single document, with a specific focus on the Catalonia region and the Municipality of Barcelona. This effort is intended to promote the alignment of interventions at both territorial and urban scales with international climate goals. The deliverable presents a desk review and comparative analysis of local adaptation policies and measures related to the climate-proofing of the built environment. The analysis is structured around key criteria, offering guidance for strategic and proactive evaluation. In this way, the deliverable supports policy makers and public administrations in implementing effective strategies and interventions to address climate-related challenges.

The main aspects covered in this document include:

- A review of local adaptation policies for the climate-proof built environment at both territorial (Catalonia region) and urban (Municipality of Barcelona) level;
- The extension of the T2.1 Catalogue with additional adaptation measures identified in local policy documents reviewed;
- The update of the factsheets already included in T2.1 Catalogue related to measures that will be implemented in the Barcelona case study (cool pavement, porous pavement and bioswale), integrating KPIs selected from T1.2 for resilience assessment.

Key results of Task 8.1 include the identification of relevant adaptation policies at both territorial and urban levels, their detailed analysis based on the key criteria developed in Task 2.1, the list of all adaptation measures included in these policies, and a comparison between locally identified measures and those listed in the Task 2.1 Catalogue. Moreover, eight additional factsheets have been developed featuring the most recurrent measures found in local policies and KPIs from T1.2 have been associated with cool pavement, porous pavement and bioswale to support their resilience assessment.

The work carried out and the results obtained directly contribute to the activities of the Task 11.2 "*Demonstration of the MULTICLIMACT framework at the urban scale*", which aims to demonstrate and test the methodologies and solutions developed in T2.1 and T8.1 on the Spanish demo site, with a primary focus on outdoor urban spaces. This will allow to test the relevance, applicability, suitability and impacts of the tools previously defined, while also contributing to the quantitative resilience assessment of local adaptation measures.

1. INTRODUCTION

This report is a deliverable of the project **"MULTICLIMACT - MULTI-faceted CLIMate adaptation ACTions to improve resilience, preparedness and responsiveness of the built environment against multiple hazards at multiple scales"**, funded by the European Commission through the European Climate, Infrastructure and Environment Executive Agency (CINEA). As stated in the Grant Agreement (GA), MULTICLIMACT aims to develop a mainstreamed framework and a tool for supporting public stakeholders and citizens to assess the resilience of the built environment and its people at multiple scales (buildings – including cultural heritage, urban areas, infrastructures) against locally relevant natural and climatic hazards and supply-chains, as well as to support them to enhance their preparedness and responsiveness across their life cycle. The mainstreamed approach includes a resilience scorecard system and a toolkit of Design Practices, Materials, and Digital Solutions, enabling public stakeholders and citizens to plan, design, implement, and monitor solutions to improve the built environment and human resilience and its protective role against climate and natural hazards. In doing so, MULTICLIMACT pursues scientific, technological, and non-technological objectives in 17 Work Packages (WPs) organized in three interlinked phases: 1) Plan and Design; 2) Develop and Test; 3) Deploy and Revise.

The activity of the second phase is dedicated to put in practice the planned and designed activities from the first phase. WP8 contributes to this aim by developing the planning and design methods through demonstration in real contexts. Each design/planning method established will be further developed in order to be tested in a MULTICLIMACT demo site (WP11). The design practices developed during the 1st phase comprise, among other things, of adaptation policies and measures that are available and appropriate for addressing climate change adaptation issues for the built environment.

In this framework, Task 8.1 "*Adaptation policies and measures for enabling a climate-proof built environment at different scales – development for the application to a real demo case*" (hereafter T8.1) relates to the translation of methods and best practices developed in T2.1 into the real context of the Spanish demo. The methodology developed in T2.1 to analyse existing adaptation policies and measures at global, European, and national levels, has been applied to the territorial (Catalonia region) and urban level (City of Barcelona) to find the most relevant adaptation policies considering local geographical contexts. This demonstrates how the previously defined practices and methods can ensure their effective application in local adaptation plans, as well as in the definition and evaluation of local adaptation measures. Moreover, the adoption of key criteria to compare local adaptation policies, enables the evaluation of their effectiveness in addressing climate adaptation challenges. Among the hazards addressed by MULTICLIMACT, T8.1 only focuses on climate hazards (heatwaves, floods, and droughts), excluding earthquakes as they pertain to natural hazards, and the related solutions do not contribute to the climate-proofing of the built environment in this specific context. The deliverable is structured in 5 chapters as detailed in section 1.6.

1.1 OBJECTIVES AND EXPECTED IMPACT

Task 8.1 concerns the translation of methods and best practices developed in T2.1 into the real context of the Spanish demo. The general objective of T8.1 is to demonstrate how the tools previously defined can be adopted to both analyse local adaptation policies and evaluate measures that will be implemented into the real context of the Spanish demo. The following Specific Objectives (SO) contribute to achieving it:

- **SO1**. Identifying the existing adaptation-related policies at the local level;
- **SO2**. Comparing and describing policies, highlighting if and which climate concerns they include;
- **SO3**. Providing guidance for evaluating the adaptation measures designed for urban spaces in Barcelona.

The results obtained from T8.1 contribute to achieving the Scientific and Technological Objective 2 (STO2) which focuses on designing methods for different types of climate adaptation policies for enabling a climate-proof built environment.

T8.1 supports the achievement of the Key Exploitable Result R3 "*D#1 Adaptation policies for climate-proof built environment*" of MULTICLIMACT, which is related to the development of specific digital guidelines to support the definition and implementation of climate-proof built environment also highlighting the correct mode to evaluate the consistency of the selected policies and measures. R3 is the result of the other three tasks to which Task 8.1 is interlinked with, which will be developed during the later project phases: the interdependencies between T2.1, T8.1, T11.2, and T15.2 are described in section §1.5. Together with all project results, R3 contributes to the achievement of the Expected Outcome EO2 "*Mainstreamed resilience as a key feature of the built environment across its life cycle*". Specifically, T8.1 contributes to the creation of the MULTICLIMACT Climate REsilience Maturity Assessment tool (CREMA) for climate-proof built environment by providing a guidance document for public decision-makers at the local level to facilitate the understanding of existing adaptation policies at different levels and the selection and evaluation of relevant adaptation measures that they can implement. The results of T8.1 contribute to delivering innovative design methods and practices for a resilient built environment that will be part of the MULTICLIMACT toolkit. All T8.1 results contribute to achieving the expected impacts of the MULTICLIMACT project related to the economic, social, and scientific dimensions, helping local public decision-makers to develop planning and designing processes oriented towards reducing the negative effects of climate change-related disruptive events, increasing the health and well-being of people, and promoting the quality of life.

1.2 PURPOSE AND TARGET GROUPS

The purpose of this document is to provide an overview of the approach adopted for the development of Task 8.1 by describing the methodology as well as the sub-tasks accomplished and the results obtained. The deliverable describes local adaptation policies and measures under specific applicability context and criteria, helping public decision-makers to identify and evaluate resilient and self-sustainable solutions that can improve the climate-proofing of the built environment.

The document is addressed to public decision-makers included in the target groups mentioned in the GA and listed below with their expected main interests:

A. **Policy Makers at the local level**, who might be potentially interested in increasing awareness of the relevance of a resilient built environment including successful implementation examples;

B. **Public administrations** (civil protection units, urban and regional planners, climate units), who might be potentially interested in replicable solutions, experiences, and guidance for the implementation of resilience measures.

In line with the expected interests outlined above, the document provides practical support and orientation for both target groups by collecting and synthesizing existing local adaptation policies. It also offers guidance on evaluating the contribution of adaptation measures to a climate-proof built environment, fostering the alignment of local interventions with national and international climate goals.

1.3 APPROACH

Task 8.1 follows an exploratory approach to identify existing local policies derived from online searching and evaluate all the references included in the study. The desk-based approach adopted to develop Task 8.1 is organized around three steps related to the above-mentioned specific objectives and resulting in three interlinked sub-tasks (Figure 1):

1. **Collect data at the local level.** The step involves collecting data from online sources and selecting criteria for the inclusion of references in the review. Data collection was carried out under the sub-task "***T8.1.1***. *Desk review of local adaptation policies (Spanish demo)*";
2. **Replication of T2.1 methodology.** The step concerns the translation of the methodology previously developed in T2.1 at the local level, by analysing adaptation policies and measures included in documents at the territorial (Catalonia region) and urban levels (City of Barcelona). The activity was carried out under the sub-task "***T8.1.2***. *Application of the T2.1 methodology to local adaptation policies and measures*";
3. **Update of the T2.1 catalogue.** This step involves updating the catalogue previously developed in T2.1 both in terms of quantity, by adding new measures and factsheets, and in terms of quality, by integrating KPIs for quantitative resilience assessment of local measures. The activity was carried out under the sub-task ***"T8.1.3***. *Update of the catalogue of adaptation measures*".

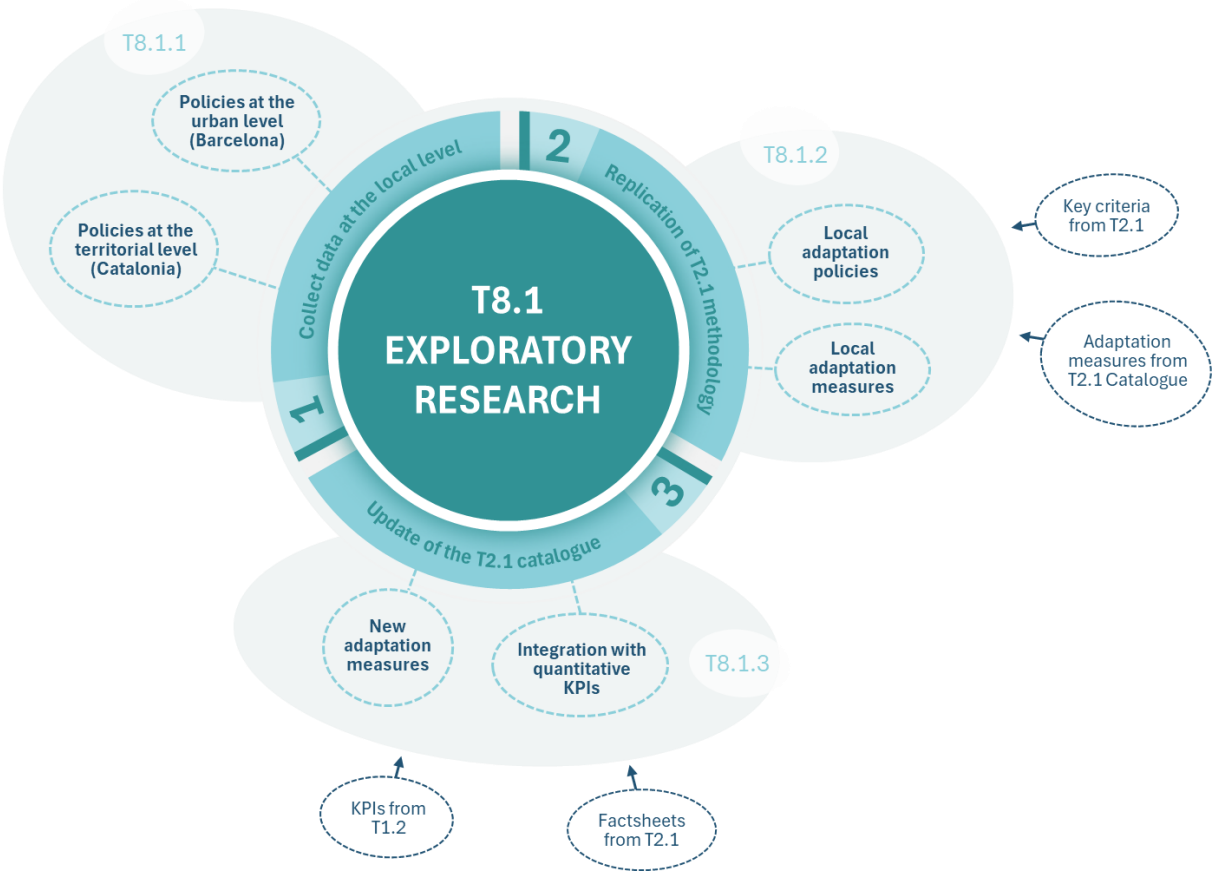


Figure 1. Overall approach adopted in T8.1 (Credits: C. Apreda).

1.4 CONTRIBUTION OF PARTNERS

The task was led by CMCC in collaboration with ICLEI, UKA, NCSRD, and BCN, and the following table depicts the specific contributions from the project's partners in developing activities and drafting deliverable D8.1.

PARTNER SHORT NAME	T8.1 SUB-TASKS	D8.1
CMCC	Coordinating all activities of Task 8.1, writing of chapters 1, 2 (section 2.2), 3, 4 and 5, and reviewing all partners contributions	
ICLEI	T8.1.1/T8.1.2: contribution in reviewing local adaptation policies and measures T8.1.3: contribution in developing new factsheets and validating KPIs associated to local adaptation measures	Contribution in writing chapter 4 (4.1.1.2)
UKA	T8.1.1/T8.1.2: contribution in reviewing local adaptation policies and measures T8.1.3: contribution in developing new factsheets and validating KPIs associated to local adaptation measures	Contribution in writing chapters 2 (sections 2.1, 2.3) and 4 (4.1.1.2)
NCSRD	T8.1.1/T8.1.2: contribution in reviewing local adaptation policies and measures T8.1.3: contribution in developing new factsheets and validating KPIs associated to local adaptation measures	Contribution in writing chapters 2 (sections 2.1, 2.3) and 4 (4.1.1.1)
BCN	T8.1.1: contribution in selecting and reviewing local adaptation policies T8.1.3: contribution in validating KPIs associated to local adaptation measures	Contribution in writing chapter 4 (4.1.1.1; 4.1.1.2)

Table 1. Contribution of consortium partners to T8.1 activities and D8.1.

1.5 INTERDEPENDENCIES WITH OTHER WPs AND TASKS

Task 8.1 contributes to the achievement of the Key Exploitable Result R3, "*D#1 Adaptation policies for climate-proof built environment*", together with three other tasks related to different phases of the project: T2.1, which is related to the project phase "*Plan and Design*", T11.2 pertaining to the phase "*Develop and Test*", and T15.2 concerning the phase "*Deploy and Revise*" (Figure 2). T8.1 concerns the incorporation of the methodologies and measures developed in T2.1 into the real context of the Spanish demo. The outputs of T2.1 have directly informed T8.1 by providing a guidance document helping the analysis and development of design and planning methods for implementing cost-effective interventions on the built environment at multiple scales, supporting and enhancing its resilience to local risks. Moreover, the Key Performance Indicators (KPIs) developed in T1.2 have also been used to supplement the factsheets of adaptation measures from T2.1 with quantitative metrics to evaluate the contribution of these measures to a climate-proof built environment. The outputs of the "*Develop and Test*" phase will be demonstrated in the field, and T11.2 and T15.2 will report the results of the demonstration and testing and continue the work on the Spanish demo at the urban scale. In particular, the factsheets from T8.1 will be used in T11.2 to evaluate adaptation measures implemented in outdoor spaces in Barcelona.

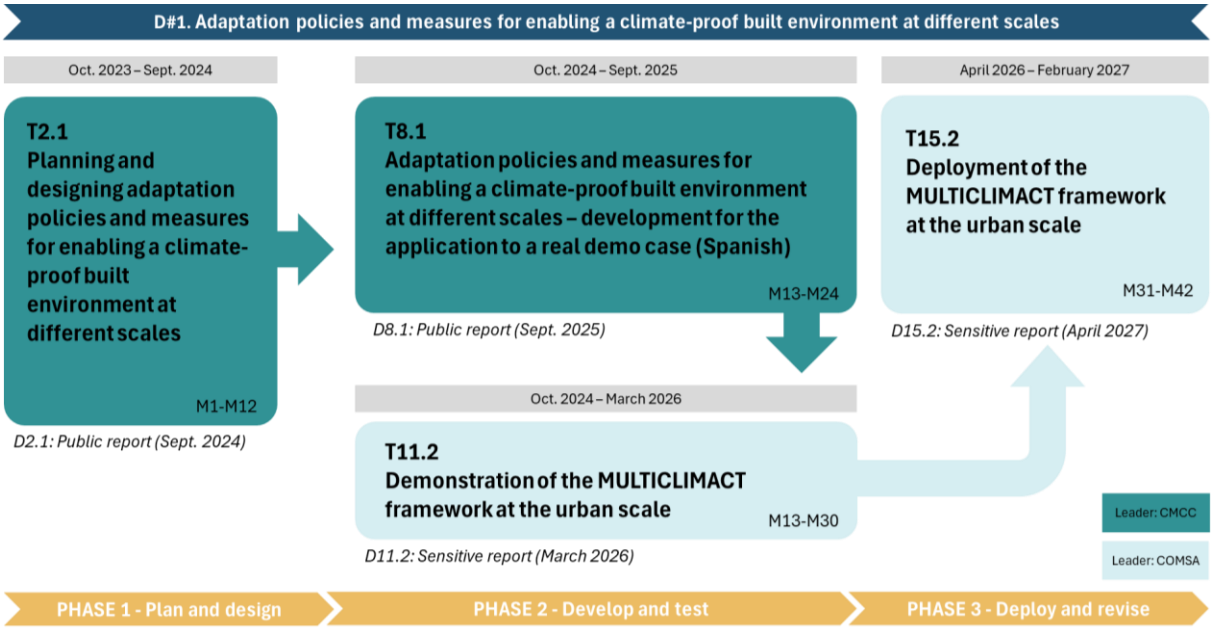


Figure 2. Interdependencies between T8.1 and other tasks (Credits: C. Apreda).

1.6 STRUCTURE OF THE DELIVERABLE

This deliverable consists of 5 chapters organized as follows:

- **Chapter 1** introduces the deliverable covering the project context, the task description and objectives, the involved partners and their contributions, and the interdependencies with other WPs and tasks;
- **Chapter 2** presents the general background and context of the study by outlining an overview of the Barcelona's local context, identifying the future climate projections and impacts at the local scale, and defining the main challenges for climate-proofing of the built environment in Barcelona;
- **Chapter 3** deals with the methodology, explaining the three sub-activities and related objectives and results;
- **Chapter 4** presents the results of the study, with a more detailed overview of the activities carried out within the three sub-tasks;
- **Chapter 5** draws the conclusions of the work and potential future advancements.

2. GENERAL BACKGROUND AND CONTEXT

This section outlines the background on Barcelona's climate and socio-economic setting, framing the conditions relevant to the task. The section aims to:

- describe the main features of the local context (e.g. geographical location, socio-economic conditions, population growth, city layout, landscape, government, etc.).
- investigate projections and future impacts at the national scale of the main climate hazards addressed in the MULTICLIMACT project (heatwave, flooding, drought), focusing on the city of Barcelona.
- identify key challenges for climate-proof built environment, including the increase of the quality of urban spaces, quality of life, and the reduction of impacts from extreme heat and floods.

2.1 OVERVIEW OF BARCELONA'S LOCAL CONTEXT

2.1.1 GEOGRAPHICAL LOCATION AND CLIMATE

Located on the Mediterranean coast, Barcelona is the capital of the Autonomous Community of Catalonia. The city experiences a climate characterised by warm, dry summers and mild winters. Constrained by the Llobregat and Besós rivers on two sides, and by the mountain range of Collserola and the Mediterranean on the others, the city is located in a plain of around 170 km^2, 100 of which are the city itself. Being on the Iberian Peninsula's northeastern coast, the Atlantic west winds often arrive in Barcelona with low humidity, producing relatively low precipitation. The average annual rainfall is less than 640 mm, ranging from 20 mm in July to 91 mm in October. Most years, the city has relatively mild winters and very warm summers. In the warmest month – August, temperatures typically range from 25 °C to 31 °C during the day and about 20 °C at night. In recent years, the highest temperature recorded during the day was 37.4 °C (August 2010), and during the August 2003 heat wave, the record average daytime maximum temperature was 32.8 °C. Under climate change, the Barcelona area is projected to experience more extreme summers, marked by reduced precipitation and more frequent and intense heatwaves. Figure 3 shows Barcelona's location in Spain, its urban structure with a satellite image, and the local climate zones of Barcelona (Lemus-Canovas et al. 2024).

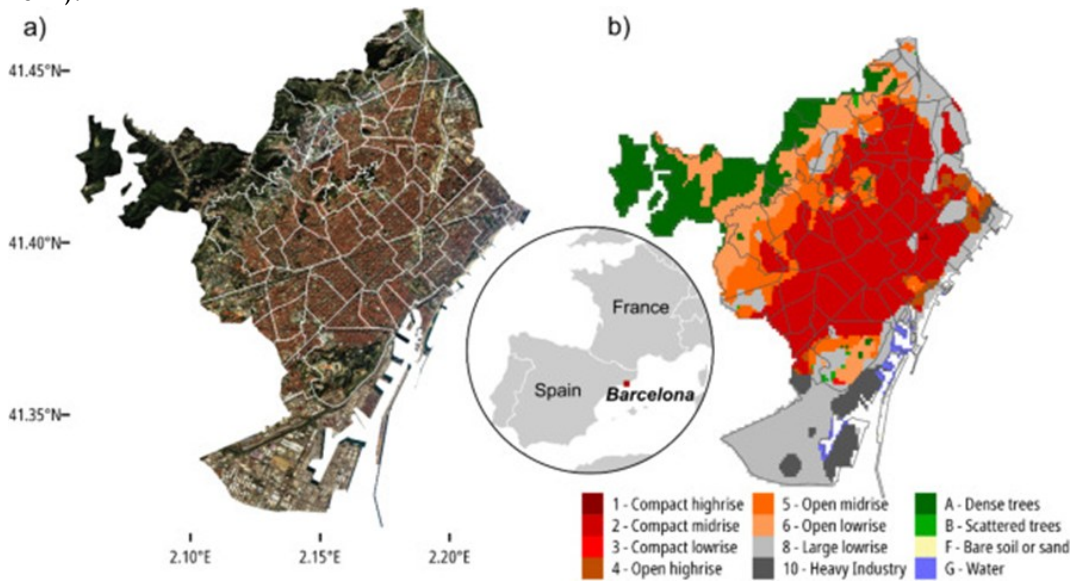


Figure 3. Urban Structure and Local Climate Zones of Barcelona, Spain (Source: Lemus-Canovas et al. 2024).

2.1.2 SOCIO-ECONOMIC CONDITIONS

Barcelona is a compact, dense city, with a population of 1.7 million over around 100 km^2. Constrained by the Llobregat and Besòs rivers on each side, it is part of a larger Metropolitan area with a population around 5.8 million, making it one of the five most populous metropolitan areas in Europe (Eurostat, 2024). The province of Barcelona with 314 municipalities is the most populated, with 76% of the region's (Catalonia) inhabitants: 4,803,363 in 2001. The metropolitan area is formed by 164 municipalities. Between 1991 and 1996, there was a population loss in the city, which was the main cause of a decrease in the entire metropolitan area. After that year, the metropolitan area evolved positively, and Barcelona has experienced a significant increase in population since 1996. Additionally, the enormous population increase that has happened since 2001, is mainly because of foreign immigration (Figure 4) (Royuela, 2011).

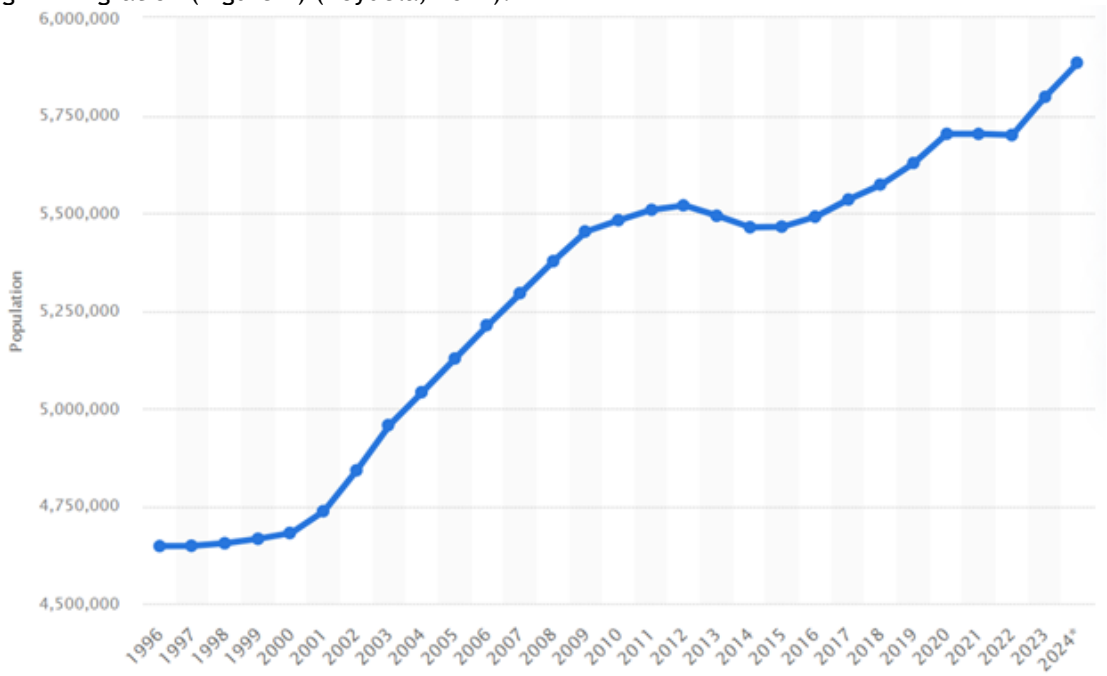


Figure 4. Population growth in the province of Barcelona in Spain 1996-2024 (Source: Statista, 2025).

The socio-economic fabric of Barcelona includes a thriving tourism sector, diverse industries, and a strong focus on innovation and sustainability. In the past decades, the city has transitioned from an industrial hub to a predominantly service-based economy, with tourism emerging as a major driver. The city's harbour has expanded beyond its traditional commercial activity to become the largest cruise node in the Mediterranean, while its airport has undergone significant expansion over the last decades (Villalbí & Ventayol, 2016). Barcelona city has gained international recognition with the 1992 Olympic Games, which played a pivotal role in boosting its global profile and attracting international tourism throughout the 1990s. This surge in urban tourism spurred the growth of the service sector, while much of the industry relocated to the wider metropolitan region (García, 2005). However, in recent years, tourism — once a cornerstone of Barcelona's development — has faced increasing criticism from residents due to rising housing prices, the overcrowding of public spaces, and broader negative impacts on quality of life (Elorrieta et al., 2022).

2.1.3 CITY LAYOUT AND LANDSCAPE

Barcelona is a global city of great cultural, financial, commercial, and touristic importance. The city is renowned for its compact urban layout and its superblocks (or superilles in Catalan). The typical grid-like layout features wide streets, chamfered corners, and internal courtyards aimed at improving

air circulation, sunlight access, and traffic flow. Additionally, the city has prioritised walkability and public spaces, integrating green corridors and public squares.

In the last years, Barcelona's administration focused on creating a network of "green streets and squares" across the whole city, by enabling some streets to be freed of road traffic and to give priority to pedestrians. The aim is to provide 33.4 hectares of new pedestrian areas and 6.6 hectares of urban green areas; in this way, each resident in the district will have a square or green street within 200 meters of their homes (Staricco et al., 2022).

The Province of Barcelona stands as one of the densest and most urbanized landscapes in Europe. However, it still has a substantial variety of natural and semi-natural ecosystems including Mediterranean forests, scrublands, grasslands, crops and wetlands. Variability in topography and climate, as well as millennia of human settlements and cultivations, are responsible for remarkable landscape heterogeneity and biodiversity richness. The frontier urban-rural is sometimes difficult to define, especially due to the strong landscape and social changes in the past 60 years. These changes had a direct impact on biodiversity conservation, especially in terms of provisioning of ecosystem services, as the area has suffered a drastic drop in agricultural surface over the last decades (Basnou et al., 2020).

2.1.4 GOVERNMENT

The city administration has a long history of implementing actions aimed at making Barcelona more sustainable, beginning with the Local Agenda 21 in the 1990s. The Energy Plan, covering the period 2011–2020 and extending beyond the city limits to the wider metropolitan area and its key infrastructure, also addresses issues such as climate change and air pollution. Moreover, the Barcelona Climate Plan focuses on climate change mitigation and the city's adaptation, while promoting climate justice and citizens' participation. Other relevant activities include the city air pollution abatement plan, the urban mobility plan, the municipal plan to enhance urban greening, the Tree Master Plan, the Superblock plan, green space development, and the creation of climate shelters (Climate-ADAPT, 2025).

The city of Barcelona has established the goal of diminishing CO2 emissions by 40% by 2030 compared to 2005 levels. By closing down a good number of public roads to normal traffic, there will also be 160 new squares in the city, which will all have to be given a new function. Many of these squares will be transformed into green parks to improve the air quality of Barcelona. Such an increase in green space within the city's urban areas combined with the reduced number of cars will have a very significant impact on Barcelona's climate change (Lopez et al., 2020).

2.2 PROJECTED CLIMATE VARIATIONS AND IMPACTS AT THE LOCAL LEVEL

The section focuses on the projected future variations for some heat-related climate indicators over Catalonia, calculated by CMCC and available on the Dataclime platform (https://www.dataclime.com/, managed by CMCC). These indicators are derived from climate projections — technical simulations of climate evolution throughout the 21st century based on greenhouse gas emission models. The projections follow the IPCC's Representative Concentration Pathways (RCPs), which outline different emissions scenarios: RCP2.6 (stringent mitigation), RCP4.5 (intermediate stabilisation), and RCP8.5 (very high GHG emissions). These high-resolution climate projections were developed in the framework of the EURO-CORDEX initiative using several regional climate models (RCMs) available over the European domain (EURO-CORDEX). They are forced by different global climate models and have a resolution of 0.11 degrees (about 12 km). The historical reference period is 1981–2010, while the future projection period is 2056–2085. The service also provides data for an intermediate period, 2036–2065.

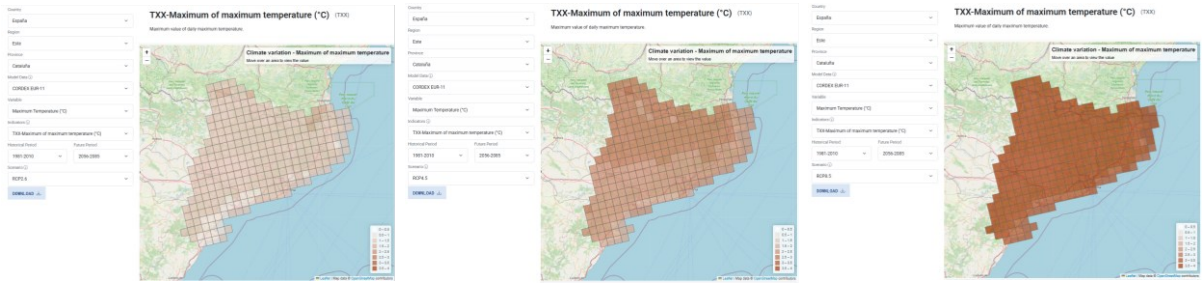
The indicators considered are the following:

- HW-Hot Waves (days)

- TX7 - Maximum 7-Day Average Maximum Temperature (°C)
- TXX-Maximum of maximum temperature (°C)
- Cooling Degree Days (DD)
- Heating Degree Days (DD)
- Tropical Nights (days)
- RX1DAY-Maximum 1-day precipitation (mm/day)
- RX5DAY-Maximum 5-day precipitation (mm/day)
- TR100pr (mm)
- TR10pr (mm)
- TR25pr (mm)
- SPEI12- Standard precipitation-evapotranspiration index 12 MONTHS (%)
- SPEI3- Standard precipitation-evapotranspiration index 3 MONTHS (%)

For the purposes of this report, only a subset of indicators is shown below, as they are considered the most representative for providing a concise description of potential climate impacts, including those related to extreme events.

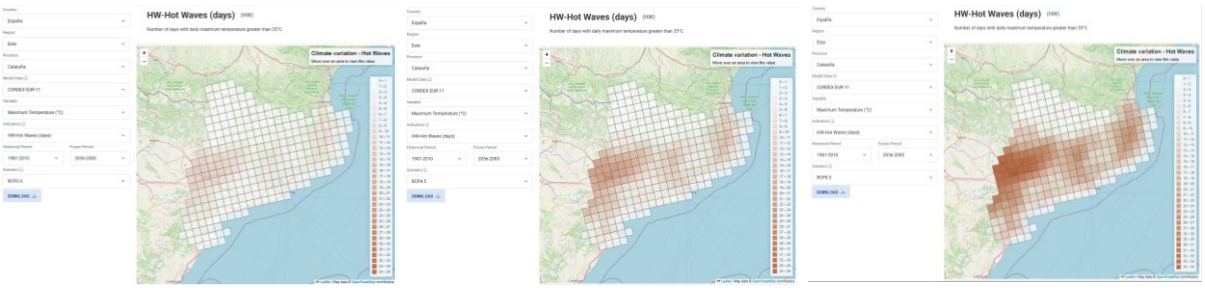
Figure 5 illustrates the variation of the TXX indicator – the maximum of maximum temperature (°C), which represents the highest daily temperature projected for the future period 2056–2085 across the three scenarios. Over the Barcelona area, an increase of approximately 1–1.5°C is expected under RCP2.6, 2–2.5°C under RCP4.5, and more than 3.5°C under RCP8.5.



(a) (b) (c)

Figure 5. Maximum value of daily maximum temperature projected variation for 2056-2085 - RCP2.6 (a), RCP4.5 (b) and RCP8.5 (c) (Credits: CMCC Foundation).

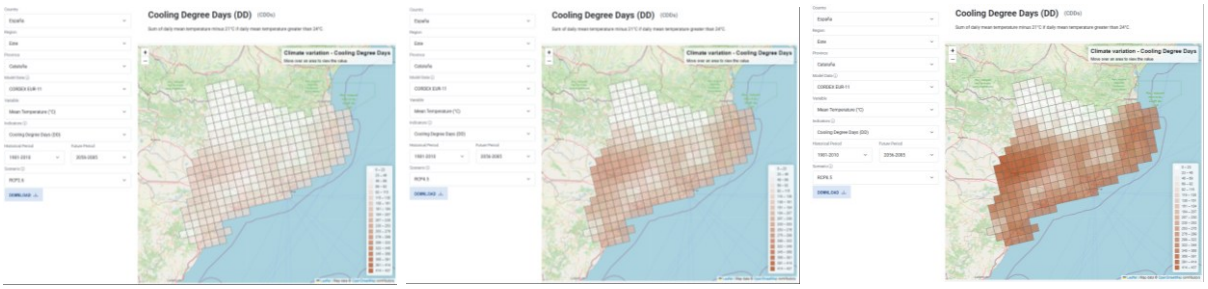
Figure 6 considers the indicator HW – Hot waves (days), defined as the number of days with a daily maximum temperature exceeding 35°C (EEA, 2019). The projections refer to the future period 2056–2085 and consider all three scenarios. Under RCP2.6, no significant increase in heat waves is expected, except in areas farther from the sea. For RCP4.5, a moderate overall increase is projected, although the Barcelona area and the coastline are expected to remain relatively less affected. In contrast, under RCP8.5, a marked increase is projected across Catalonia, with the Barcelona area experiencing approximately 5 additional heat wave days.



(a) (b) (c)

Figure 6. Heat waves – number of days with daily maximum temperature greater than 35°C - projected variation for 2056-2085 - RCP2.6 (a), RCP4.5 (b) and RCP8.5 (c) (Credits: CMCC Foundation).

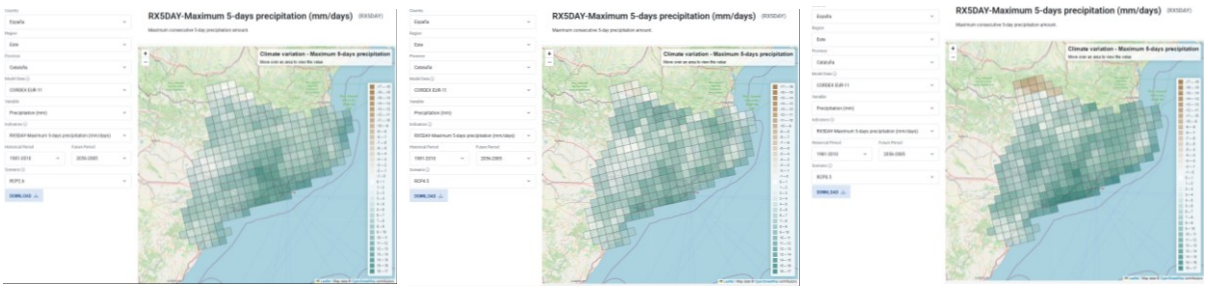
Figure 7 shows the results for the Cooling Degree Days (DD) indicator, which represents the number of degree-days during which cooling is required (EEA, n.a.). As illustrated in the figures, all RCP scenarios project a significant increase in cooling degree-days for the period 2056–2085. Under RCP2.6, Barcelona is expected to experience approximately 100 additional degree-days compared to current conditions, rising to around 150 under RCP4.5 and exceeding 300 under RCP8.5. These results indicate that a significant increase in the demand for electricity for cooling purposes is highly probable.



(a) (b) (c)

Figure 7. Cooling degree days projected variation for 2056-2085 - RCP2.6 (a), RCP4.5 (b) and RCP8.5 (c) (Credits: CMCC Foundation).

Figure 8 describes the future variation for the final indicator considered in this summary: RX5DAY – Maximum 5-day precipitation (mm/days), which is used to assess extreme precipitation events (Karl et al., 1999). Across all scenarios, the projected variation over the Barcelona area is positive, with the most pronounced increases observed under RCP2.6 and RCP8.5.



(a) (b) (c)

Figure 8. Maximum consecutive 5-day precipitation amount projected variation for 2056-2085 - RCP2.6 (a), RCP4.5 (b) and RCP8.5 (c) (Credits: CMCC Foundation).

2.3 KEY CHALLENGES IN CLIMATE-PROOFING THE BUILT ENVIRONMENT IN BARCELONA

Barcelona is already experiencing the effects of climate change, with rising temperatures, more frequent heatwaves, reduced water availability, drought, localized flooding and shrinking beaches due to sea level rise. Below are described the primary challenges Barcelona city is facing: 1) heat waves; 2) water availability, quality and management; 3) flooding risks; 4) air quality; 5) public health; 7) quality of urban spaces; and 8) socio-economic challenges.

2.3.1 HEAT-RELATED RISKS

The city of Barcelona is exposed to heat waves, which are increasing in frequency and intensity due to climate change, and which aggravate the urban “heat island” phenomenon. The average annual temperature in Barcelona has risen at a rate of +0.08ºC/C/decade since 1780, that is, an overall

increase of 1.9ºC. Climate projections suggest that if the current rate of emissions continues, the average temperature of the region could rise by more than 4 degrees Celsius by the end of this century (EEA, 2025).

Heatwaves in Barcelona could increase by a factor of 8 by the end of the century. For this reason, the Barcelona City Council has been working for some time on different measures to tackle high temperatures, especially with programs for the most vulnerable groups, such as the elderly, infants, people with chronic conditions or people with functional diversity with limited mobility and self-care. The recent Heat Plan 2025-2035 is a noticeable initiative of the municipality to confront the pressing challenges posed by extreme temperatures. Figure 9 shows the projections of some climate indicators related to heat.

Indicador	Dades de partida resultat de la mitjana del període 1982-2015	Dades 2020	Dades 2021	Dades 2022	Dades 2023	Dades 2024	Projeccions escenari compromès a finals de segle	Projeccions escenari passiu a finals de segle
Onada de calor/any (temperatura màxima supera el percentil 98 dels tres mesos més calorosos de l'any). Per 2020 aquest llindar va ser 33,6ºC	0,25 (1 cada 4 anys)	0	0	2	1	2	2	4-5
Dia càlid (>30ºC)/any	22	37	26	64	42	52	50	80
Dia tòrrid (>35ºC)/any	0,5 (1 cada 2 anys)	0	0	2	4	3	2,5	8,5
Nit tropical (>20ºC)/any	38	74	88	105	82	86	83	112
Nit tòrrida (>25ºC)/any	1	7	1	14	13	23	2,5	6
Nits roents (>30ºC)/any	sense dades	sense dades	sense dades	0	0	0	sense dades	sense dades

Figure 9. Evolution of heatwaves, hot and torrid days, and tropical and torrid nights from the period 1982-2015 up to the years 2022, 2023, and 2024, along with a comparison with the committed and passive scenarios for the end of the century (Source: Barcelona City Council).

2.3.2 WATER AVAILABILITY, QUALITY AND MANAGEMENT

Climate change may result in fewer days of precipitation, and heavy occasional rains, which can cause overflowing of the sewage system and the sewage treatment capacity in the city. Over the last decades, a system of underground water retention tanks has been developed to deal with this issue and could store 600,000m^3 of rainwater by 2014. Plans for further expansion of this system continue. Also, the Llobregat and Besòs rivers on both sides of the city may be subject to wide flow variations periodically. This may threaten key infrastructure located near the mouth of these rivers. However, the main issue posed in the Mediterranean basin by a change in precipitation pattern refers to water availability and quality. This has been addressed over the last decade, as the city had to confront periodic droughts, and a water supply from sources that were polluted. The city of Barcelona derives most of its drinking water from surface water. Besides the challenges posed by human pressure in a densely populated area for water quality, the Llobregat basin suffers from pollution caused by potash mining (González et al., 2012).

Major investments were made in water treatment plants in the Llobregat basin, so that by 2009 the more stringent EU limits were met. At the same time, a desalinisation plant which was being built in

the Llobregat delta was also finished by 2009, after a severe drought in 2007–2008. These new facilities seem to be able to meet the challenges posed by water quality and scarcity in the next decades for the city and its metropolitan area. Further, water consumption has been declining over the last years, due to lower industrial use caused by economic changes, greater use of the city aquifer by local services (for parks, watering sidewalk trees, summer street flushing, etc.), and public education to reduce domestic consumption (Villalbí et al., 2016).

2.3.3 FLOODING RISKS

The results of recent climate projections for the city of Barcelona show a significant increase in the maximum rainfall intensities for the future period. Without the adoption of adaptation measures, the city could face a substantial rise in flood-related impacts. It was demonstrated that increments of maximum rainfall intensity of 12–16% could cause increments of more than 25–30% in terms of social impacts (e.g., intangible damages such as the increase of areas classified with high hazard conditions in case of pluvial flood events) and of 42% of economic losses (including tangible direct and indirect damages) expressed in monetary terms through the concept of the expected annual damage (EAD). Economic losses from traffic disruptions caused by pluvial floods are projected to rise by 9%, while damages to the electrical system could increase by up to 70%, even though the overall Expected Annual Damage (EAD) remains relatively low. Additionally, the average recovery time of the city — defined as the period during which urban services fail to return to normal — could extend from 1.5 to 2 hours due to the impacts of climate change (Russo et al., 2020).

2.3.4 AIR QUALITY

Barcelona faces persistent challenges in terms of air quality due to its dense urban fabric and high levels of vehicular traffic, which contribute significantly to nitrogen dioxide (NO_2) and particulate matter ($PM_{2.5}$ and PM_{10}) emissions. Despite improvements in recent years, Barcelona has some of the highest levels of air pollution in Spain, surpassing recommendations from the World Health Organization (WHO), and posing health risks to residents (Lopez et al. 2020). The city's geography, nestled between the sea and surrounding hills, can cause the stagnation of pollutants, particularly during periods of low wind. To address this, Barcelona has implemented measures such as low-emission zones, promoting public and active transportation, and increasing urban greenery to enhance air filtration. These efforts are critical as poor air quality is a significant contributor to respiratory and cardiovascular health issues (Villalbí et al., 2016). This could improve both the overall neighbourhood's liveability and air quality, as shown in Figure 10.

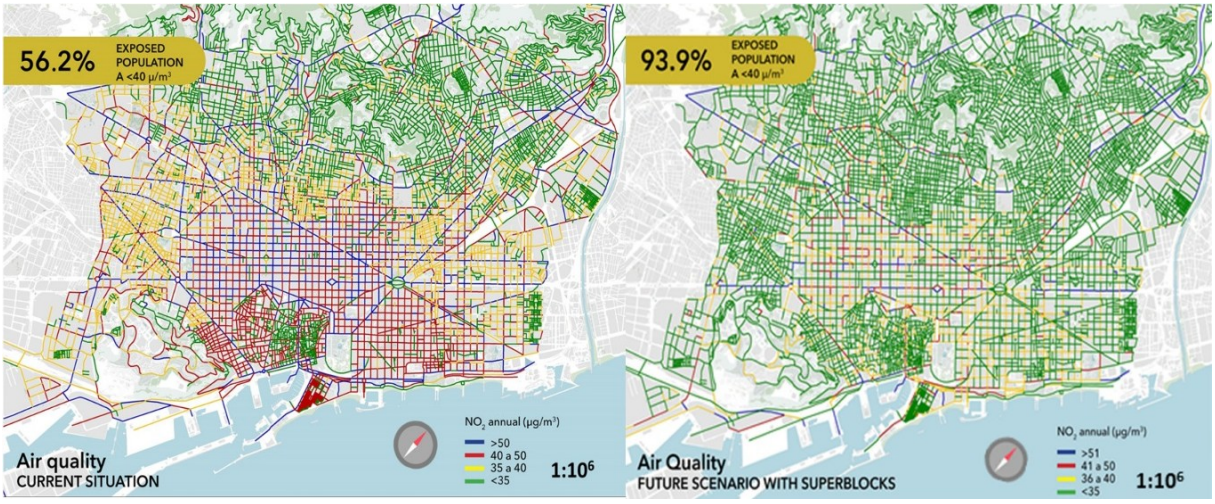


Figure 10. Population exposed to air quality, current situation and future scenario with Superblocks in Barcelona (Source: López et al., 2020).

2.3.5 PUBLIC HEALTH

- **Diseases Transmitted by Vectors**

Public health services have anticipated emerging risks derived from climate change and prepared for vector-borne diseases. Vector control actions can be anticipated to reduce the risks posed by warming. Mosquitoes as vectors are a concern in Barcelona. Warming means more breeding opportunities: the duration of a breeding cycle shortens, the warm period extends, and there are more breeding cycles within the warm season. Thus, the mosquito population may grow exponentially. Over the last decades, globalization trends have also brought more international travel to and from endemic areas for malaria, dengue or chikungunya (Villalbí et al., 2016).

- **Vulnerable Populations**

Analysis of the adverse health effects of climate change have shown that some population subgroups are particularly at risk. They include mostly the older population, particularly those living alone, as well as the socially disadvantaged. Critical analysis of heat wave warning systems have found that older people may not respond to such interventions as expected. Studies developed in Barcelona have confirmed that among the factors related to higher mortality during heat waves, deprivation and advanced age are both key variables (Borrell et al., 2006, Villalbí et al., 2016).

2.3.6 QUALITY OF URBAN SPACES

The greening of cities is considered an effective strategy to confront climate change in urban settings, reducing the heat island effect. Greening has a potential role in pollution abatement, and it is crucial for mitigation. Additionally, it has many benefits for human wellbeing. It may also have the potential to improve adaptation, as more vegetation is linked to reducing temperature.

The city of Barcelona has undertaken important efforts in expanding the number and surface of green spaces, and the presence of trees and vegetation in sidewalks and paved areas as seen in Figure 11. After years of increasing the presence of trees in sidewalks and squares, in recent years the city administration has experimented with several vertical gardens, with mixed results. It is now piloting innovative schemes for a mosaic integration of green roofs with solar energy technology and rainwater collection in a few city buildings.

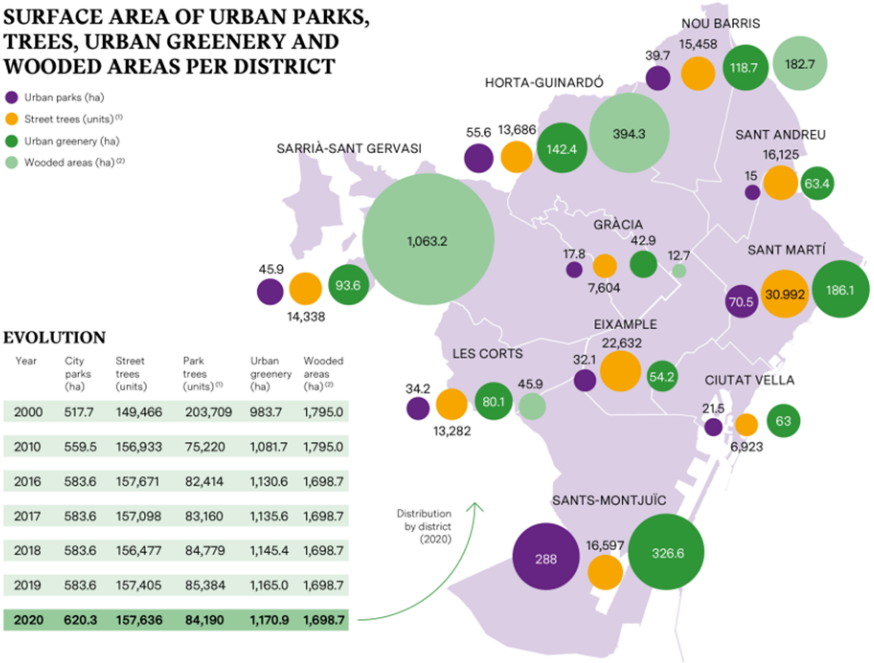


Figure 11. Trees and urban green space in Barcelona, 2000-2020 (Credits: Barcelona City Council).

2.3.7 SOCIOECONOMIC CHALLENGES

Climate change is closely interconnected with socioeconomic challenges in Barcelona, particularly those concerning urban health, social inequalities, and housing precariousness. In particular, rising housing costs and property values in areas undergoing greening initiatives have led to unequal access to green infrastructure, resulting in environmental injustice. According to the Barcelona Lab for Urban Environmental Justice and Sustainability, green gentrification is high in the desired areas of Barcelona (i.e., city centre and coast), while it is low in other areas located at a long distance from cultural amenities and the city centre. This makes low- and middle-income residents more vulnerable to the effects of climate change (Anguelovski et al., 2022).

On the other hand, the food supply chain is responsible for more than one third of GHG emissions. For this reason, climate mitigation measures promote local food production and changes in our diet to reduce food waste. This way, GHG emissions will be reduced, and all residents will have access to a sustainable and healthy diet even during disruptive events. Barcelona is already heading towards this direction through The Barcelona Challenge for Good Food and Climate, which aims to (i) establish coherent and participative governance mechanisms, (ii) ensure the transition to sufficient, sustainable, nutritious and culturally appropriate diets for all, (iii) promote social and economic equity, (iv) transit to sustainable food production, (v) adapt food supply and distribution to climate change and (vi) reduce food waste.

3. METHODOLOGY AND DEVELOPMENT

This chapter presents the Methodology developed to accomplish Task 8.1. The primary aim has been to ensure consistency with the MULTICLIMACT objectives, particularly Task 2.1, which focuses on reviewing adaptation policies and measures for the built environment to ensure their long-term effectiveness under changing climate conditions, while not neglecting the mitigative ability of some adaptation measures, thereby supporting climate-proof development. For the purposes of T8.1, climate-proofing assessment of the built environment is intended as a systematic evaluation of policies and measures to determine their capacity to maintain or improve the resilience of the sector under current and projected climate variations. This includes assessing the ability of policies to address multiple climate hazards, supports adaptive and flexible solutions across sectors, and combines structural and soft measures to promote resilience, sustainability, and societal benefits. Furthermore, the definition of the most relevant adaptation options has been carried out by expanding the T2.1 catalogue with additional measures and identifying KPIs for quantitative resilience assessment of local adaptation measures to be implemented in the Spanish demo case.

Operationally, the climate-proof assessment in Task 8.1 was implemented by combining the following activities (Figure 12):

- **T8.1.1**. Desk review of local adaptation policies of the Spanish demo (Barcelona);
- **T8.1.2**. Application of the methodological approach developed in T2.1 to local adaptation policies and measures;
- **T8.1.3**. Update of the catalogue of adaptation measures.

This approach supports public stakeholders in designing and implementing climate-proofing strategies and solutions, while strengthening their capacity to understand and apply existing adaptation policies across different governance levels. The following sub-sections further explain these activities, along with the identified research questions and objectives.

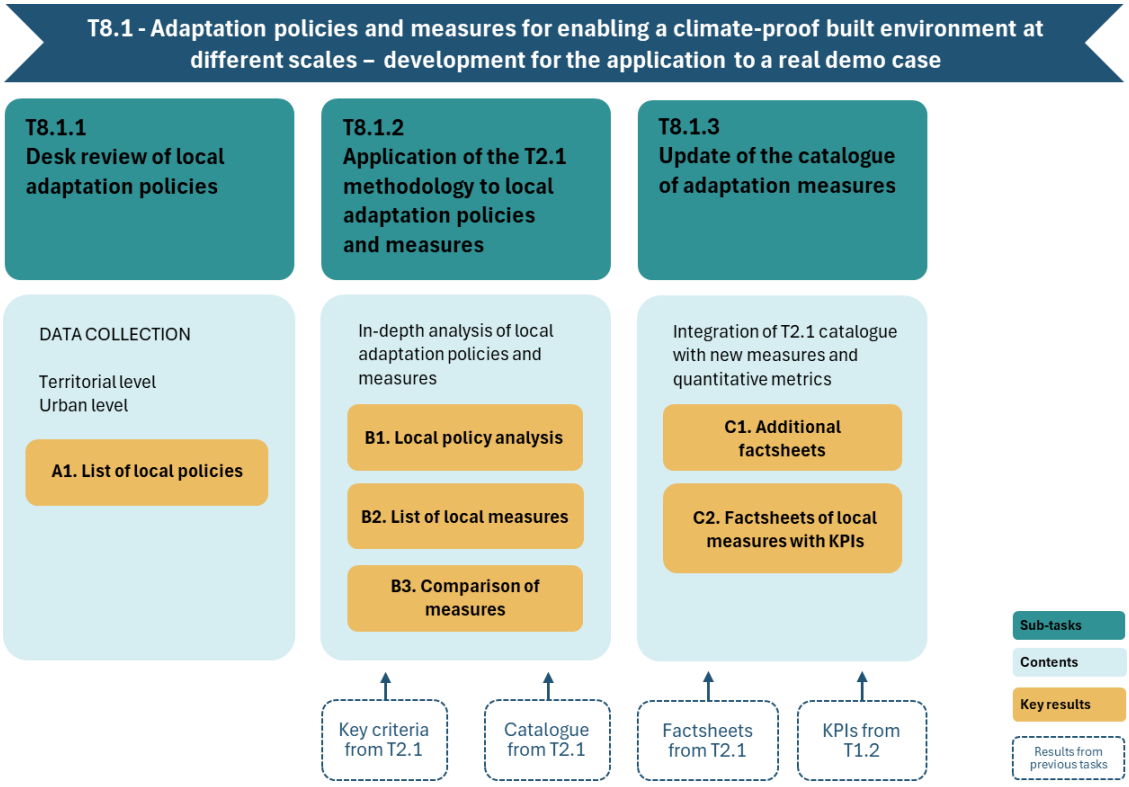


Figure 12. Overview of the methodology developed for T8.1 (Credits: C. Apreda).

The activities have been carried out according to a structured timeline, from inception to completion, with key milestones and deadlines (Figure 13). Completing each sub-task allows for achieving one or more key outputs: T8.1.1 contributes to defining the list of local adaptation policies to be analysed in T8.1.2 for retrieving the recommended measures to be applied at the local level. Then, such policies and measures have been compared with those included in the T2.1 catalogue to identify additional measures to be incorporated into the catalogue itself. Finally, in T8.1.3 additional factsheets have been developed for selected measures, while for the measures to be implemented and tested into the real context of the Spanish demo, the factsheets from T2.1 have been supplemented with quantitative KPIs to support the evaluation of the AS IS and TO BE conditions.

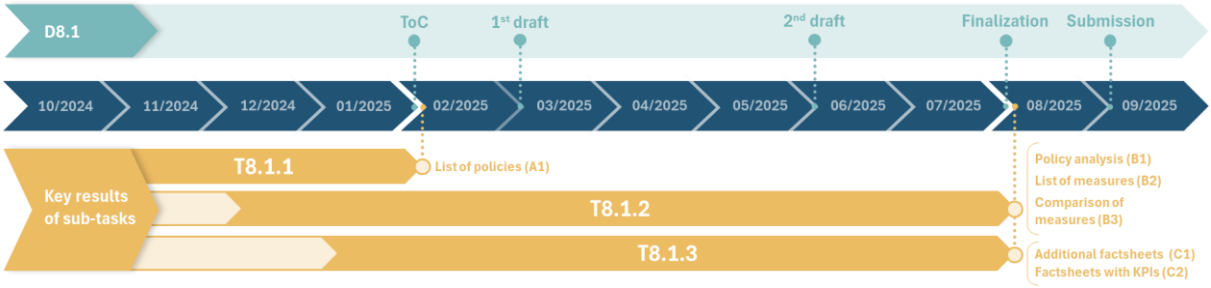


Figure 13. Timeline of T8.1 activities (Credits: C. Apreda).

3.1 T8.1.1: DESK REVIEW OF LOCAL ADAPTATION POLICIES

The sub-task T8.1.1 collects the adaptation policies for climate-proof built environment developed in the Barcelona Municipality and the Catalonia Region and identifies the main objectives proposed in each selected instrument. The guiding question for this sub-task is: "*What is the state of the art regarding the development of adaptation policies for enabling a climate-proof built environment into the real context of the Spanish demo?*". Hence, the general aim of this sub-task is to identify the main adaptation-related policies highlighting the different objectives for developing a climate-proofing strategy at the following levels of analysis: "territorial level" (Catalonia region) and "urban level" (City of Barcelona). T8.1.1 provides an easy-to-read synthesis of existing local adaptation policies for climate-proof built environment, so that practitioners and policy-makers can easily identify the information and tools that are most relevant to their needs. The key output for this sub-task is a table for each level of analysis with the list of selected policies (result A1. List of local policies). For each policy, the following general information is reported: ID, title, short description, type of instrument, binding/non-binding, year, and reference (section §4.1.1 Local adaptation policies). The review was conducted by searching for relevant urban policies on the official website of the Barcelona City Council and territorial policies on the website of the Catalan Office for Climate Change (Figure 14).

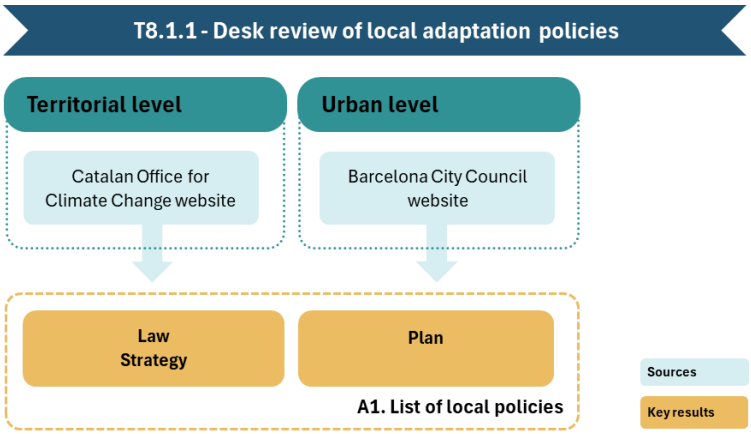


Figure 14. Overview of T8.1.1 (Credits: C. Apreda).

3.2 T8.1.2: APPLICATION OF THE T2.1 METHODOLOGY TO LOCAL ADAPTATION POLICIES AND MEASURES

Sub-task T8.1.2 applies the T2.1 methodology to analyse local adaptation policies and measures. T2.1 was structured into three main sub-tasks. First, adaptation policies were collected at global, European, and national levels from official websites of international institutions (e.g., EUR-Lex, Climate-ADAPT Platform), relevant literature (e.g., EUCRA report, EEA, March 2024), and partners' knowledge. Next, key features of policies and measures were identified through two lists of criteria—KC-P for policies and KC-M for measures—to enable policy comparison and qualitative evaluation of measures. Finally, a comparative analysis of existing policies based on KC-P, and a qualitative evaluation of measures based on KC-M, was conducted. The review of adaptation measures included in the National Adaptation Plans of the four demo countries, complemented by additional sources (Climate-ADAPT database; "*EU-level technical guidance on adapting buildings to climate change - Best practice guidance*", EC-DG Clima, 2023), supported the development of a catalogue of measures. This catalogue follows the Key Types of Measures (KTMs) classification from the European Topic Centre on Climate Change Adaptation (ETC/CCA, EEA) and includes '*KTM C: Physical and Technological*' and '*KTM D: Nature-Based Solutions and Ecosystem-based Approaches*'.

Building on T2.1 methodology, T8.1.2 focuses on the local context of the Spanish demo case. The guiding question for this sub-task is: "*How to apply the T2.1 methodology for analysing how local adaptation policies and measures contribute to a climate-proof built environment in the real context of the Spanish demo?*". The general aim is to compare and describe policies highlighting if and what climate concerns they include and to identify the planned adaptation measures for the built environment at the local level. T8.1.2 provides an in-depth analysis of local adaptation policies and measures for a climate-proof built environment based on key criteria developed in T2.1 to highlight weak and strong characteristics of each local policy and their alignment with national adaptation policies. T8.1 provides three key outputs: 1) table with the detailed description of local policies based on key criteria for evaluating adaptation policies (KC-P) from T2.1 (result B1. Local policy analysis); 2) table with the list of adaptation measures included in the local policies (result B2. List of local measures); 3) comparison table of measures from local policies and those in the catalogue (from T2.1) (result B3. Comparison of measures). Result B1 includes a detailed analysis of policies based on the following key criteria: climate-related hazards, climate-sensitive sectors, adaptation methods, and adaptation measures (section §4.1.1 Local adaptation policies). Result B2 includes the list of all adaptation measures retrieved from territorial and urban policies and categorised according to the Key Type Measures (KTMs) developed by the European Environment Agency (Leitner et al., 2020), while result B3 provide a comparison of measures identified in local plans with those included in the catalogue developed in T2.1, in order to identify additional measures to be incorporated into the catalogue itself (section §4.1.2 Adaptation measures from local policies) (Figure 15).

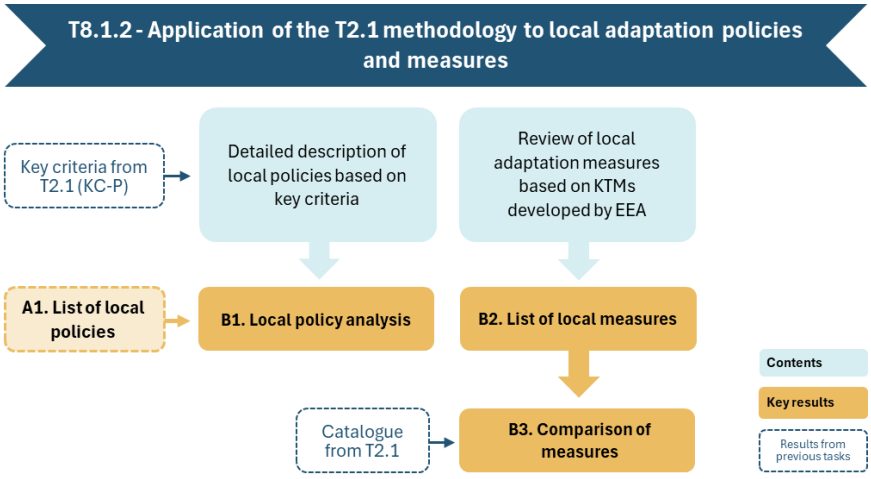


Figure 15. Overview of T8.1.2 (Credits: C. Apreda).

3.3 T8.1.3: UPDATE OF THE CATALOGUE OF ADAPTATION MEASURES

Sub-task T8.1.3 concerns the update of the catalogue of adaptation measures developed in T2.1 with additional solutions and quantitative information. The guiding question for this sub-task is: *"How to expand and update the catalogue with additional adaptation measures from local policies and KPIs to evaluate the AS IS and TO BE conditions of measures to be implemented in the Spanish demo?"*. The general aim is to update the catalogue in terms of quantity, by adding new measures and factsheets, and quality, by integrating KPIs for quantitative resilience assessment of local measures. The key results are: 1) additional factsheets with measures identified within local adaptation plans (result C1. Additional factsheets); 2) integration of factsheets from T2.1 for cool pavement, porous pavement and bioswale with KPIs selected from T1.2 for resilience assessment (result C2. Factsheets of local measures with KPIs) (Figure 16).

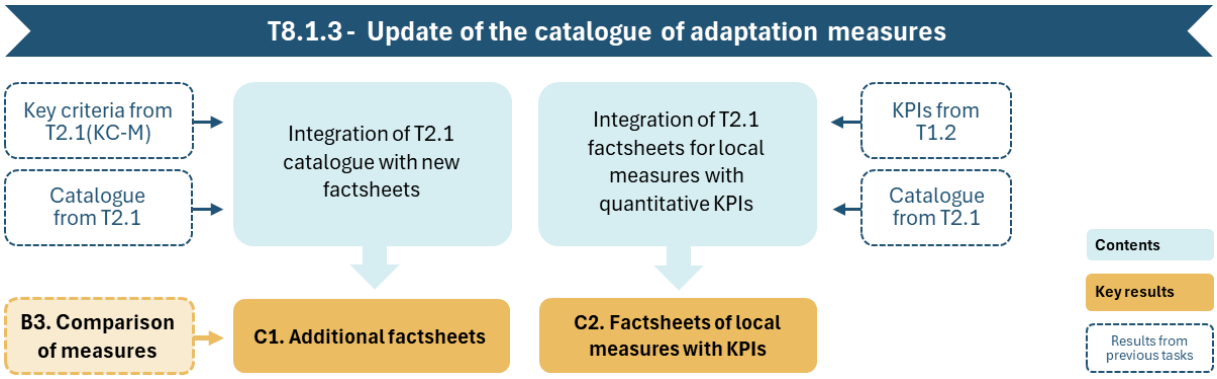


Figure 16. Overview of T8.1.3 (Credits: C. Apreda).

Regarding **additional measures** to be included in the T2.1 Catalogue with factsheets, these were identified through the comparison carried out in the previous step. Starting from a list of policy measures not yet represented in the Catalogue, new measures were selected based on the following criteria: 1) expert judgment from the partners involved in the task; and 2) recurrence of the measures across various documents, aiming to include relevant measures while avoiding an excessive number of solutions.

To identify the **KPIs for resilience assessment** to be associated with local adaptation measures, only the KPIs from T1.2 related to outdoor spaces were selected. A validation process based on the SMART approach was then applied, combined with the expert judgement of the partners involved in the task. This method ensured that each indicator is specific, measurable, achievable, relevant, and time-bound. Applying these criteria guaranteed that the selected indicators are clear, practical, and effective for monitoring and assessing the performance of adaptation actions. This systematic approach supports a reliable evaluation of resilience outcomes and facilitates consistent tracking over time. The criteria adopted are as follows:

- **Specific**: means that the KPI should focus on a clearly defined and narrow aspect of hazard that pertains to the built and natural environment, such as buildings, infrastructure, and their interactions. This specificity ensures that the KPI addresses particular risks or combinations of risks that are significant to the safety, sustainability, and efficiency of the built environment;
- **Measurable**: refers to the ability to quantify a KPI with objective, numerical data. This characteristic is essential for monitoring progress, identifying trends, and making informed decisions. The KPI must be expressible in numbers. For example, the percentage of reduction in risk incidents, the number of mitigated risks, or the financial savings from reduced risk;
- **Achievable**: refers to the practicality and attainability of the objectives set by the KPI. It ensures that the goals are achievable given the current resources, constraints, and conditions within the built environment. This involves establishing objectives related to behavioural issues

or specific actions that can be realistically accomplished. The objectives should be based on realistic assessments of the current situation, including any constraints or limitations that may affect the achievement of the goals.

- **Relevant**: assesses if the indicator accurately captures at least one of the resilience dimensions of the MULTICLIMACT project (physical, human health, digital, economic, environmental, and organizational) with clarity;
- **Time-Bound**: refers to the ease with which decision-makers and other stakeholders can comprehend and effectively use the indicator within a defined timeframe.

From a predefined list of indicators derived from T1.2 and associated with each local measure, partners were asked to indicate the relevance of each KPI for each measure. Tables 2-4 show an example of the tables that was provided to each partner for validation.

KEY PERFORMANCE INDICATORS TO ASSESS RESILIENCE OF COOL PAVEMENT					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Cool surfaces in proportion to the number of dwellings					
Recovery Time Indicator (RTI) for Extreme Heat					
Time to recovery adequate level of Land Surface Temperature					
Mean time to repair					
Adaptation protection cost index (APCI)					
Damages for Highways and Railroads due to natural hazards					
Adaptation benefits					
General construction cost index (GCCI)					
Maintenance cost efficiency index (MCEI)					
Occurrence probability of a certain consequence					
Ambient temperature					
Surface temperature of pavement					
Global solar radiation					
Hours outside comfort temperature					
Operational continuity					
Mean Time of Recovery					
Mean Time for Mitigation					

Table 2. List of KPIs to be validated for cool pavement.

KEY PERFORMANCE INDICATORS TO ASSESS RESILIENCE OF POROUS PAVEMENT					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Drainage system capacity					
Urban drainage stormwater robustness					
Mean time to repair					
Adaptation protection cost index (APCI)					
Damages for Highways and Railroads due to natural hazards					
Adaptation benefits					
General construction cost index (GCCI)					
Maintenance cost efficiency index (MCEI)					

Occurrence probability of a certain consequence					
Floodwater depth					
Permeability and infiltration rate					
Operational continuity					
Mean Time of Recovery					
Mean Time for Mitigation					

Table 3. List of KPIs to be validated for porous pavement.

KEY PERFORMANCE INDICATORS TO ASSESS RESILIENCE OF BIOSWALE					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Drainage system capacity					
Urban drainage stormwater robustness					
Mean time to repair					
Adaptation protection cost index (APCI)					
Damages for Highways and Railroads due to natural hazards					
Adaptation benefits					
General construction cost index (GCCI)					
Maintenance cost efficiency index (MCEI)					
Occurrence probability of a certain consequence					
Floodwater depth					
Permeability and infiltration rate					
Operational continuity					
Mean Time of Recovery					
Mean Time for Mitigation					

Table 4. List of KPIs to be validated for bioswale.

The matrix, containing the KPIs and the corresponding evaluation criteria, was submitted to the task partners to collect their feedback. Only the KPIs that met all five criteria were considered valid. Finally, the responses received from the partners were compared to identify which KPIs fulfilled all five validation criteria.

4. RESULTS

4.1 DESK REVIEW OF LOCAL ADAPTATION POLICIES AND MEASURES

This section presents the key results of the sub-tasks T8.1.1 and T8.1.2. The main output of sub-task T8.1.1 is the list of local adaptation policies already implemented at the territorial and urban levels summarised in Tables 5 and 6. T8.1.2 provides a detailed analysis of local policies based on key criteria (Tables 7 and 8), the list of all adaptation measures retrieved from territorial and urban policies (Tables 9 and 10) and a comparison between local measures and those included in the T2.1 catalogue (Tables 11-14). The following sub-sections illustrate the most relevant documents at each level, outlining the local policy context and the planned adaptation measures. A general description for each policy is provided to identify the main objectives and issues of interest.

4.1.1 LOCAL ADAPTATION POLICIES (RESULTS A1 & B1)

The following sub-sections describe the main adaptation policies identified at the territorial and urban levels. The policies included in the review are listed below (Tables 5 and 6):

TERRITORIAL LEVEL

- T1 - Climate Change Law of Catalonia (Llei 16/2017);
- T2 - Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030).

URBAN LEVEL

- U1 - TREES FOR LIFE Master Plan for Barcelona's Trees 2017 – 2037;
- U2 - Barcelona Resilience Action Plan (RAP);
- U3 - Barcelona Nature Plan;
- U4 - Barcelona Climate Plan.

For each policy, a general overview is provided, including its main objectives (e.g. climate challenges addressed, overall goals), the policy and institutional framework (e.g. legal status, links to other policies, responsible authorities and institutions), timeline and implementation, sources of financing (e.g. public funds, EU funding, private sector, partnerships), and mechanisms for tracking progress. Furthermore, potential alignment with other strategies or policies, as well as synergies with key themes such as sustainable development, mitigation, and disaster risk reduction, are also highlighted. Based on the T2.1 methodology for analysing adaptation policies, a further analysis was carried out for all above-listed policies to identify the climate hazards addressed, the climate-sensitive sectors covered, and the adaptation methods and measures adopted and/or suggested by each policy (Tables 7 and 8).

4.1.1.1 Territorial level

The adaptation policies currently in place in the Catalonia Region are as follows:

- **T1 - Climate Change Law of Catalonia (Llei 16/2017)**

The main objectives of the *Climate Change Law of Catalonia 16/20127* released by the Generalitat de Catalunya are to mitigate the effects of climate change, reducing greenhouse gas emissions, promoting the energy transition through the use of renewable energy sources and improving energy efficiency. It also promotes adaptation to climate change and increasing resilience to its effects, as well as education and awareness among citizens. All of this takes into account climate challenges such as changes in precipitation, heat waves and drought. This law establishes a legal framework in Catalonia for climate action. This law aligns with international commitments such as the Paris Agreement, as well as with state and European regulations on climate change and energy. It is also linked to other public policies related to energy, sustainable mobility, waste management,

environmental protection and territorial management. In this sense, it is also aligned with the Energy Transition Law of Catalonia. Furthermore, it encourages municipal authorities to adopt policies that promote mitigation and adaptation actions. The law is developed in several phases with immediate and long-term measures. The main short-term mitigation objectives are set for 2020, 2030 and 2050, with the promotion of the necessary measures in the field of renewable energies so that Catalonia's electricity consumption comes -50% in 2030 and 100% in 2050- from these renewable sources. Every five years, the climate strategy and progress must be reviewed to ensure compliance with the established objectives. With regard to financing, the law supports municipal climate plans through the Climate Fund, and in addition, the Government must promote and facilitate, through the Catalan Institute of Finances, access to financing to contribute to the development of projects aimed at meeting the objectives of this law, as a complement to the private financial sector. The law will establish the instruments for monitoring greenhouse gas emissions in Catalonia and for the various sectors, products and services, throughout their entire life cycle.

The Climate Change Law of Catalonia (Llei 16/2017) addresses both acute and chronic climate hazards, with a focus on heatwaves, wildfires, droughts, and water stress. The law impacts various sectors, including agriculture, water management, biodiversity, energy, health, transport, tourism, and urban planning. It adopts a cross-sectoral approach, recognising the interconnectedness of these sectors in addressing climate change and its impacts. The methodological approach combines several assessment tools, including Climate Impact Assessments (CIA), Climate Vulnerability and Capacity Assessments (CVAC), and Strategic Environmental Assessments (SEA). Additionally, the law includes carbon footprint assessments to measure the environmental impact of products and activities across sectors. The planned actions in the law are organized into several key types of measures (KTMs). Governance and Institutional measures focus on empowering municipalities to incorporate climate resilience strategies, such as integrating WHO recommendations for urban green spaces and encouraging compact land use models, as well as local authorities are incentivized to adopt tax policies that promote climate mitigation and adaptation actions within the private sector. In the Economic and Finance realm, the law supports municipal climate plans through the Climate Fund and incentivizes private-sector climate actions with fiscal policies. It also includes initiatives like the Catalan Institute of Finances offering financing to projects that meet climate adaptation objectives. Physical and Technological measures emphasize bioclimatic construction, renewable energy use in buildings, and the installation of electric vehicle charging points. Public facilities are committed to sourcing renewable energy, with specific targets for 2020 and 2030. The law also promotes Nature-Based Solutions (NbS) and Ecosystem-based Approaches, encouraging municipalities to integrate urban greenspaces into their planning as per WHO recommendations. Knowledge and Behavioural Change measures aim to raise public awareness through educational campaigns, digital platforms, and the creation of energy transition offices. These initiatives provide a platform for sharing scientific advancements, climate change adaptation strategies, and successful mitigation policies, ensuring that citizens and socio-economic agents are informed and engaged in the transition to a more sustainable future.

- **T2 - Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)**

The *Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)* has as its strategic objective to improve adaptation to climate change in Catalonia and reduce the vulnerability of the territory, society and economy to the impacts of climate change. It does this by establishing a series of operational objectives that, in turn, are deployed in a set of adaptation measures for each natural system (biodiversity, water, forests and marine ecosystems), socio-economic area (agriculture and livestock, financial sector, energy, industry, services and trade, mobility, research and training, natural risks, health, tourism and housing) and territory (inland, coast and mountains). The ESCACC30 is based on the Catalan Law 16/2017 on climate change, which establishes the regulatory framework for climate action in Catalonia, and is aligned with global policies such as the European Green Deal and the EU's European Climate Change Adaptation Strategy. At the state level, it is linked to the Spanish government's National Climate Change Adaptation Plan 2021-2030 (PNACC), and at the local level with the aforementioned Law 16/2017 as well as a series of sectoral policies. The Catalan Office for Climate Change (OCCC), within the Department of Climate Action, Food and Rural Agenda (DACC),

is the main responsible authority. The time horizon of the strategy is for a decade (2021-2030) and the periodicity of the reports is 5 years, in 2026 and 2031. And it is specified in 18 operational objectives for the four natural systems, 46 operational objectives for the ten socio-economic areas and 12 operational objectives for the three territories. The implementation is planned through the mobilization of public and private resources of a diverse nature, with the recovery plan for Europe (Next Generation EU) being one of the main drivers (through the ERDF and the ESF, for example), although there is also state and national funding. Within the government administration, it will be within the Adaptation Working Group of the Interdepartmental Climate Change Commission where the mechanisms that ensure effective monitoring and evaluation of the measures and operational objectives of the ESCACC30 will be agreed upon. These mechanisms will include the degree of incorporation in the sectoral planning and programming of the departments of the Generalitat, the degree of deployment of the operational objectives and measures, the definition and tracking of status and efficiency indicators, and the prioritization of measures based on their relevance, impact, and feasibility.

The Catalan Strategy for Adapting to Climate Change 2021–2030 (ESCACC2030) tackles a wide range of climate hazards, both acute — such as heatwaves, cold spells, droughts, wildfires, and extreme precipitation — and chronic, like rising temperatures, sea-level rise, and ocean acidification. It adopts a comprehensive cross-sectoral approach, covering natural systems (biodiversity, water, forestry, marine ecosystems), socio-economic sectors (agriculture, energy, transport, health, tourism, urban planning, among others), and different territorial areas (inland, coastal, and mountainous regions), while also addressing issues of social and territorial vulnerability. The strategy builds on Climate Risk Assessment (CRA) and Climate Impact Assessment (CIA) methods to guide its planning and integrates participatory processes for better stakeholder involvement. ESCACC2030 proposes a wide array of measures across key action areas. Under Governance and Institutional measures, it strengthens territorial planning by linking urban development with energy planning, encourages population stability in small villages, and promotes concepts like urban self-sufficiency and the “15-minute city”, where resident can access to daily necessities and services within a 15-minute walk, ride or public transit trip. It also aims to naturalize urban spaces and address equity in adaptation policies. In the Economic and Financial sphere, it recommends fiscal incentives and subsidies to renovate existing buildings for better efficiency and resilience against climate hazards, notably to combat the urban heat island effect. Physical and Technological actions focus on promoting renewable energy installations on rooftops and public infrastructure, retrofitting buildings to achieve positive energy balances, and advancing smart management systems for greater sustainability. Additionally, Nature-Based Solutions are a strong focus of the strategy, emphasizing the expansion and improvement of urban green spaces according to WHO guidelines, the use of sustainable water sources for irrigation, and the promotion of green roofs, vertical gardens, and sustainable urban drainage systems. In terms of Knowledge and Behavioural Change, ESCACC2030 highlights the need to develop practical tools for climate impact assessments in planning, enhance data on building energy performance, foster eco-innovation in construction materials, and strengthen training programs for public officials and professionals in relevant sectors.

4.1.1.2 Urban level

The adaptation policies currently in place in the Municipality of Barcelona are as follows:

- **U1 – TREES FOR LIFE: Master Plan for Barcelona’s Trees (2017–2037)**

The *TREES FOR LIFE* Master Plan is Barcelona’s middle- and long-term urban forestry strategy aiming to enhance the ecological, social, and climate resilience functions of the city’s tree population. Its main goals include increasing tree canopy cover, improving biodiversity, and enhancing urban comfort in response to climate change impacts, particularly heatwaves and air pollution. The plan is integrated within the city’s broader sustainability and climate adaptation strategies, such as the *Barcelona Green Infrastructure and Biodiversity Plan*. Legally, it operates as a sectoral planning tool and is managed by the city’s Department of Ecology, Urban Planning and Mobility. The timeline spans 20 years (2017–2037), with phased implementation through municipal programming and budgets. Funding is primarily

public, supplemented by EU funds and public-private partnerships for specific projects. Progress is monitored through a set of indicators to periodically evaluate the degree of compliance with the actions' scheduled time frames, i.e. a system that measures the amount of activity carried out per action. The plan aligns with SDGs, climate mitigation (via carbon sequestration), and disaster risk reduction by buffering against extreme weather.

While it does not directly address specific climate hazards, the Plan takes a proactive, sector-specific approach focused on urban biodiversity, ecosystem services, and green infrastructure, indirectly supporting adaptation to urban heat, air pollution, and water management challenges. The plan is underpinned by a climate vulnerability assessment (CVA) and risk analysis (RA) targeting the health, diversity, and resilience of the urban tree stock. It includes both regulatory and technical measures to ensure the integration of tree management in urban planning, construction, and maintenance, with the goal of improving the metabolic functioning of urban systems, the city's habitability and the health of its population. It also sets guidelines for selecting climate-resilient species, avoiding those that cause most urban problems, improving planting conditions, and adapting tree care practices to changing environmental conditions, maximising the benefits and minimising the disadvantages. Adaptation measures span governance (e.g. regulatory frameworks and planning integration), physical and technological solutions (e.g. pruning protocols, pest control, smart irrigation), and nature-based approaches (e.g. soil improvement, increased tree cover, connectivity with natural ecosystems). Knowledge and behavioural change are central, with emphasis on public awareness, stakeholder training, and participatory stewardship of green spaces.

- **U2 – Barcelona Resilience Action Plan (RAP)**

The *Barcelona Resilience Action Plan* (RAP) is a strategic policy developed for the city of Barcelona within the RESCCUE project framework[1] and aimed at strengthening the city's capacity to anticipate, respond to, and recover from a wide range of shocks and stresses, including those driven by climate change with focus on the urban water cycle. Its objectives encompass social cohesion, environmental sustainability, and climate adaptation, focusing on risks such as heatwaves, flooding, and energy insecurity. The plan has a medium/long term horizon of 10 years, from 2020 to 2030, and can be considered as a "*living document*" with decadal periodic updating. The RAP is non-binding but aligned with key municipal strategies, including the *Barcelona Climate Plan* and the *Urban Mobility Plan*. The Plan is funded through municipal budgets, EU programs (e.g., Horizon 2020), and partnerships with civil society and private actors. The Plan includes a monitoring and review process to track the progress of the resilience strategies' implementation and related resilience outcomes, as well as to identify early deviations that may require corrective action. Progress is assessed every two years, while a full review of all steps in the planning process is conducted every ten years.

The RAP presents a comprehensive and cross-sectoral strategy to address the city's exposure to multiple climate-related hazards. These include acute threats such as extreme heat, pluvial and coastal flooding, storms, and drought, as well as chronic challenges like sea-level rise and long-term water stress. The RAP covers a wide array of interconnected sectors, including water management, urban drainage, wastewater treatment, energy, waste, and mobility, emphasizing the systemic nature of urban resilience. The RAP applies Climate Vulnerability Assessments (CVA), Risk Assessments (RA), Cost-Benefit Analysis (CBA), and SWOT analysis to evaluate both physical infrastructure and institutional preparedness. A key aspect of the plan is its participatory development process, which involved a range of stakeholders from municipal authorities, infrastructure operators, and service providers to academic and technical partners. A wide set of adaptation measures is proposed. Governance and institutional actions include establishing a control centre and coordination mechanisms for emergency management. Economic tools such as water pricing strategies aim to

[1] The RESCCUE Project – "RESilience to cope with Climate Change in Urban arEas – a multisectorial approach focusing on water" – was a Horizon 2020 project aimed at helping urban areas around the world become more resilient to climate change by enhancing their capacity to anticipate, prepare for, respond to, and recover from multiple hazard threats with minimal damage. The project focused on a multisectoral approach, with particular emphasis on the urban water cycle.For more information, see: https://toolkit.resccue.eu/.

promote efficient and sustainable water use. Physical and technological measures are central to the plan, including expansion of sewer and drainage capacity, construction of CSO storage tanks, optimisation of desalination systems, and deployment of smart technologies like early warning systems and self-healing algorithms in the power grid. Nature-based solutions are also featured, with green roofs, infiltration trenches, and aquifer recharge using regenerated water supporting urban water resilience. Although knowledge and behavioural change measures are less detailed, the plan implies the importance of public engagement and capacity-building for long-term success.

- **U3 – Barcelona Nature Plan (2021–2030)**

The *Barcelona Nature Plan (2021–2030)* is a strategic initiative aimed at transforming the city into a greener, more sustainable urban environment, with a goal of increasing the city's green space, to conserve and promote biodiversity, to develop knowledge, enjoyment and care of urban nature and to facilitate and promote citizen involvement. The Barcelona Nature Plan is a municipal non-binding initiative that aligns with national and European Union environmental directives and its implementation is guided by Barcelona's Climate Plan and Urban Agenda. The plan complements other policies, such as Barcelona's Climate Change Adaptation Strategy and Barcelona's Sustainable Mobility Plan. The Plan was scheduled for implementation over a decade (2021–2030) and consists of 20 actions which consider the context and the big concepts and strategies for acting under and which are deployed through approximately 100 projects, 10 of which are considered priority and intended to be implemented during the 2021-2025 period and are known as lead projects which shape the action programme of the Nature Plan. The financing of the Barcelona Nature Plan come from a combination of public and private funds. Being the main local government budget through the Barcelona City Council, the Catalan and Spanish government for urban environmental projects and other EU fundings. The monitoring and tracking is prepared by the Urban Ecology Department and other stakeholders, with a focus on metrics such as hectares of green space added, biodiversity improvements, and reductions in urban heat, also the citizen feedback and participation are central to the implementation.

The Barcelona Nature Plan provides the city's strategic vision to expand and improve urban green infrastructure as a key part of ecological health and climate resilience. By treating green infrastructure as a lever to improve air quality, stormwater management and urban liveability, the plan positions urban nature at the heart of Barcelona's adaptation agenda. Underpinning the plan is a climate vulnerability assessment that maps deficits in tree cover, ecological connectivity and green space access across neighbourhoods. This risk-informed analysis pinpoints areas for priority intervention and informs the spatial targeting of new parks, green corridors and ecological restoration projects. While the plan does not detail a formal participatory framework, it incorporates community-driven initiatives, including citizen involvement in greening actions and public space improvements. Planned measures span five Key Types of Measures. In the Governance and Institutional domain, the city has created cross-cutting work boards to integrate nature into strategic planning. Economic and Financial actions include incentives to promote biodiversity in the built environment. Physical and Technological initiatives range from recycling pruning waste to improving irrigation systems. Nature-Based Solutions are central to the plan, including the incorporation of green roofs in large renovation projects and alternative water systems for irrigation. Finally, Knowledge and Behavioural Change measures include awareness campaigns and efforts to strengthen public engagement in protecting and expanding urban biodiversity.

- **U4 – Barcelona Climate Plan (2024–2030)**

The main objectives of the *Barcelona Climate Plan* revolve around the fight against climate change through mitigation and adaptation. The expected goals are reducing heat vulnerability, guaranteeing adequate water resources, reducing the risk of flooding due to poor drainage, increasing greenery-related social and environmental services, protecting the coastline and advocate for climate justice. "Pla Clima Barcelona" is an official municipal climate action plan adopted by the Barcelona City Council. It is a legally binding framework that guides climate policy and integrates climate objectives into all aspects of urban governance. The Pla Clima Barcelona sets an ambitious timeline for achieving

its climate goals, setting short-term actions and long-term actions, like to achieve net-zero emissions and full climate resilience by 2050. The financing for “Pla Clima Barcelona” is diversified and includes a mix of public and private sources. Barcelona City Council allocates a portion of its budget to climate action projects under Pla Clima, and also from the Catalan and Spanish government and the EU for specific climate programs. The progress of “Pla Clima Barcelona” is tracked through regular reports published by the Urban Ecology Department, detailing emissions reductions, energy efficiency improvements, and climate adaptation milestones. Indicators such as CO2 emissions, renewable energy share, green space per capita, and urban heat island mitigation are monitored and assessed annually.

The Barcelona Climate Plan articulates a cross-sectoral roadmap to mitigate and adapt to heatwaves, floods, droughts and wildfire risk through integrated measures across energy, buildings, mobility, waste and water resources. Addressing these hazards head-on, it seeks not only to reduce greenhouse gas emissions but also to support the city’s capacity to withstand extreme events and protect vulnerable populations. Central to the plan is a comprehensive risk and vulnerability assessment that layer's hazard maps (heat intensity, flood zones, wildfire exposure) with socio-economic data (age demographics, housing quality) to identify priority neighbourhoods. This evidence base informs participatory processes including institutional collaboration across municipal departments and external stakeholders such as civil protection authorities. The action portfolio is organized along the five Key Types of Measures. In Governance and Institutional terms, the plan launches a private-housing renovation program to improve thermal comfort and energy efficiency and develops coordination mechanisms for emergency response. Economic and Financial levels include financial support and incentives to accelerate climate-adaptive investments. On the Physical and Technological front, the plan calls for adapting schools and care homes to extreme heat and deploying a network of environmental monitoring stations. Nature-Based Solutions are embedded through interventions on city paving and rooftops to manage stormwater and reduce urban temperatures. Lastly, Knowledge and Behavioural Change measures involve civil protection plans, public studies on climate risks, and awareness-raising efforts.

ID	TITLE	DESCRIPTION	ORGANIZATION	TYPE	BINDING/ NON-BINDING	YEAR	SCALE OF INTERVENTION			REFERENCE	LINK
							Territorial	Urban	Building		
TERRITORIAL LEVEL											
T1	Climate Change Law of Catalonia (Llei 16/2017)	The Climate Change Law of Catalonia (Llei 16/2017) aims to address and mitigate the impacts of climate change while promoting a sustainable and low-carbon economy. The law sets ambitious targets for reducing greenhouse gas emissions, enhancing energy efficiency, and increasing the use of renewable energy sources. It also includes measures for climate adaptation, such as improving water management and protecting biodiversity. The law establishes a framework for monitoring and reporting progress, ensuring that climate policies are integrated across all sectors of the economy.	Parliament of Catalonia	Law	Binding	2017	✓			Parlament de Catalunya (2017). *Climate Change Law. Law 16/2017.*	Legal portal of Catalonia: *https://portaljuridic.gencat.cat/ca/document-del-pjur/?documentId=794493*
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	ESCACC2030 establishes the strategic guidelines that sectoral public policies must follow to adapt to the impacts of climate change and, consequently, reduce the vulnerability of their territory. This new strategic framework proposes 312 specific measures to facilitate the adaptation of natural environments, socio-economic activities and the territory to the new environmental scenarios. These measures have been developed following a solid review of the scientific knowledge and information on climate and environmental changes in the Mediterranean and Catalonia from technical and scientific assessment reports.	Government of the Generalitat de Catalunya	Strategy	Binding	2023	✓			Govern de la Generalitat de Catalunya (2023). *Marc estratègic de referència d'adaptació al canvi climàtic per a l'horitzó 2030 (ESCACC30).* Departament d'Acció Climàtica, Alimentació i Agenda Rural, Govern de la Generalitat de Catalunya.	Climate portal of Catalonia: *https://canviclimatic.gencat.cat/web/.content/03_AMBITS/adaptacio/ESCACC_2021_2030/00_Memoria-ESCACC30_rev_ling.pdf*

Table 5. Result A1, List of local policies - territorial level.

ID	TITLE	DESCRIPTION	ORGANIZATION	TYPE	BINDING/ NON-BINDING	YEAR	SCALE OF INTERVENTION			REFERENCE	LINK
							Territorial	Urban	Building		
URBAN LEVEL											
U1	TREES FOR LIFE Master Plan for Barcelona's Trees 2017 - 2037	The Plan is the strategic municipal document that defines the vision, objectives, strategic lines and actions for the planning, management and conservation of the city's tree population, both public and private, in accordance with their biogeographical and urban characteristics, in order to guarantee the contribution of those trees to a healthier city for the current population as a whole and for future generations, where the naturalisation and extension of green areas is a key factor for creating living, habitable public areas for people.	Area of Urban Ecology, Barcelona City Council	Plan	Non-binding	2017		✓		Bayo, K., París, A. (2017). *TREES FOR LIFE, Master Plan for Barcelona's Trees 2017 - 2037*. Àrea d'Ecologia Urbana. Ajuntament de Barcelona.	Official website of Barcelona City Council: https://ajuntament.barcelona.cat/ecologiaurbana/sites/default/files/Pla-director-arbrat-barcelona-ENG.pdf
U2	Barcelona Resilience Action Plan (RAP)	The RAP has been developed for the city of Barcelona within the RESCCUE project framework, becoming a new instrument to tackle with the effects of climate change and complementing the Climate Plan strategic measures and the climate action pathway. The plan has a medium/long term horizon of 10 years, from 2020 to 2030, in articulation with the strategic planning horizons for Barcelona. In this sense, Barcelona RAP can be considered as a "living document" with decadal periodic updating. Notwithstanding, it refers to other information sources with a broader horizon, e.g. 2100, like the studies carried out within RESCCUE on climate projections, impact analysis and Cost Benefit Analysis of adaptation measures. The scope of the plan is the urban resilience to climate change (CC) with focus on the urban water cycle.	Barcelona City Council	Plan	Non-binding	2020		✓		González, A., Gabàs, A., Cardoso, M.A., Brito, R.S., Pereira, C., Russo, B., Martínez, M., Velasco, M., Domínguez, J.L., Sánchez-Muñoz, D., Pardo, M., Monjo, R., Martinez, E., Guerrero, M., Forero, E., Pagani, G., Fourniere, H., Locatelli, L. (2020). *Barcelona Resilience Action Plan*. In Resilience Action Plans of the RESCCUE cities. D6.2 RESCCUE project (Public).	Official website of the RESCCUE project: https://toolkit.resccue.eu/wp-content/uploads/2020/11/Barcelona-Resilience-Action-Plan_Toolkit.pdf

Table 6. Result A1, List of local policies - urban level.

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ID	TITLE	DESCRIPTION	ORGANIZATION	TYPE	BINDING/ NON-BINDING	YEAR	SCALE OF INTERVENTION			REFERENCE	LINK
							Territorial	Urban	Building		
URBAN LEVEL											
U3	Barcelona Nature Plan	The Pla Natura 2021-2030 is Barcelona's strategic plan to enhance and protect the city's biodiversity and green spaces. It outlines specific actions and goals to create a greener, more sustainable urban environment. The plan focuses on increasing green infrastructure, promoting urban biodiversity, and ensuring that natural spaces are accessible and beneficial to all residents. While not legally binding, it serves as a crucial guide for the city's environmental policies and initiatives.	Area of Urban Ecology, Barcelona City Council	Plan	Non-binding	2021		✓		Barcelona City Council (2021). Barcelona Nature Plan 2021-2030. Area of Urban Ecology, Barcelona City Council.	Open Knowledge Repository of the Barcelona City Council: *https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/123630*
U4	Climate Plan	The Pla Clima 2024 is Barcelona's strategic plan to achieve climate neutrality and resilience by 2030. With a budget of over €1.8 billion, it focuses on enhancing public transport, increasing renewable energy, improving energy efficiency, expanding climate shelters, and implementing neighborhood-level climate actions. The plan aims to make Barcelona a more sustainable, resilient, and healthy city, ensuring that no one is left behind.	Barcelona City Council	Plan	Binding	2024		✓	✓	Barcelona City Council (2024, November). *Government Measure Climate Plan*. Barcelona City Council.	Open Knowledge Repository of the Barcelona City Council: *https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/138664*

ID	TITLE	KEY CRITERIA FOR POLICIES - KC-P				REFERENCE	LINK	NOTES
		KC-P1. Climate-related hazard	KC-P2. Climate-sensitive sector	KC-P3. Adaptation method	KC-P4. Adaptation measure			
T1	Climate Change Law of Catalonia (Llei 16/2017)	Acute: heat wave, wildfire, drought, Chronic: water stress	Agriculture and livestock Fishing and aquaculture Water Biodiversity Forests and forest management Energy Industry, services and trade Infrastructure Waste Health Transport and mobility Tourism Vocational training, universities and research Urban planning and housing	CIA CVAC SEA CRA Others: carbon footprint assessment system of products	A. Governance and Institutional (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1) E. Knowledge and Behavioural Change (E1, E2)	Parlament de Catalunya (2017). *Climate Change Law. Law 16/2017.*	Legal portal of Catalonia: *https://portaljuridic.gencat.cat/ca/document-del-pjur/?documentId=794493*	Sector considered: urban planning and housing
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	Acute: heat wave, cold wave, drought, heavy precipitation, drought, strong winds, wildfire, landslide, avalanche Chronic: changing temperature (air, marine water), sea level rise, acidification	Natural systems: Biodiversity, water, forests and forestry, marine ecosystems and fisheries Socio-economic spheres: Agriculture and livestock, insurance and financial sector, energy, industry, services and trade, mobility infrastructures, natural risks and civil protection, research and training, health, tourism, urban planning and housing Territories: Inland, coastal and mountain areas Cross-cutting issues: territorial vulnerability and social vulnerability	CRA CIA	A. Governance and Institutional (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1, D2) E. Knowledge and Behavioural Change (E1, E2)	Govern de la Generalitat de Catalunya (2023). *Marc estratègic de referència d'adaptació al canvi climàtic per a l'horitzó 2030 (ESCACC30).* Departament d'Acció Climàtica, Alimentació i Agenda Rural, Govern de la Generalitat de Catalunya.	Climate portal of Catalonia: *https://canviclimatic.gencat.cat/web/.content/03_AMBITS/adaptacio/ESCACC_2021_2030/00_Memoria-ESCACC30_rev_ling.pdf*	Sector considered: urban planning and housing

LEGEND

Adaptation methods
CIA Climate Impact Assessment
EIA Environmental Impact Assessment SEA Strategic Environmental Assessment LCA Life-Cycle Assessment
LCC Life-Cycle Costing
CVA Climate Vulnerability Assessment
CRA Climate Risk Assessment CBA Benefit-Cost Analysis
CEA Cost-Effectiveness Analysis MCA Multi-Criteria Analysis

Key Type Measures
A: Governance and Institutional (A1: Policy instruments, A2: Management and planning; A3: Coordination, cooperation and networks)
B: Economic and Finance (B1:Financing and incentive instruments, B2: Insurance and risk sharing instruments)
C: Physical and Technological (C1: Grey options, C2: Technological options)
D: Nature-Based Solutions and Ecosystem-based Approaches (D1: Green options, D2: Blue options)
E: Knowledge and Behavioural change (E1: Information and awareness raising; E2: Capacity building, empowering and lifestyle practices)

Table 7. Result B1, Local policy analysis based on T2.1 methodology – territorial level.

ID	TITLE	KEY CRITERIA FOR POLICIES - KC-P				REFERENCE	LINK	NOTES
		KC-P1. Climate-related hazard	KC-P2. Climate-sensitive sector	KC-P3. Adaptation method	KC-P4. Adaptation measure			
U1	TREES FOR LIFE Master Plan for Barcelona's Trees 2017 - 2037	No specific hazard is addressed/ assessed	Tree heritage Biodiversity	CVA: Study the tree population's functions, values, services and disservices RA: risk evaluation for trees and palm trees	A. Governance and Institutional (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1, D2) E. Knowledge and Behavioural Change (E1, E2)	Bayo, K., París, A. (2017). *TREES FOR LIFE, Master Plan for Barcelona's Trees 2017 - 2037*. Àrea d'Ecologia Urbana. Ajuntament de Barcelona.	Official website of Barcelona City Council: *https://ajuntament.barcelona.cat/ecologiaurbana/sites/default/files/Pla-director-arbrat-barcelona-ENG.pdf*	N/A
U2	Barcelona Resilience Action Plan (RAP)	Acute: extreme temperature, coastal and pluvial flooding, storm, drought Chronic: sea level rise, water stress Others: Combined Sewer Overflows (CSO), Water Turbidity	Urban drainage Wastewater treatment Beaches Water sourcing Water treatment Water supply Water transportation Waste Energy Mobility	CVA RA CEA CBA Others: Resilience Assessment, SWOT analysis	A. Governance and Institutional (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1, D2)	González, A., Gabàs, A., Cardoso, M.A., Brito, R.S., Pereira, C., Russo, B., Martínez, M., Velasco, M., Domínguez, J.L., Sánchez-Muñoz, D., Pardo, M., Monjo, R., Martinez, E., Guerrero, M., Forero, E., Pagani, G., Fourniere, H., Locatelli, L. (2020). *Barcelona Resilience Action Plan*. In Resilience Action Plans of the RESCCUE cities. D6.2 RESCCUE project (Public).	Official website of the RESCCUE project: *https://toolkit.resccue.eu/wp-content/uploads/2020/11/Barcelona-Resilience-Action-Plan_Toolkit.pdf*	N/A

LEGEND

Adaptation methods
CIA Climate Impact Assessment
EIA Environmental Impact Assessment SEA Strategic Environmental Assessment LCA Life-Cycle Assessment
LCC Life-Cycle Costing
CVA Climate Vulnerability Assessment
CRA Climate Risk Assessment CBA Benefit-Cost Analysis
CEA Cost-Effectiveness Analysis MCA Multi-Criteria Analysis

Key Type Measures
A: Governance and Institutional (A1: Policy instruments, A2: Management and planning; A3: Coordination, cooperation and networks)
B: Economic and Finance (B1:Financing and incentive instruments, B2: Insurance and risk sharing instruments)
C: Physical and Technological (C1: Grey options, C2: Technological options)
D: Nature-Based Solutions and Ecosystem-based Approaches (D1: Green options, D2: Blue options)
E: Knowledge and Behavioural change (E1: Information and awareness raising; E2: Capacity building, empowering and lifestyle practices)

Table 8. Result B1, Local policy analysis based on T2.1 methodology – urban level.

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ID	TITLE	KEY CRITERIA FOR POLICIES - KC-P				REFERENCE	LINK	NOTES
		KC-P1. Climate-related hazard	KC-P2. Climate-sensitive sector	KC-P3. Adaptation method	KC-P4. Adaptation measure			
U3	Barcelona Nature Plan	No specific hazard is addressed/ assessed	Greenery Biodiversity Conservation of the natural heritage Community engagement Knowledge Governance	CVA: identifying areas deficient in greenery for prioritization LCA/LCC: studying environmental and social benefits, including the costs of green infrastructure maintenance	A. Governance and Institutional (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1, D2) E. Knowledge and Behavioural Change (E1, E2)	Barcelona City Council (2021). *Barcelona Nature Plan 2021-2030*. Area of Urban Ecology, Barcelona City Council.	Open Knowledge Repository of the Barcelona City Council: *https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/123630*	N/A
U4	Climate Plan	Acute: heat wave, flooding, wildfire, drought Chronic: heat stress, sea level rise	Energy Buildings Mobility Waste Water resources Biodiversity Health	CVA: mapping of homes vulnerable to drought and heat impacts CBA	A. Governance and Institutional Measres (A1, A2, A3) B. Economic and Financial (B1) C. Physical and Technological (C1, C2) D. Nature-Based Solutions and Ecosystem-Based Approaches (D1, D2) E. Knowledge and Behavioural Change (E1, E2)	Barcelona City Council (2024, November). *Government Measure Climate Plan*. Barcelona City Council.	Open Knowledge Repository of the Barcelona City Council: *https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/138664*	The review includes all measures associated with each line of action across the six programs included in the Plan.

LEGEND

Adaptation methods
CIA Climate Impact Assessment
EIA Environmental Impact Assessment SEA Strategic Environmental Assessment LCA Life-Cycle Assessment
LCC Life-Cycle Costing
CVA Climate Vulnerability Assessment
CRA Climate Risk Assessment CBA Benefit-Cost Analysis
CEA Cost-Effectiveness Analysis MCA Multi-Criteria Analysis

Key Type Measures
A: Governance and Institutional (A1: Policy instruments, A2: Management and planning; A3: Coordination, cooperation and networks)
B: Economic and Finance (B1:Financing and incentive instruments, B2: Insurance and risk sharing instruments)
C: Physical and Technological (C1: Grey options, C2: Technological options)
D: Nature-Based Solutions and Ecosystem-based Approaches (D1: Green options, D2: Blue options)
E: Knowledge and Behavioural change (E1: Information and awareness raising; E2: Capacity building, empowering and lifestyle practices)

4.1.2 ADAPTATION MEASURES FROM LOCAL POLICIES (RESULTS B2 & B3)

The section presents the results of the comparison between adaptation measures included in local policies and those listed in the catalogue developed in T2.1. The aim is to identify new measures to be included in the T2.1 catalogue that have not been previously considered. Building on the detailed analysis of local adaptation policies based on the key criteria described in the previous section (Tables 7 and 8), a comprehensive list of adaptation measures identified in territorial and urban policies has been compiled (Tables 9 and 10). These local measures have then been compared with those included in the T2.1 catalogue of adaptation measures (Tables 11–14). Since the catalogue developed in T2.1 includes only measures under *KTM C: Physical and Technological*, and *KTM D: Nature-Based Solutions and Ecosystem-based Approaches*, the comparison was carried out by considering only these two categories. Moreover, the comparison takes into account only three of the six documents included in the desk review:

- T2 - Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030);
- U2 - Barcelona Resilience Action Plan (RAP);
- U4 - Barcelona Climate Plan.

The rationale behind this selection lies in the objective of analysing policies that incorporate measures directly applicable at the local scale, while also ensuring the inclusion of at least one reference document for each level of analysis — territorial and urban — with the aim of verifying the alignment between policies with similar goals and perspectives and analysing the multilevel governance in Spain's efforts for climate adaptation.

The comparison reveals a greater correspondence on technological options (KTM C2), especially regarding active cooling and ventilation and renewable energy systems, and green options (KTM D1) for outdoor spaces and buildings, which are included in all the documents analysed. Grey measures from T2.1 catalogue are less common within local policies, since these include different types of engineering solutions, primarily focused on the increase of the drainage system capacity and shading systems. Such a comparison reveals that several adaptation measures included in the policies have no correspondence in the T2.1 catalogue. Table 15 summarizes, for each KTM, the list of adaptation measures from policies without any correspondence. This list was adopted to identify new measures to be included in the catalogue based on the following criteria: 1) expert judgment from the partners involved in the task; 2) recurrence of the measures across various documents, with the aim of including relevant measures without introducing an excessive number of solutions. Table 15 also shows the measures selected to expand the catalogue. In addition, partners also suggest adding '*backup power systems'* and '*diversion tunnels*' as they represent key measures in ensuring the resilience and continuity of critical infrastructure under extreme climate events.

ID	TITLE	WHAT KINDS OF ADAPTATION MEASURES FOR THE BUILT ENVIRONMENT ARE PROPOSED WITHIN EACH KEY TYPE OF MEASURES?										
		A: GOVERNANCE AND INSTITUTIONAL			B: ECONOMIC AND FINANCE		C: PHYSICAL AND TECHNOLOGICAL		D: NATURE BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES		E: KNOWLEDGE AND BEHAVIOURAL CHANGE	
		A1: Policy instruments	A2: Management and planning	A3: Coordination, cooperation and networks	B1: Financing and incentive instruments	B2: Insurance and risk sharing instruments	C1: Grey options	C2: Technological options	D1: Green options	D2: Blue options	E1: Information and awareness raising	E2: Capacity building, empowering and lifestyle practices
T1	Climate Change Law of Catalonia (Llei 16/2017)	Adaptation of urban and energy regulation so that new residential areas have maximum energy self-sufficiency and are designed in accordance with the following hierarchy of criteria: to reduce energy demand, to be efficient in the design of the systems that meet the energy demand, use local energy resources, to promote the use of low environmental impact building materials and to compensate the carbon dioxide emissions from the energy impact of the buildings with renewable energy generation facilities Adaptation of urban and environmental regulation so that both the figures of new urban planning and their modifications and revisions as well as territorial planning incorporate a quantitative analysis and a descriptive valuation of the impact on greenhouse gas emissions and the impacts of climate change on the new planning, as well as measures to mitigate it and to adapt to it. This analysis shall include the emissions linked to the mobility generated, energy consumption of the water cycle and waste, and energy consumption from residential and tertiary uses Promotion of active policies that promote energy recovery of housing stock and improve energy saving and efficiency. The Catalan Strategy to upgrade the energy efficiency of buildings shall prioritise the accessibility and energy efficiency of buildings and housing by using renewable energy, and shall cover the need to act on a minimum of fifty thousand houses per year Creation of environmental taxes The Government shall develop an energy saving and efficiency plan every five years for its buildings and facilities Integration of the objectives of the law into sectoral plans and programmes in a period of eighteen months from when this law enters into force, in terms of reducing greenhouse gas emissions and vulnerability to the impacts of climate change Regulation to establish the functioning of the Climate Fund Development of a regulatory framework that encourages self-consumption of renewable energy Development of a draft law on biodiversity, natural heritage and biological connectivity	Take into consideration, by municipalities, in their urban planning, the recommendations by the World Health Organisation on the surface of urban green spaces per citizen The development of compact land occupation models and some more efficient and intense uses of urbanised land in territorial and urban legislation The Government encourage local authorities through a tax policy to incentivise actions in the private sectors aimed at make mitigation and adaptation policies effective (e.g. promotion of renewable energy, energy efficient housing, water saving, reduction of impacts on health, sustainable forest management, etc.)	The Interdepartmental Commission on Climate Change, a collegiate body affiliated with the ministry responsible for climate change, coordinates climate policy planning and monitors its completion by submitting to the Government proposals related to the mitigation of emissions and for the adaptation to the impacts of climate change; coordinating the action of the ministries of the Generalitat in fighting against climate change; approving proposals of mitigation and adaptation strategic frameworks; monitoring and assessing climate policies and sectoral action plans; establishing the priorities of Climate Fund action, according to economic availability, sectoral planning and cost-efficient analysis The Climate Change Social Roundtable is a collegiate body affiliated with the ministry responsible for climate change that channels participation, information and consultation to the most representative institutions and organisations in the social, economic and environmental fabric of Catalonia on climate policies The Government shall promote, through current collaboration and cooperation mechanisms and bodies, the participation of local authorities both in climate policy planning as well as sectoral action plans of each ministry in the relevant aspects to comply with the objectives of this law The Government shall maintain and strengthen their international commitment and activity in the following areas, among others: a) The United Nations Climate Change Conferences; b) Discussions within the framework of the European Union on climate policies; c) The networks and other collaboration spaces with other territories for exchanging information and knowledge and for the development of joint mitigation and adaptation projects; d) Support at a local level, with the objective of maintaining their commitment with European and international initiatives in this area	The municipal plans to fight against climate change may be financed with the Climate Fund if the municipalities apply fiscal policies that incentivise good practices, favouring mitigation and decreasing vulnerability, and that discourage poor practices The Government shall develop and implement a simplification strategy for administrative processing and tax incentives to the most appropriate private actions to tackle climate change, enhancing telematics means The Government shall promote and provide, through the Catalan Institute of Finances, access to financing to contribute to the development of projects aimed at complying with the objectives of this law, as an addition to the private financial sector The public administrations of Catalonia shall tax actions that increase the vulnerability or increase greenhouse gas emissions and shall introduce tax incentives for actions that promote the adaptation to climate change or the reduction of greenhouse gas emissions whenever it is technically and economically possible	N/A	Promotion of the construction with bioclimatic criteria with the objective that by 2020 new buildings will have nearly zero-energy consumption	Promotion of the use of energy from renewable sources in the building sector, prioritising those that do not generate a transfer towards other pollutants with local impacts Selection and classification of spaces that are already urbanised or occupied by infrastructure and services with the potential to place or share surfaces to capture renewable energy Promotion of the use, by professionals in the design, planning and construction of residential areas, of renewable energy sources for heating, refrigeration and sanitary hot water, and constructive solutions, both structural as well as insulation, that are highly energy-efficient Promotion of the stock of charging points for electric vehicles in workplaces and public buildings Promotion of the guarantee, in new urban developments, of the energy supply with 100% renewable energy sources, be it by connection to the consumption grid or self-consumption, or where appropriate, building closed grids Energy consumption from renewable sources in public facilities: (i) by 2020 a minimum of 70% of total electrical energy consumed from all ministries of the Generalitat and dependent bodies shall come from renewable sources. By 2030 it shall be 100%; (ii) (by 2020 a minimum of 20% of the total energy consumption in all public facilities shall come from their own renewable source)	Take into consideration, by municipalities, in their urban planning, the recommendations by the World Health Organisation on the surface of urban green spaces per citizen	N/A	The Government shall promote the creation of municipal or regional offices for energy transition that shall aim to inform the public and their own local authorities, as well as providing instruments for their development The Government shall create a digital platform that includes, among other issues, scientific advances in terms of climate change and successful international experiences in mitigation and adaptation policies, and shall put within reach the transfer of the knowledge that these advances and experiences entail for citizens and socio-economic agents The Government shall provide adequate information and promote the participation of citizens in all climate policies through the Climate Change Social Roundtable or a decentralised process throughout the whole territory The Government, town and city halls, and district councils shall establish the technical telematic and accessible means to inform citizens of public climate initiatives and actions. Also, the sectoral plans and programmes whose content is relevant to climate change shall be made available to the public in the different headquarters of the ministries of the Generalitat and of the local and supra-local administrations The Government, together with other research and science institutions, shall periodically draft a report on the state of climate change knowledge in Catalonia The Generalitat shall promote informational and educational campaigns among citizens and workers with the aim of making known the latest scientific advances on climate change and on the public policies to mitigate and adapt to it Inventory of Atmospheric Emissions in Catalonia Inventory of greenhouse gas emissions in the ministries of the Generalitat and dependent bodies	The external delegations of the Administration of the Generalitat shall incentivise and facilitate access to international markets for Catalan companies and services that offer technologies to reduce greenhouse gas emissions and to adapt to the impacts of climate change The Government shall create a digital platform that includes, among other issues, scientific advances in terms of climate change and successful international experiences in mitigation and adaptation policies, and shall put within reach the transfer of the knowledge that these advances and experiences entail for citizens and socio-economic agents The Generalitat shall promote informational and educational campaigns among citizens and workers with the aim of making known the latest scientific advances on climate change and on the public policies to mitigate and adapt to it The Government, through the ministries responsible for teaching, energy and climate change, shall promote awareness towards environmental issues in primary, secondary education, advanced vocational training and higher education, as well as in initial and permanent teacher training programmes

Table 9. Result B2, List of measures from local adaptation policies - territorial level.

continues from the previous page

ID	TITLE	*WHAT KINDS OF ADAPTATION MEASURES FOR THE BUILT ENVIRONMENT ARE PROPOSED WITHIN EACH KEY TYPE OF MEASURES?*									
		A: GOVERNANCE AND INSTITUTIONAL			B: ECONOMIC AND FINANCE		C: PHYSICAL AND TECHNOLOGICAL		D: NATURE BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES		E: KNOWLEDGE AND BEHAVIOURAL CHANGE	
		A1: Policy instruments	A2: Management and planning	A3: Coordination, cooperation and networks	B1: Financing and incentive instruments	B2: Insurance and risk sharing instruments	C1: Grey options	C2: Technological options	D1: Green options	D2: Blue options	E1: Information and awareness raising	E2: Capacity building, empowering and lifestyle practices
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	1.1. Ensure the coherence of the different strategic territorial planning instruments with climate change adaptation policies 2.1. Integrate measures for adaptation to climate change into territorial plans, as has been done with the Partial Territorial Plan of the Penedès 2.2. Integrate measures to adapt to the impacts of climate change in future revisions of the Territorial Plan of Catalonia 2.3. To promote strategic environmental assessment as a procedure for integrating adaptation to climate change into planning with territorial and landscape implications 3.1. Strengthen strategic environmental assessment as a procedure for integrating adaptation into urban planning 5.1. Develop a catalog of climate change adaptation measures to be integrated into the urban planning regulations 5.3. Integrate climate change adaptation into building regulations: review of current housing regulations to incorporate the life cycle perspective and climate change adaptation in the construction and management of residential buildings (habitability, conservation, 6.6. Promote municipal and/or supramunicipal sustainable construction ordinances sustainability, etc.)	1.3. Endow territorial plans with greater legal capacity and territorial and urban planning links 2.6. Implement support and promotion actions for small villages to help stabilize the population in the territory 2.7-3.5. Integrate territorial and urban planning with energy planning and ensure the compatibility of spaces designated for the production and distribution of renewable energy with agricultural and livestock activities through the Renewable Energy Territorial Plan 2.8. Increase self-sufficiency in cities to reduce the environmental impact on the territory 2.9. Ensure that adaptation measures are equitable and fair across the territory, with special attention to vulnerable groups and individuals 3.4. Prioritize urban regeneration over outward expansion 3.8. Promote mixed-use development and the concept of the “15-minute city” 3.10. Reduce risk and hazard in flood-prone areas occupied by activities and buildings 4.1. Naturalize urban areas and improve the quality of urban green spaces	1.2. Strengthen interdepartmental coordination mechanisms to avoid maladaptation or measures that are contrary to the measures that run counter to adaptation to climate change 1.4. Promote public-private dialogue panels and spaces for citizen participation 2.5. Establish a technical working group between the Directorate General of Urban Planning and the Catalan Office on climate change to develop a catalog of adaptation measures in the formulation of territorial plans	5.13. Explore fiscal incentives and subsidies to improve existing buildings and promote resource-saving and efficiency measures, as well as initiatives to mitigate the urban heat island effect	N/A	5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (high-quality materials, water conservation, etc)	3.6. Promote the installation of renewable energy generation points, primarily on rooftops and in residual spaces or other areas deemed most suitable depending on the project type 4.3. Promote the installation of renewable energy generation points (such as photovoltaic panels for self-consumption) on infrastructure, rooftops, residual spaces, and other areas deemed suitable 5.4. Promote more efficient building systems that also foresee the installation of renewable energy production systems and smart management systems, aiming to construct buildings with a positive energy balance 5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (energy savings, home automation, etc)	3.3. Prioritize corrective measures through nature-based solutions (NBS) 3.7. Strengthen green infrastructure and the naturalization of urban areas: ensure access to green spaces (a minimum of 0.5 ha within 500 m, according to WHO standards) 5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (green roofs, etc) 5.7. Promote research and development on the naturalization of buildings: green roofs, vertical gardens, and similar initiatives 5.8. Naturalization of urban areas: access to green spaces (a minimum of 0.5 hectares and within 500 meters, according to WHO recommendations) and improvement of urban green quality 5.9. Promote green canopies and vegetated pergolas in areas with few trees	4.2-5.10. Develop sustainable water use criteria for new green spaces (using water from alternative resources: rainwater, groundwater, reclaimed water, greywater, etc.) 5.12. Promote sustainable urban drainage systems	2.4. Develop tools and manuals for identifying and assessing the impacts of climate change on territorial, landscape, and sectoral planning with territorial impact 3.2. Develop tools and manuals for identifying and assessing the impacts of climate change on urban planning 3.9. Incorporate new climate scenarios into natural risk assessment and civil protection in urban planning 5.5. Create maps to assess the solar potential of building rooftops in municipalities with more than 20,000 inhabitants 5.6. Study the need to incorporate climate control (cooling) systems and insulation measures, as well as improve the thermal performance of buildings due to the projected increase in temperatures 5.7. Promote research and development on the naturalization of buildings: green roofs, vertical gardens, and similar initiatives 5.11. Study municipal irrigation needs during heatwave episodes 6.1. Promote public databases on construction materials, building rehabilitation, and maintenance, with environmental indicators 6.2. Promote eco-innovation in construction materials based on life cycle analysis and environmental product declarations 6.5. Update data on the energy status of buildings (IDESCAT, Territorial Housing Plan of Catalonia, ICAEN) 6.7. Improve the interoperability of building data. Enhance knowledge of the existing housing stock to facilitate the management of rehabilitation aids and their impact by improving data interoperability (Next Generation funds)	6.3. Explore the possibility of offering training sessions, through the School of Public Administration of Catalonia, for local government professionals working in urban planning areas 6.4. Continue collaborating with the training activities of professional associations related to the sector (Environmental Scientists Association, Architects Association, etc.)

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		A1: Policy instruments	A2: Management and planning	A3: Coordination, cooperation and networks	B1: Financing and incentive instruments	B2: Insurance and risk sharing instruments	C1: Grey options	C2: Technological options	D1: Green options	D2: Blue options	E1: Information and awareness raising	E2: Capacity building, empowering and lifestyle practices
U1	TREES FOR LIFE Master Plan for Barcelona's Trees 2017 - 2037	4.2. Including the value of the tree population in planning 5.1. Producing a plan for preserving iconic tree species in Barcelona 5.6. Organising and reviewing technical and regulatory documents concerning trees and their protection	4.4. Reviewing the planning and design criteria for tree planting in city projects 5.4. Ensuring the protection of trees during construction work 5.6. Organising and reviewing technical and regulatory documents concerning trees and their protection 6.1. Applying integrated control of pests and disease 6.3. Seeking alternatives to herbicides for the control of spontaneous vegetation 6.4. Applying the strategy to combat and control the red palm weevil 7.1. Ensuring the long-term supply of trees 7.2. Purchasing high-quality trees 7.3. Improving tree planting 7.4. Rethinking tree nurseries 8.1. Reviewing and unifying pruning criteria for trees	2.6. Improving training for specialist personnel regarding the tree population and fostering ways of collaborating with other municipal departments 2.7. Creating knowledge and experience exchange networks with other national and international cities	5.5 – Reviewing the evaluation and economic compensation criteria for trees and transplanting	N/A	5.3. Applying more efficient physical protection systems for trees 9.4. Resolving the compatibility between tree wells and accessibility 9.5. Designing new tree wells and surfacing, rationalising services 8.2. Pruning young trees to shape them 8.4. Finding new uses for plant residue	2.8. Seeking and applying new methods for controlling and monitoring the physiological state of trees (infra-red, drones, sensors, etc.) 3.4. Using new technologies to inform people about the city's tree heritage 10.2. Apply the most efficient irrigation technologies	1.2. Balancing out the abundance of all species of trees and palm trees in the city 1.3. Strengthening the tree population as part of an ecosystem with native fauna and flora 1.4. Planning the replacement of trees 4.1. Increasing the city's tree body of trees by planting more trees and bushes and improving the quality of existing trees 4.3. Connecting the tree population with urban and natural environments 4.5. Ensuring that each tree species is provided with the best possible agronomic conditions in the urban environment 9.1. Trying out and applying new types of soil and permeable surfacing 9.2. Improving the quality of soil in new plantings 9.3. Improving soil quality for existing trees	10.1. Adjust the amount and frequency of watering to each species 10.3. Prioritising the use of alternatives to drinking water 10.4. Making use of run-off water in parks and woodland areas, and also for street trees 10.5. Seeking appropriate alternative resources for future water availability	1.1. Getting to know Barcelona's tree heritage and producing a complete inventory 2.1. Studying the tree population's functions, values, services and disservices 2.2. Assigning an economic value to the benefits of the tree population 2.3. Studying the effects of climate change on the urban microclimate and its impact on trees 2.4. Studying how to tackle the scarcity of natural resources in the tree population's management 2.5. Minimising environmental impact on tree management 2.9. Selecting tree species with an eye to the future (resistance to urban environment, size and shape, flowering) 3.1. Producing and applying a communication strategy for the tree population 3.3. Promoting and supporting projects for involving the general public 3.4. Using new technologies to inform people about the city's tree heritage 5.2. Improving and informing the general public about trees of local interest in Barcelona 5.5. Reviewing the evaluation and economic compensation criteria for trees and transplanting 6.2. Promoting and informing the general public about the value of beneficial plants, fostering the growth of spontaneous vegetation 8.3. Improving risk evaluation for trees and palm trees	2.6. Improving training for specialist personnel regarding the tree population and fostering ways of collaborating with other municipal departments 3.2. Promoting educational projects on the tree population in education centres and for the general public
U2	Barcelona Resilience Action Plan (RAP)	Elaborate a Resilience Action Plan for the city according to RESCCUE methodology	Perform a Resilience Diagnosis of the city by using RESCCUE methodology and tools	To locate a control centre and a situation room	Increase the water cost for specific uses	N/A	Improvements of surface drainage system (New inlets) Promote rainwater collection and its reuse in buildings developments Increase of sewer system capacity (I) (New pipes) Increase of sewer system capacity (II) (New detention tanks for flooding protection) Promote rainwater collection and its reuse in buildings developments Storage tanks for CSO prevention Storage tanks for combined sewer overflows (CSOs) prevention End of pipe CSO treatment Improvements of the capacity of sewer interceptor and WWTP Optimize desalinization plant production Continue reducing leakage in water distribution networks	Early Warning System Ensure the stability of waste containers Self-healing algorithm implemented in the electrical distribution grid	Green roofs	Infiltration trenches Detention basins Promote the use of grey water in new housing Study the feasibility of producing regenerated water at the Besòs WWTP to feed the Besòs aquifer, to maintain the river's ecological flows and feed the purification plant Exploit the Besòs aquifer resource as potable water and build a purification plant Utilise regenerated water from the River Llobregat for the industrial uses of the Zona Franca Consortium and for recharging the aquifer Inter-basins connections	N/A	N/A

Table 10. Result B2, List of measures from local adaptation policies – urban level.

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ID	TITLE	*WHAT KINDS OF ADAPTATION MEASURES FOR THE BUILT ENVIRONMENT ARE PROPOSED WITHIN EACH KEY TYPE OF MEASURES?*									
		A: GOVERNANCE AND INSTITUTIONAL			B: ECONOMIC AND FINANCE		C: PHYSICAL AND TECHNOLOGICAL		D: NATURE BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES		E: KNOWLEDGE AND BEHAVIOURAL CHANGE	
		A1: Policy instruments	A2: Management and planning	A3: Coordination, cooperation and networks	B1: Financing and incentive instruments	B2: Insurance and risk sharing instruments	C1: Grey options	C2: Technological options	D1: Green options	D2: Blue options	E1: Information and awareness raising	E2: Capacity building, empowering and lifestyle practices
U3	Barcelona Nature Plan	1. To plan the city's green infrastructure, based on the diagnosis of priority areas of action under the Greenery Model 6. To include the design guidelines of the various planning tools and to evaluate the possibility of including them in mandatory regulations 22. To devise action plans for species and groups to protect in particular fauna 29. To devise action plans for protecting species and groups of great interest found in the coastal and marine environment 53. To take part actively from Barcelona in deploying the Special Protection Plan for the natural environment and landscape of Parc Natural de la Serra de Collserola (PEPNat), likewise taking the defined functional space into consideration 59. To make and implement plans with specific uses for nature and/or historical places that are frequently visited or especially sensitive to the effects of over-use by people or dogs 91. To revise and update current legislation to resolve legal pitfalls regarding citizen action in urban greenery, legalisation of beekeeping, marketing of farming products, etc	2. To include the planning of the city's green infrastructure in the Urban Development Master Plan (PDU) and develop it in other planning tools 4. To apply the Greenery and Biodiversity Charter to projects for urbanising, building and improving public spaces 5. To apply the Greenery Charter's criteria to the Passeig Marítim de Sant Martí master project, as a pilot test of naturalisation in a coastal environment 10. To implement the projects planned under the Greenery Model to continue with the target of achieving 160 new hectares by 2030 11. To prioritise increasing greenery in the more deficient neighbourhoods located in districts such as Ciutat Vella and Eixample 12. To implement projects for connecting greenery projects inside the city and with the metropolitan green infrastructure 13. To promote urban green corridors, paying special attention to the Ciutadella-Collserola corridor with the intervention on Carrer de Pi i Margall 15. To renovate parks and gardens attending to intervention priorities 16. To landscape municipal facilities, such as schools, community centres, sports centres, senior citizens' centres, neighbourhood centres, libraries, museums and so on and to green roofs there applying the protocol for greening roofs in municipal buildings 17. To create spaces for greenery and biodiversity in temporarily vacant green land plots and to establish the criteria for ensuring the conservation of their nature and greening to the full 18-19-20. To formalise the protection of the Tres Turons, Montjuïc and Rec Comtal as local nature reserves; to establish and apply a conservation protocol 21. To take part actively from Barcelona in implementing the "*Healthy Besòs. A joint vision of interventions for renaturalisation and sustainable mobility in spaces of opportunity along the banks of the River Besòs*" and "*Experience the River Besòs. Plan for conserving and restoring ecosystems and biodiversity and for preserving the coastal space and water resources*" projects 33. To apply the forest-management system defined for ZIN-ZINA management (areas of natural interest and altered areas of natural interest) 34. To reduce and monitor tree and shrub pruning 40. To implement actions for conserving flora of special nature interest (for example, orchids, aquatic flora, Montjuïc flora, rupicolous flora) and to highlight the city's spontaneous herbaceous flora 41. To define the most problematic invasive plant species, prioritise the zones and area to act on and define the methodology for acting with and applying 48. To make a purchasing policy sensitive to sustainability and biodiversity values 49. To establish criteria for conserving biodiversity in the implementation of the Strategic Framework of Historical Gardens and to apply them 50. To specify and implement naturalisation actions in heritage gardens 51. To look after the natural heritage in cemeteries establishing criteria for conserving biodiversity 54. To implement naturalisation projects in the area of contact between Barcelona's urban fabric and Parc de Collserola, both inside the area of the park and in the functional space 55. To implement projects for conserving the Vallvidrera river and marsh, attending to its naturalisation, flora and fauna values and regulation of uses 56. To promote and apply conservation measures to the open landscape of dry meadows on the Barcelona slope 57. To attend to the new needs of parks such as interaction with nature in children's playing, adapting parks as climate shelters, regulating uses for pandemics, gender perspective and social justice 62. To create park councils among the Authorities and city residents, for better management of parks and gardens 66. To approve a tool that enables the effective protection of private greenery, attending especially to the gardens along the Collserola strip 70.To create a networking system for bringing nature to city residents in neighbourhoods through both existing and new facilities 92. To analyse the cost of maintaining existing and planned greenery and biodiversity, with regard to human, financial and material resources. To include the new associated infrastructures such as SUDS, structural soils, green roofs 94. To set up a Parks and Gardens organisation suitable for the new ecological and naturalisation management of greenery and biodiversity, taking into consideration the resources, need for new professional profiles and the promotion of the eco-gardening profession 95. To approve and implement the municipal instructions for conserving and promoting urban biodiversity in every work, maintenance, activity and practice that may have an impact on biodiversity 99. To study the application of nature rights in the city Barcelona 100. To monitor the Nature Plan periodically through the Citizen Council for Sustainability	97. To establish three cross-cutting work boards: Greenery and Health; Biodiversity Conservation and City Greenery Model 90. To strengthen and expand collaboration with research institutions and centres to facilitate decision-taking based on knowledge 98. To take part actively in international initiatives and with the most important bodies committed to dealing with biodiversity problems	67. To maintain, expand and create subsidies and financial competitions that promote nature in the city 93. To study the possibilities of green taxation and alternative management and funding channels for creating and maintaining green spaces, such as private sponsorship, stewardship actions, temporary assignments of use, permits, discounts etc	N/A	47. To recycle pruning waste for gardening and other projects: cushioning, compost, fauna structures, etc	49. To continue advancing in the sustainable management of water irrigation, with special attention to promoting the use of alternative water resources	3. To incorporate green roofs in big renovation projects and new public works ensuring compatibility with other environmental uses 14. To implement initiatives such as fauna paths, butterfly gardens, tree plantations etc., to boost the ecological connectivity of fauna and the general functioning of the ecosystem 27. To plant trees and shrubs in parks and gardens to enrich the woody stratum, replace losses and improve biodiversity 28. To cultivate coastal plants in backshore spaces, creating solutions for sheltering from increased temperatures and sunlight 31. To increase the city's total number of naturalised green areas 32. To create biodiversity shelters in green spaces and to draft and apply conservation protocols for existing ones 35. To diversify shrub species, balancing the abundance among the various species and increasing native species 36. To establish meadows and grasslands for more ecological management and to encourage fauna such as pollinators 38. To minimise the planting of seasonal flowers, increasing the number of deciduous flowering-plant groups 39. To consolidate the spontaneous flora project in tree pits and expand the friendly flora project by attending to the diversity of types in the city and the various areas (urban, coastal, forest etc.) 63. To carry out initiatives on private greenery by promoting allotments and the greening of balconies, terraces, roof terraces, roofs, walls and gardened courtyards as well as ecological management	8. To include the supply of alternative water resources in the new green spaces, wherever possible (for example, use of ground water, collection of rainwater). 9. To implement soil-permeabilisation projects in public spaces (parks and gardens, roads surfaces and pavements) by replacing pavings with plants. To establish structural soils that produce a large useful volume of plants and to implement SUDS projects 30. To increase the number of naturalised ponds and to make new naturalised head ponds in Collserola's torrents 49. To continue advancing in the sustainable management of water irrigation, with special attention to promoting the use of alternative water resources	7. To carry out work sessions and other initiatives, to disseminate the Greenery Charter's criteria among professional 45. To promote the Tres Pins Plant Nursery as a research and experimentation space for improving the soil, plants and fauna, at the service of the city 71. To create and provide an interpretation centre with greenery and biodiversity in Barcelona 74. To create a website on greenery and biodiversity in Barcelona 75. To issue technical-type and outreach publications and videos on nature issues (for example, good gardening practices for shops, associations and organisations) 76. To carry out communication actions for advancing towards a positive citizen perception of nature, using communication media, digital media, street performances, etc 77. To publish an annual assessment of the advances of the plan and the state of biodiversity in Barcelona 79. In the framework of the Biodiversity Observatory, to devise studies for monitoring the state and development of the natural heritage with a data bank 80. To maintain and expand the Atles de biodiversitat de Barcelona, with information on not just terrestrial but also coastal and marine communities 81. To elaborate and publish an assessment of the overall impact of nature on the health of city residents 82. To study the plant species adapted to each type of greenery, above all to green walls and roofs 83. To study the plant species most adapted to shading and the areas that need especially thermoregulatory plants and admit xerophile plants 84. To calculate the impact of maintaining green spaces with regard to the various environmental aspects 85. To assess the benefits of greenery in each of the city's transformation projects 88. To deepen our knowledge of the impact of cities on the Earth's overall biodiversity 89. To promote research into the effects of climate change on natural heritage	57. To carry out citizen-involvement projects for nature actions in the city and to encourage more voluntary workers 61. To establish shared diagnoses with districts and citizens of the uses and socio-environmental services of the green spaces and beaches 96. To bolster training on greenery and biodiversity for the entire municipal workforce, under the "More Sustainable City Council" programme 63. To carry out initiatives on private greenery by promoting allotments and the greening of balconies, terraces, roof terraces, roofs, walls and gardened courtyards as well as ecological management 64. To open private green spaces for public use 65. To develop a training, advice, subsidy and resource-supplying services to attend to the needs of the various organisation (associations, hospitals, shops, hotels, enterprises, industries etc.,) to expand nature in its spaces in the framework of the More Sustainable Barcelona Network 68. To carry out nature environmental-education projects, attending to the wealth and diversity of its habitats. 69. To carry out education projects for co-existence between animals and city residents 72. To hold nature festivals for city residents in green spaces 73. To create open days in private gardens and extend their benefits to local residents 78. To promote the incorporate of biodiversity among professionals, by planning and applying training actions

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ID	TITLE	*WHAT KINDS OF ADAPTATION MEASURES FOR THE BUILT ENVIRONMENT ARE PROPOSED WITHIN EACH KEY TYPE OF MEASURES?*									
		A: GOVERNANCE AND INSTITUTIONAL			B: ECONOMIC AND FINANCE		C: PHYSICAL AND TECHNOLOGICAL		D: NATURE BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES		E: KNOWLEDGE AND BEHAVIOURAL CHANGE	
		A1: Policy instruments	A2: Management and planning	A3: Coordination, cooperation and networks	B1: Financing and incentive instruments	B2: Insurance and risk sharing instruments	C1: Grey options	C2: Technological options	D1: Green options	D2: Blue options	E1: Information and awareness raising	E2: Capacity building, empowering and lifestyle practices
U4	Barcelona Climate Plan	Developing a renovation programme for the private residential sector to establish a stable framework for the energy renovation of buildings Implementing the Neighbourhood Plan 2025-2028 Designing a health and climate change strategy Implementing a municipal drought resilience plan Implementing the local and interior spaces programme (PEPI) to enhance the quality of public spaces, buildings' envelopes, and create shaded areas	Increasing current efforts to reduce the risk of flooding Taking account of climate considerations in mental health programmes, providing more resources and working collaboratively with the community in relation to these matters Developing a byelaw for the use of greywater as a key tool to reduce the consumption of drinking water at home Using all available tools to encourage spending by other sectors and secure the necessary involvement of other public authorities	Model framework for coordination and operational action in the event of a wildfire Putting in place a group of experts to advise the Catalan Government on sustainability and climate issues Strengthening the More Sustainable Barcelona network to ensure that tools and resources to fight the climate emergency are available to individual citizens too	Increasing financial support and incentives for helping citizens generate energy and maximise energy production in their buildings Financial support for guaranteeing adequate water resources Providing financial support for the installation of water pressure sets, the renovation of facilities and the provision of any social services that may be needed Holding biennial calls for applications for subsidies for non-profit legal entities to fund initiatives for concrete and innovative action to tackle the climate emergency effectively	N/A	Adapting schools and care homes to the heat - shading Adapting schools and care homes to the heat - passive air conditioning solutions Acting on the city's paving and rooftops to make the soil more reflective Expanding the network of climate shelters Providing the necessary infrastructure to reduce the number of fires Compartmentalise the area to prevent large wildfires Adapting the city's sewers to make the soil more permeable Enhancing the catchment and purification systems and infrastructure to increase the amount of drinking water available Reinforcing the wall on Passeig de la Nova Mar Bella and Passeig del Llevant Increasing the number of children's play areas with seasonal awnings Constructing new energy-efficient buildings Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more shade Installing anti-flooding detention and retention tanks Expanding and upgrading city's sewers Increasing the drainage capacity of the drainage systems in Carrer Vila i Vilà and Avinguda Diagonal Developing pilot projects with reflective paving and roofs	Creating a network of monitoring stations in the city's various neighbourhoods Constructing new energy-efficient buildings Installing fixed photovoltaic pergolas for thermal comfort Decarbonising heating and air conditioning and domestic hot water (DHW) systems Consolidating, implementing and expanding heating and cooling networks: efficient heating and air conditioning Generating local and renewable energy (solar) Adapting schools and care homes to the heat -solar energy systems Developing pilot projects for cooling through efficient solar energy-powered cooling systems Ensuring that there are alternative energy supply systems and resources in place in case there is a fault with the healthcare system	Acting on the city's paving and rooftops to make the soil more permeable Permeabilising large green spaces and open spaces in the city and facilities, such as school playgrounds Installing aligned tree pits Increasing the coverage of green areas for those parts of the city that suffer from shortfalls in social and environmental services Making the city's green cover compatible with the water restrictions in place Adding sand to some of the city's beaches (by the Spanish Ministry) Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more shade and more greenery Replanting 7,500 palm and other trees Adapting schools and care homes to the heat - renaturing actions, depaving Promoting the installation of green roofs	Acting on the city's paving and rooftops to make the soil more permeable Upgrading tarmac to permeable paving in some places Using alternative resources for appropriate purposes (such as watering green areas, cleaning streets and sewers) Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more water (while ensuring an efficient and optimised use of water resources) Supplying recycled water to the Marina del Prat Vermell neighbourhood for the irrigation of green areas and to clean the streets and use in toilet cistern Building the rainwater retention system on Avinguda Prim Sustainable urban drainage systems Headwater ponds Restoring underwater ecosystems Providing drinking fountains in municipal facilities Adapting schools and care homes to the heat - fountains Creating a cooling water play area for children in each district	Carrying out a study on the protection of Barcelona's beaches Strengthening and publicising current tools, such as the Critical Episode Viewer and the Resilience Atlas Updating the available information on the infrastructures affected by climate risks (such as those particularly affected by rising sea levels or flooding) Drawing up a map of potentially vulnerable homes in Barcelona based on drought restrictions for the three emergency scenarios and considering three parameters: building height, residents' age and sex, and socio-economic level Continuing to work on gaining a better understanding of critical infrastructure to ensure that it works properly (such as mapping, contingency situations, cascading effects and resilience) Preparing the current electricity grid for the energy transition and conducting relevant capacity, impact and feasibility studies, as well as good planning. Publicising and spreading the word about the city's oceanographic and climate variable viewers (such as oceanographic buoys or cameras to monitor the width of beaches or artificial reefs) Producing more communication materials (such as fans, drinking glasses, advertisements and improvements to the website) Increasing the public's knowledge about the urban climate by installing weather stations that provide information from all over the city Increasing the heat campaign and producing new inclusive communication materials to make them accessible for the elderly, people with disabilities or foreigners (e.g. an inclusive website, short videos, fans, baseball caps, canteens, parasols or the delivery of tips through voice messages rather than SMS) Developing an app with information on all the heat adaptation resources available in the city (such as shelters, shade, routes, water-based cooling areas and fountains) Reinforcing the energy advice points and expanding the service to turn them into climate advice points Providing newcomers with a climate welcome kit containing energy saving and climate adaptation information and resources Boosting a wide range of research lines to improve scientific knowledge and support the highest standards in the implementation of public policies (studies on risks and adaptation, climate change and health, fiscal tools to encourage decarbonisation, cost-benefit analysis method for adaptation actions)	Maintaining the civil defence plans, holding training and information sessions in mountain neighbourhoods and increasing self-protection measures Holding environmental education actions in climate shelters Democratising the actions needed to tackle the climate emergency through inclusive participatory processes (2nd Citizen Climate Assembly)

				Catalogue of Adaptation Measures - KTM C1: Grey options																			
				Structural defence						Climate-proofed design of infrastructures and outdoor spaces				Climate-proofed design of buildings									
				C1.1	C1.2	C1.3	C1.4	C1.5	C1.6	C1.7	C1.8	C1.9	C1.10	C1.11	C1.12	C1.13	C1.14	C1.15	C1.16	C1.17	C1.18	C1.19	C1.20	C1.21
Adaptation policy ID	**Title**	**Adaptation measure ID**	**Description of measures**	Cliff strengthening and stabilisation	Groynes, breakwaters and artificial reefs	Improved design of dikes, dams and levees	Raising and advancing coastal land	Seawalls and jetties	Storm surge gates and flood barriers	Adjustment of bituminous mixture design	Adjustment of structural design of the pavement	Light-coloured and reflective materials for paving surfaces	Hollow roads	Insulation of the envelope	Passive heating/cooling systems	Light-coloured and reflective materials for the envelope	Construction materials	Flood-resistant materials	Flood barriers	Wet flood-proofing	Dry flood-proofing	Hip roof	Flood-proof buildings	Rainwater harvesting
U2	Barcelona Resilience Action Plan (RAP)	U2.C1.1	Improvements of surface drainage system (New inlets)																				
		U2.C1.2	Increase of sewer system capacity (I) (New pipes)																				
		U2.C1.3	Increase of sewer system capacity (II) (New detention tanks for flooding protection)																				
		U2.C1.4	Promote rainwater collection and its reuse in buildings developments																				✓
		U2.C1.5	Storage tanks for CSO prevention																				
		U2.C1.6	Storage tanks for combined sewer overflows (CSOs) prevention																				
		U2.C1.7	End of pipe CSO treatment																				
		U2.C1.8	Improvements of the capacity of sewer interceptor and WWTP																				
		U2.C1.9	Optimize desalinization plant production																				
		U2.C1.10	Continue reducing leakage in water distribution networks																				
U4	Climate Plan	U4.C1.1	Adapting schools and care homes to the heat - shading																				
		U4.C1.2	Adapting schools and care homes to the heat - passive air conditioning solutions												✓								
		U4.C1.3	Acting on the city's paving and rooftops to make the soil more reflective									✓				✓							
		U4.C1.4	Expanding the network of climate shelters																				
		U4.C1.5	Providing the necessary infrastructure to reduce the number of fires																				
		U4.C1.6	Compartmentalise the area to prevent large wildfires																				
		U4.C1.7	Adapting the city's sewers to make the soil more permeable																				
		U4.C1.8	Enhancing the catchment and purification systems and infrastructure to increase the amount of drinking water available																				
		U4.C1.9	Reinforcing the wall on Passeig de la Nova Mar Bella and Passeig del Llevant					✓															
		U4.C1.10	Increasing the number of children's play areas with seasonal awnings																				
		U4.C1.11	Constructing new energy-efficient buildings											✓	✓								
		U4.C1.12	Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more shade																				
		U4.C1.13	Installing anti-flooding detention and retention tanks																				✓
		U4.C1.14	Expanding and upgrading city's sewers																				
		U4.C1.15	Increasing the drainage capacity of the drainage systems in Carrer Vila i Vilà and Avinguda Diagonal																				
		U4.C1.16	Developing pilot projects with reflective paving and roofs									✓				✓							
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	T2.C1.1	5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (high-quality materials, water conservation, etc)														✓						✓

Table 11. Result B3, Comparison of adaptation measures between the T2.1 catalogue and local policies – KTM C1: Grey options (measures without correspondence in the T2.1 catalogue are highlighted in light orange).

				Catalogue of Adaptation Measures - KTM C2: Technological options				
				Climate-informed decision making			Climate-proofed design of buildings	
				C2.1	C2.2	C2.3	C2.4	C2.5
Adaptation policy ID	**Title**	**Adaptation measure ID**	**Description of measures**	Early warning systems	Climate services	Decision support system	Active cooling and ventilation	Renewable energy systems
U2	Barcelona Resilience Action Plan (RAP)	U2.C2.1	Early Warning System	✓				
		U2.C2.2	Ensure the stability of waste containers					
		U2.C2.3	Self-healing algorithm implemented in the electrical distribution grid					
U4	Climate Plan	U4.C2.1	Creating a network of monitoring stations in the city's various neighbourhoods					
		U4.C2.2	Constructing new energy-efficient buildings				✓	✓
		U4.C2.3	Installing fixed photovoltaic pergolas for thermal comfort					✓
		U4.C2.4	Decarbonising heating and air conditioning and domestic hot water (DHW) systems				✓	
		U4.C2.5	Consolidating, implementing and expanding heating and cooling networks: efficient heating and air conditioning				✓	
		U4.C2.6	Generating local and renewable energy (solar)					✓
		U4.C2.7	Adapting schools and care homes to the heat - solar energy systems					✓
		U4.C2.8	Developing pilot projects for cooling through efficient solar energy-powered cooling systems					✓
		U4.C2.9	Ensuring that there are alternative energy supply systems and resources in place in case there is a fault with the healthcare system					
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	T2.C2.1	3.6. Promote the installation of renewable energy generation points, primarily on rooftops and in residual spaces or other areas deemed most suitable depending on the project type					✓
		T2.C2.2	4.3. Promote the installation of renewable energy generation points (such as photovoltaic panels for self-consumption) on infrastructure, rooftops, residual spaces, and other areas deemed suitable					✓
		T2.C2.3	5.4. Promote more efficient building systems that also foresee the installation of renewable energy production systems and smart management systems, aiming to construct buildings with a positive energy balance					✓
		T2.C2.4	5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (energy savings, home automation, etc)				✓	

Table 12. Result B3, Comparison of adaptation measures between the T2.1 catalogue and local policies – KTM C2: Technological options (measures without correspondence in the T2.1 catalogue are highlighted in light orange).

				Catalogue of Adaptation Measures - KTM D1: Green options									
				Protection and restoration of ecosystems		Renaturalization of coastal areas		Climate-proofed design of outdoor spaces				Climate-proofed design of buildings	
				D1.1	D1.2	D1.3	D1.4	D1.5	D1.6	D1.7	D1.8	D1.9	D1.10
Adaptation policy ID	**Title**	**Adaptation measure ID**	**Description of measures**	Soil structure improvement	Parks and protected areas	Beach and shoreface nourishment	Dune construction and strengthening	Open green spaces	Urban farming	Urban forests (afforestation, reforestation)	Drought-tolerant and drought-resistant plants	Green roofs (extensive, intensive)	Green facades (ground-based greening, facade-bounded greening)
U2	Barcelona Resilience Action Plan (RAP)	U2.D1.1	Green roofs									✓	
U4	Climate Plan	U4.D1.1	Acting on the city's paving and rooftops to make the soil more permeable					✓				✓	
		U4.D1.2	Permeabilising large green spaces and open spaces in the city and facilities, such as school playgrounds					✓					
		U4.D1.3	Installing aligned tree pits										
		U4.D1.4	Increasing the coverage of green areas for those parts of the city that suffer from shortfalls in social and environmental services					✓					
		U4.D1.5	Making the city's green cover compatible with the water restrictions in place								✓		
		U4.D1.6	Adding sand to some of the city's beaches (by the Spanish Ministry)			✓							
		U4.D1.7	Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more shade and more greenery					✓		✓			
		U4.D1.8	Replanting 7,500 palm and other trees							✓			
		U4.D1.9	Adapting schools and care homes to the heat - renaturing actions, depaving					✓	✓	✓	✓		
		U4.D1.10	Promoting the installation of green roofs									✓	
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	T2.D1.1	3.3. Prioritize corrective measures through nature-based solutions (NBS)					✓	✓	✓	✓	✓	✓
		T2.D1.2	3.7. Strengthen green infrastructure and the naturalization of urban areas: ensure access to green spaces (a minimum of 0.5 ha within 500 m, according to WHO standards)					✓	✓	✓	✓	✓	
		T2.D1.3	5.2. Renovate the existing building stock to improve its energy efficiency and sustainability in current buildings (green roofs)									✓	
		T2.D1.4	5.7. Promote research and development on the naturalization of buildings: green roofs, vertical gardens, and similar initiatives									✓	✓
		T2.D1.5	5.8. Naturalization of urban areas: access to green spaces (a minimum of 0.5 hectares and within 500 meters, according to WHO recommendations) and improvement of urban green quality										
		T2.D1.6	5.9. Promote green canopies and vegetated pergolas in areas with few trees										

Table 13. Result B3, Comparison of adaptation measures between the T2.1 catalogue and local policies - KTM D1: Green options (measures without correspondence in the T2.1 catalogue are highlighted in light orange).

Adaptation policy ID	Title	Adaptation measure ID	Description of measures	Catalogue of Adaptation Measures - KTM D2: Blue options							
				Protection and restoration of ecosystems		Climate-proofed design of outdoor spaces					
				D2.1	D2.2	D2.3	D2.4	D2.5	D2.6	D2.7	D2.8
				Rehabilitation and restoration of rivers and floodplains	Wetlands (construction, restoration, and management)	Infiltration elements	Filtration elements	Water channels	Retention and detention areas	Floodable areas	Water elements
U2	Barcelona Resilience Action Plan (RAP)	U2.D2.1	Infiltration trenches			✓					
		U2.D2.2	Detention basins						✓		
		U2.D2.3	Promote the use of grey water in new housing								
		U2.D2.4	Study the feasibility of producing regenerated water at the Besòs WWTP to feed the Besòs aquifer, to maintain the river's ecological flows and feed the purification plant								
		U2.D2.5	Exploit the Besòs aquifer resource as potable water and build a purification plant								
		U2.D2.6	Utilise regenerated water from the River Llobregat for the industrial uses of the Zona Franca Consortium and for recharging the aquifer								
		U2.D2.7	Inter-basins connections								
U4	Climate Plan	U4.D2.1	Acting on the city's paving and rooftops to make the soil more permeable			✓					
		U4.D2.2	Upgrading tarmac to permeable paving in some places			✓					
		U4.D2.3	Using alternative resources for appropriate purposes (such as watering green areas, cleaning streets and sewers)								
		U4.D2.4	Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more water (while ensuring an efficient and optimised use of water resources)								✓
		U4.D2.5	Supplying recycled water to the Marina del Prat Vermell neighbourhood for the irrigation of green areas and to clean the streets and use in toilet cistern								
		U4.D2.6	Building the rainwater retention system on Avinguda Prim						✓		
		U4.D2.7	Sustainable urban drainage systems			✓	✓	✓	✓	✓	
		U4.D2.8	Headwater ponds						✓		
		U4.D2.9	Restoring underwater ecosystems								
		U4.D2.10	Providing drinking fountains in municipal facilities								✓
		U4.D2.11	Adapting schools and care homes to the heat - fountains								✓
		U4.D2.12	Creating a cooling water play area for children in each district							✓	
T2	Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030)	T2.D2.1	4.2-5.10. Develop sustainable water use criteria for new green spaces (using water from alternative resources: rainwater, groundwater, reclaimed water, greywater, etc.)								
		T2.D2.2	5.12. Promote sustainable urban drainage systems			✓	✓	✓	✓	✓	

Table 14. Result B3, Comparison of adaptation measures between the T2.1 catalogue and local policies – KTM D2: Blue options (measures without correspondence in the T2.1 catalogue are highlighted in light orange).

KTM C1

Adaptation measure ID	Description of measures without correspondence in the T2.1 catalogue	New measures to be included in the catalogue
U2.C1.1	Improvements of surface drainage system (New inlets)	Increase the drainage capacity
U2.C1.2	Increase of sewer system capacity (I) (New pipes)	
U2.C1.3	Increase of sewer system capacity (II) (New detention tanks for flooding protection)	
U2.C1.5	Storage tanks for CSO prevention	
U2.C1.6	Storage tanks for combined sewer overflows (CSOs) prevention	
U2.C1.7	End of pipe CSO treatment	
U2.C1.8	Improvements of the capacity of sewer interceptor and WWTP	
U2.C1.9	Optimize desalinization plant production	
U2.C1.10	Continue reducing leakage in water distribution networks	
U4.C1.1	Adapting schools and care homes to the heat - shading	Shading systems
U4.C1.4	Expanding the network of climate shelters	
U4.C1.5	Providing the necessary infrastructure to reduce the number of fires	
U4.C1.6	Compartmentalise the area to prevent large wildfires	
U4.C1.7	Adapting the city's sewers to make the soil more permeable	
U4.C1.8	Enhancing the catchment and purification systems and infrastructure to increase the amount of drinking water available	
U4.C1.10	Increasing the number of children's play areas with seasonal awnings	
U4.C1.12	Speeding up and boosting climate adaptation measures in public spaces to meet the thermal comfort needs with more shade	Shading systems
U4.C1.14	Expanding and upgrading city's sewers	
U4.C1.15	Increasing the drainage capacity of the drainage systems in Carrer Vila i Vilà and Avinguda Diagonal	Increase the drainage capacity

KTM C2

Adaptation measure ID	Description of measures without correspondence in the T2.1 catalogue	New measures to be included in the catalogue
U2.C2.2	Ensure the stability of waste containers	
U2.C2.3	Self-healing algorithm implemented in the electrical distribution grid	
U4.C2.1	Creating a network of monitoring stations in the city's various neighbourhoods	Monitoring Systems
U4.C2.9	Ensuring that there are alternative energy supply systems and resources in place in case there is a fault with the healthcare system	Backup power systems

KTM D1

Adaptation measure ID	Description of measures without correspondence in the T2.1 catalogue	New measures to be included in the catalogue
U4.D1.3	Installing aligned tree pits	Urban tree planting systems (include tree pits, tree wells, tree boxes)
T2.D1.5	5.8. Naturalization of urban areas: access to green spaces (a minimum of 0.5 hectares and within 500 meters, according to WHO recommendations) and improvement of urban green quality	
T2.D1.6	5.9. Promote green canopies and vegetated pergolas in areas with few trees	Shading systems with green elements

KTM D2

Adaptation measure ID	Description of measures without correspondence in the T2.1 catalogue	New measures to be included in the catalogue
U2.D2.3	Promote the use of grey water in new housing	Water recycling and reuse systems
U2.D2.4	Study the feasibility of producing regenerated water at the Besòs WWTP to feed the Besòs aquifer, to maintain the river's ecological flows and feed the purification plant	
U2.D2.5	Exploit the Besòs aquifer resource as potable water and build a purification plant	
U2.D2.6	Utilise regenerated water from the River Llobregat for the industrial uses of the Zona Franca Consortium and for recharging the aquifer	Water recycling and reuse systems
U2.D2.7	Inter-basins connections	
U4.D2.3	Using alternative resources for appropriate purposes (such as watering green areas, cleaning streets and sewers)	Water recycling and reuse systems
U4.D2.5	Supplying recycled water to the Marina del Prat Vermell neighbourhood for the irrigation of green areas and to clean the streets and use in toilet cistern	Water recycling and reuse systems
U4.D2.9	Restoring underwater ecosystems	
T2.D2.1	4.2-5.10. Develop sustainable water use criteria for new green spaces (using water from alternative resources: rainwater, groundwater, reclaimed water, greywater, etc.)	Water recycling and reuse systems

Table 15. Overview of adaptation measures from territorial and urban policies without correspondence in the T2.1 catalogue.

4.2 UPDATED CATALOGUE OF ADAPTATION MEASURES

This section presents the key results of the sub-task T8.1.3: 1) additional factsheets with measures identified within local adaptation plans; 2) integration of factsheets from the T2.1 catalogue for cool pavement, porous pavement and bioswale with KPIs selected from T1.2 for resilience assessment. The following sub-sections include the new and updated factsheets related to the KTMs included in the comparison described in section 4.1.2: 1) KTM C: Physical and Technological; 2) KTM D: Nature-Based Solutions and Ecosystem-based Approaches. In particular, the new factsheets presented in section 4.2.1 derive from the comparison of adaptation measures derived from local policies with those in the T2.1 catalogue. They enrich the previous results by expanding the catalogue with additional adaptation measures, allowing for a broader selection and more comprehensive assessment. The KPIs to be associated with adaptation measures to be implemented in the Barcelona case study, shown in section 4.2.2, derive from a validation process based on the SMART approach and combined with the expert judgement of the partners involved in the task. They complement the previous results by enabling a more actionable and measurable assessment of adaptation measures.

4.2.1 ADDITIONAL FACTSHEETS OF ADAPTATION MEASURES (RESULT C1)

The newly identified measures for each KTM, each accompanied by a detailed factsheet, are:

KTM C: PHYSICAL AND TECHNOLOGICAL

- GREY OPTIONS - KTM C1.1_Increase of the drainage capacity – hard engineering solutions
- GREY OPTIONS - KTM C1.2_Shading systems
- TECHNOLOGICAL OPTIONS - KTM C2.1_Backup power systems
- TECHNOLOGICAL OPTIONS - KTM C2.1_Monitoring systems

KTM D: NATURE-BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES

- GREEN OPTIONS - KTM D1.1_Urban tree planting systems
- GREEN OPTIONS - KTM D1.2_Shading systems with green elements
- BLUE OPTIONS - KTM D2.1_Water recycling and reuse systems
- BLUE OPTIONS - KTM D2.2_Diversion tunnels

Tables 16 and 17 provide a synthesis of the additional measures included in the catalogue, including key information on the climate-related hazards addressed, the processes and functions delivered, the benefits and co-benefits provided, and the scale of intervention.

KTM	Sub-KTMs	Lines of actions from NAPs	Id	Measures	MULTICLIMACT categorization	Climate-related hazards	Functions	Benefits	Co-benefits	Scales of intervention		
										Territorial	Urban	Building
C Physical and Technological	C1 Grey options	Climate-proofed design of infrastructures and outdoor spaces	C1.1	Increase the drainage capacity – hard engineering solutions	M&T	• Flood (pluvial, riverine, coastal) • Heavy precipitation • Storms	• Flood regulation (pluvial, riverine, coastal) • Storm protection • Stormwater management	• Flood risk reduction (pluvial, riverine, coastal) • Extreme events risk reduction • Disaster risk reduction • Storm risk reduction	• Improvement of quality of life • Improvement of human health and wellbeing • Reduction in livelihoods losses • Reduction in the cost of rehabilitation/reconstruction • Deaths and injuries reduction • Stimulation of local economies and job creation	X	X	
			C1.2	Shading systems	M&T	• Extreme temperature events • Heat stress • Temperature variability	• Heat regulation • Surface temperature regulation	• Heat stress risk reduction • Extreme events risk reduction	• Improvement of quality of life • Improvement of human health and wellbeing • Improvement of outdoor and/or indoor microclimate conditions, increase in indoor thermal comfort • Reduction in energy consumption • Stimulation of local economies and job creation		X	X
	C2 Technological options	Climate-proofed design of buildings	C2.1	Backup power systems	M&T	• Extreme temperature events • Heat stress • Temperature variability • Heavy precipitation • Storms • Cyclones, hurricanes, typhoons, tornados • Flood (pluvial, riverine, coastal) • Storm surge • Wildfires	• Energy production • Heat regulation	• Heat stress risk reduction • Extreme events risk reduction • Disaster risk reduction	• Increase in self-sufficiency • Improvement of quality of life (through maintained essential services) • Improvement of human health and wellbeing • Reduction in deaths and injuries			x
		Climate-informed decision making	C2.2	Monitoring systems	DS	• All hazards (depending on the type and scope of option)	• Monitoring and prediction of weather and climate conditions • Delivering data and information	• Extreme events risk reduction • Disaster risk reduction	• Able to contribute to delivering multiple co-benefits	X	X	X

Table 16. Result C1, List of additional adaptation measures included in the T2.1 catalogue – KTM C.

KTM	Sub-KTMs	Lines of actions from NAPs	Id	Measures	MULTICLIMACT categorization	Climate-related hazards	Processes	Functions	Benefits	Co-benefits	Scales of intervention		
											Territorial	Urban	Building
D Nature-Based Solutions and Ecosystem-Based Approaches	D1 Green options	Climate-proofed design of outdoor spaces	D1.1	Urban tree planting systems	M&T	• Extreme temperature events • Temperature variability • Heat stress • Flood (pluvial)	• Evapotranspiration cooling • Air cleaning • Shade • Carbon sequestration	• Pluvial flood regulation • Heat regulation • Storm protection	• Pluvial flood risk reduction • Heat stress risk reduction • Storm risk reduction	• Stimulation of local economies and job creation • Improvement of human health and wellbeing • Increase in biodiversity • Contribution to education • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Improvement of air quality • Contribution to GHG emission reduction	X	X	
			D1.2	Shading systems with green elements	M&T	• Extreme temperature events • Temperature variability • Heat stress	• Evapotranspiration cooling • Shade • Carbon sequestration	• Heat regulation	• Heat stress risk reduction	• Increase in biodiversity • Improvement of air quality • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Contribution to GHG emission reduction		X	X
	D2 Blue options	Climate-proofed design of outdoor spaces	D2.1	Water recycling and reuse systems	M&T	• Heavy precipitation • Flood • Storms • Drought	• Water collection • Water storage and reuse • Water cleaning	• Stormwater management • Water purification	• Flood risk reduction	• Improvement of quality of life • Stimulation of local economies and job creation • Improvement of human health and wellbeing • Reduction in livelihoods losses • Water supply • Increase in self-sufficiency • Improvement of water quality and sediment management • Cost savings	X	X	X
			D2.2	Diversion tunnels	M&T	• Flood (pluvial) • Heavy precipitation • Storms	• Water delay • Stormwater and wastewater redirection • Floodwater conveyance	• Pluvial flood regulation • Stormwater attenuation	• Pluvial flood risk reduction	• Improvement of quality of life • Reduction in livelihood losses • Reduction in the cost of rehabilitation/reconstruction • Improvement of water quality and sediment management • Improvement of recreational value and tourism • Improvement of cultural and social interaction	X	X	

Table 17. Result C1, List of additional adaptation measures included in the T2.1 catalogue – KTM D.

4.2.1.1 KTM C: PHYSICAL AND TECHNOLOGICAL

KTM C1: Grey options

C1 GREY OPTIONS

C1.1 Increase the drainage capacity – hard engineering solutions | **Climate-proofed design of infrastructures and outdoor spaces**

Source: https://volteco.com/

Increasing drainage capacity helps manage rainfall and reduce flood risks. Hard engineering drainage solutions include the upgrading of sewer networks and collectors, detention and retention basins, drainage channels and bypass canals, deep underground tunnels, pumping stations and barriers, as well as reinforced or lined channels. These measures increase the hydraulic capacity of urban systems, allow temporary storage and controlled release of excess water, enable rapid conveyance of stormwater away from critical areas, and ensure drainage even in flat or low-lying zones. Their main benefit is providing reliable protection against extreme rainfall and flooding, safeguarding infrastructure and urban areas, although they often require significant investment and maintenance.

Scale of intervention

- Territorial
- Urban

Climate-related hazards

- Flood (pluvial, riverine, coastal)
- Heavy precipitation
- Storms

Functions

- Flood regulation (pluvial, riverine, coastal)
- Storm protection
- Stormwater management

Benefits

- Flood risk reduction (pluvial, riverine, coastal)
- Extreme events risk reduction
- Disaster risk reduction
- Storm risk reduction

Co-benefits

- Improvement of quality of life
- Improvement of human health and wellbeing
- Reduction in livelihoods losses
- Reduction in the cost of rehabilitation/reconstruction
- Deaths and injuries reduction
- Stimulation of local economies and job creation

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: Very effective in reducing flood risks, managing high stormwater volumes, and protecting critical assets such as transport and utilities. Effectiveness strongly depends on design thresholds; when exceeded, systems may fail abruptly and without backup. **Robustness:** Built with durable materials, long service life, resistant to erosion and wear, ensuring reliable performance over decades. Failures can be catastrophic (e.g., pipe collapse, pump breakdown) due to limited redundancy; costly to reinforce.

Human health, well-being, and quality of life

Social outcomes: Protects communities from property damage, health hazards, and disruptions to essential services; improves perceived safety. Construction can cause temporary noise, dust, and traffic disruption; visual intrusion in urban areas. **Equity**: Strong protection for dense urban cores, safeguarding high population concentrations and economic activities. Benefits often uneven, with peripheral or vulnerable groups less protected; may reinforce existing inequalities if siting is not inclusive.

Technical resilience

Flexibility: Delivers reliable performance under predicted conditions with clear standards and tested designs. Very rigid; difficult to adapt to climate variations or urban expansion without major retrofitting; limited capacity to integrate with innovative or green solutions.

Economic resilience

Economic efficiency: Prevents large-scale flood damages, reduces insurance losses, and protects long-term investments in infrastructure and property. Requires very high capital investment and continuous maintenance; potential risk of stranded assets if climate patterns exceed projections.

Environmental resilience

Environmental outcomes: Can reduce combined sewer overflows and pollution discharge during storms; protects built environments from flood-related contamination. Often resource- and energy-intensive; accelerates runoff, reducing natural infiltration; little or no ecosystem services provided. **Mitigative capacity:** No direct mitigation benefits; does not reduce GHG emissions or enhance carbon sequestration; limited contribution to environmental sustainability.

Organizational resilience

Timescale: Implementation can vary from months to several years, according to the size and the level of complexity of the construction works. Once implemented, ensures long-term protection (decades) with relatively stable performance. **Feasibility:** Technically feasible with well-established engineering practices; solutions are replicable and standardized globally. Requires strong institutional capacity, skilled workforce, and significant funding; feasibility limited in resource-constrained contexts. **Synergies**: Strong alignment with flood protection and infrastructure safety goals; can be integrated with urban planning. Limited co-benefits with other urban agendas (biodiversity, recreation, climate adaptation); may compete with land uses.

References

https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/climate-proofed-standards-for-road-design-construction-and-maintenance

C1 GREY OPTIONS

C1.2 Shading systems | Climate-proofed design of infrastructures and outdoor spaces

Source: https://www.dezeen.com/2007/01/24/dezeen-loves-public-space-shading-canopy/

Shading systems are passive cooling technologies designed to reduce solar heat gain within buildings by blocking or deflecting direct sunlight. These systems can be fixed or dynamic, external or internal, and can also include natural solutions such as green shading. The main benefit is the reduction in outdoor and indoor temperatures, which helps avoid overheating, reduces the reliance on mechanical cooling (e.g. air conditioning), and contributes to energy savings. Beyond energy efficiency, shading systems offer substantial benefits for health and well-being by reducing the risk of heat-related illnesses, improving thermal comfort, and enhancing the overall liveability of indoor and outdoor spaces.

Scale of intervention

- Urban
- Building

Climate-related hazards

- Extreme temperature events
- Heat stress
- Temperature variability

Functions

- Heat regulation
- Surface temperature regulation

Benefits

- Heat stress risk reduction
- Extreme events risk reduction

Co-benefits

- Improvement of quality of life
- Improvement of human health and wellbeing
- Improvement of outdoor and/or indoor microclimate conditions, increase in indoor thermal comfort
- Reduction in energy consumption
- Stimulation of local economies and job creation

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: High; reduces heat stress, lowers indoor/outdoor temperatures, supports passive cooling strategies. Performance may vary with extreme conditions or improper installation. **Robustness**: Effective across various climate conditions and building types; durable materials. Requires maintenance to preserve shading performance; extreme weather can damage structures.

Human health, well-being, and quality of life

Social outcomes: Improves thermal comfort and usability of public and private spaces; promotes public comfort. May not provide equal coverage in all areas; requires planning to reach vulnerable populations. **Equity**: Offers relief in heat-prone areas; increases adaptive capacity of underserved communities. Especially beneficial for vulnerable groups (e.g., elderly, children, low-income communities). Distribution must be carefully planned to avoid uneven benefits.

Technical resilience

Flexibility: High; systems are scalable and adaptable to different building designs and urban contexts. Limited effectiveness if integrated with poorly designed building layouts.

Economic resilience

Economic efficiency: Low to moderate cost; long-term savings on energy bills and potential healthcare cost reductions. Initial investment may be a barrier for large-scale deployment; financial benefits realized over time.

Environmental resilience

Environmental outcomes: Contributes to urban heat reduction. Minimal direct water or biodiversity benefits unless integrated with green infrastructure. **Mitigative capacity:** Reduces GHG emissions by lowering cooling demand. Supports passive cooling strategies and contributes to climate mitigation objectives. Cannot replace systemic mitigation measures; effectiveness limited to building-scale.

Organizational resilience

Timescale: Quick implementation (1–5 years), depending on scale and integration in urban planning. Deployment may be constrained by urban regulations or building codes. **Feasibility:** High; relies on existing technologies and standard design practices. Requires planning for long-term maintenance and integration. **Synergies**: Integrates well with nature-based solutions, energy efficiency measures, and urban greening strategies. Limited standalone environmental co-benefits without complementary measures.

References

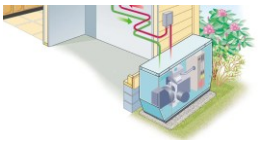
https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/climate-proofing-of-buildings-against-excessive-heat

KTM C2: Technological options

C2 TECHNOLOGICAL OPTIONS

C2.1 Backup power systems

Climate-proofed design of buildings



Source: www.thisoldhouse.com

Backup power systems offer a reliable and cost-effective solution to reduce the risk of economic losses and societal disruption caused by power outages. As climate change increases the frequency and intensity of extreme events - such as coastal and inland flooding, storms, wildfires, and heatwaves - energy infrastructure becomes more vulnerable, making resilient backup solutions increasingly essential. Backup power systems also support renewable energy sources integration by addressing variability and ensuring continuity of essential services.

Scale of intervention

- Building

Climate-related hazards

- Extreme temperature events
- Heat stress
- Temperature variability
- Heavy precipitation
- Storms
- Cyclones, hurricanes, typhoons, tornados
- Flood (pluvial, riverine, coastal)
- Storm surge
- Wildfires

Functions

- Energy production
- Heat regulation

Benefits

- Heat stress risk reduction
- Extreme events risk reduction
- Disaster risk reduction

Co-benefits

- Increase in self-sufficiency
- Improvement of quality of life (through maintained essential services)
- Improvement of human health and wellbeing
- Reduction in deaths and injuries

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: High effectiveness in reducing energy shortages in case of extreme events. Reduces the heat stress risks caused by power outages during heatwaves. Performance depends on system capacity, fuel or storage; limited during prolonged outages or multi-site failures. **Robustness**: High utility under unforeseeable conditions; reliable operation in diverse climate and urban contexts. Vulnerable if maintenance is insufficient or if damaged by extreme events (flooding, storms, wildfires).

Human health, well-being, and quality of life

Social outcomes: Reduces dependence on central supply networks; maintains operation of hospitals, emergency services, and essential services; protects population safety. Benefits concentrated in areas served; communities without access remain vulnerable. **Equity**: High potential but may not be financially feasible for all vulnerable communities.

Technical resilience

Flexibility: The level of technical resilience varies significantly depending on the type of system: simple portable systems can be easily adjusted and removed while complex battery systems require careful planning and integration.

Economic resilience

Economic efficiency: Reduces economic loss due to power shortages. protects businesses and critical services; ensures continuity of operation. Can have high costs of installation and management.

Environmental resilience

Environmental outcomes: Depending on the type of systems, the environmental impacts of manufacturing the batteries can be high. **Mitigative capacity:** Battery systems paired with renewable energy sources have the most potential in mitigative capacity while diesel or gasoline generators are sources of GHG emissions.

Organizational resilience

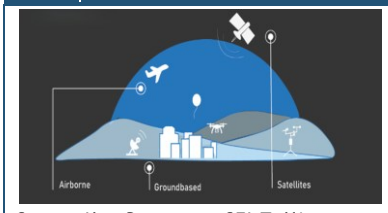
Timescale: Mostly easy and quick to install; fast benefits for critical services. Planning, permitting, and large-scale deployment may still require months. **Feasibility:** Feasible for most buildings; well-understood technologies. Space requirements or urban constraints may limit deployment in certain cases. **Synergies**: Works well if combined with renewable sources; can support other adaptation options during outages. Limited synergies with non-energy urban co-benefits (e.g., biodiversity, recreation).

References

https://climate-adapt.eea.europa.eu/en/eu-adaptation-policy/sector-policies/energy
https://www.nema.org/storm-disaster-recovery/backup-generation/backup-power-systems
https://securepower.com/blog/post/why-sustainable-backup-power-systems-are-the-future/

C2 TECHNOLOGICAL OPTIONS

C2.2 Monitoring systems | **Climate-informed decision making**



Source: Ilse Boonstra, SEI Tallinn

Weather and climate monitoring systems are fundamental for tracking weather variables and key climate indicators associated with climate-related hazards. These systems operate at various spatial and temporal scales, using a wide range of instruments and technologies depending on the specific hazard, resolution and scale. Monitoring tools can generally be categorized into two main types: Ground-based services – such as meteorological stations or IoT sensor - and Satellite-based services - such as Satellite remote sensing. By providing reliable data, these systems inform the public and the decision-makers about both weather forecast and climate trends. These systems also support the effectiveness of other adaptation options such as early warning systems or decision support systems.

Scale of intervention

- Territorial
- Urban
- Building

Climate-related hazards

All hazards (depending on the type and scope of option)

Functions

- Monitoring and prediction of weather and climate conditions
- Delivering data and information

Benefits

- Extreme events risk reduction
- Disaster risk reduction

Co-benefits

Able to contribute to delivering multiple co-benefits

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: Provides accurate, timely, and relevant weather and climate information; enables early detection of hazards and informed decision-making. Dependent on sensor reliability, data quality, and network coverage; effectiveness may be limited during extreme or unforeseen events if instruments fail. **Robustness:** Moderate to high; systems can operate under diverse environmental conditions and support multiple applications. Vulnerable to physical damage from extreme events (storms, floods, heatwaves) or cyber threats for digital monitoring networks.

Human health, well-being, and quality of life

Social outcomes: Increases public knowledge, awareness, and preparedness; supports timely protective actions. Benefits require dissemination and education; communities without access to data may remain vulnerable. **Equity:** Can target vulnerable populations by prioritizing deployment in high-risk areas; promotes inclusive risk reduction. Implementation may be uneven if resources or technical capacity are limited; marginalized communities may still lack access.

Technical resilience

Flexibility: Can be adapted to local hazards, urban or rural contexts, and specific monitoring needs; scalable from small-scale installations to regional networks. May require specialized technical expertise for installation, calibration, and maintenance; integration with other systems may be complex.

Economic resilience

Economic efficiency: Helps reduce long-term economic losses by supporting proactive responses to hazards; cost-effective when integrated into decision-making frameworks. Variable initial and maintenance costs depending on system complexity and coverage; benefits are indirect and may take time to materialize.

Environmental resilience

Environmental outcomes: Supports sustainable environmental management by providing accurate data on weather, climate trends, and environmental parameters. Does not directly reduce hazards; requires energy and resources for operation, potentially contributing to environmental footprint. **Mitigative capacity:** Does not directly reduce GHG emissions.

Organizational resilience

Timescale: Can be implemented relatively quickly depending on the scale and instrumentation type. Large-scale networks may require extensive planning, coordination, and regulatory approval. **Feasibility:** Relatively easy to implement with existing technologies; systems can be integrated with early warning systems, climate services, and decision support platforms. Feasibility may be constrained by technical expertise, funding, or infrastructure limitations. **Synergies:** Enhances the effectiveness of other measures (Climate Services, Early Warning Systems, Decision Support Systems); provides critical data for emergency planning and urban resilience strategies. Benefits depend on integration and data accessibility; isolated monitoring without downstream applications has limited impact.

References

https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/monitoring-modelling-and-forecasting-systems

4.2.1.2 KTM D: NATURE-BASED SOLUTIONS AND ECOSYSTEM-BASED APPROACHES

KTM D1: Green options

D1 GREEN OPTIONS

D1.1 Urban tree planting systems

Climate-proofed design of outdoor spaces

Source: https://treebuilders.eu/

Urban tree planting enriches cityscapes with shaded corridors, enhances stormwater management, and improves air quality. Structural soil systems beneath pavements maintain load-bearing capacity while allowing root growth and infiltration, leading to healthier trees and reduced runoff. Structural-soil tree pits, bioswale-integrated tree trenches and tree-infiltration planters are examples of urban tree planting systems.

Scale of intervention

- Territorial
- Urban

Climate-related hazards

- Extreme temperature events
- Temperature variability
- Heat stress
- Flood (pluvial)

Processes	Functions	Benefits	Co-benefits
• Evapotranspiration cooling • Air cleaning • Shade • Carbon sequestration	• Pluvial flood regulation • Heat regulation • Storm protection	• Pluvial flood risk reduction • Heat stress risk reduction • Storm risk reduction	• Stimulation of local economies and job creation • Improvement of human health and wellbeing • Increase in biodiversity • Contribution to education • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Improvement of air quality • Contribution to GHG emission reduction

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: Trees buffer buildings and pedestrians against heat and moderate stormwater impacts. Mature street canopies can lower surface temperatures by 5–12 °C, reducing pedestrian heat exposure. Poor placement may block wind or street lighting, creating safety issues. **Robustness**: Tree survival depends on species, soil volume, and post-planting care. Mortality can reach 30–50% if species are mismatched. Drought, pests, and invasive species threaten long-term resilience.

Human health, well-being, and quality of life

Social outcomes: Shade reduces heat-related illnesses and supports mental health and social cohesion. Well-maintained trees can lower local crime. Neglected trees may raise safety concerns or perceptions of disorder. New plantings can contribute to green gentrification, displacing vulnerable residents. **Equity**: Community-focused planting improves access for underserved areas. Canopy distribution must be managed; without governance, affluent neighbourhoods may receive more coverage, widening environmental justice gaps.

Technical resilience

Flexibility: Multiple pit designs fit different street types; above- and below-ground integration possible. Pop-up planters allow rapid greening for events or pilots, later replaced by permanent systems. Utility conflicts and root growth may limit placement and damage pavements or underground infrastructure if not engineered properly.

Economic resilience

Economic efficiency: Average cost per tree (including soil system) €2000–4000; stormwater credits may apply. Maintenance (watering, pruning, pest control) can exceed planting costs, especially during establishment or climate stress. Limited budgets may cause neglect.

Environmental resilience

Environmental outcomes: Enhances urban biodiversity and air purification. Effectiveness depends on species; some emit BVOCs or allergenic pollen, and leaf litter may clog drains. Cumulative canopy sequesters carbon and reduces HVAC energy demand. **Mitigative capacity:** Cumulative urban canopy can sequester carbon and reduce HVAC energy demand.

Organizational resilience

Timescale: Canopy establishment 2–5 years; infiltration benefits immediate. Long-term benefits (cooling, biodiversity, carbon sequestration) take decades, less aligned with urgent adaptation needs. **Feasibility:** Requires coordination among foresters, engineers, and utilities; fragmented governance can complicate responsibilities for planting and maintenance. **Synergies**: Works with bioswales, permeable pavements, and green roofs. Without integrated planning, tree planting may compete with other urban uses and be deprioritized in budgets.

References

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https://treebuilders.eu/solutions/urban-tree-planting-solutions/; https://time.com/6996432/trees-heat-waves-essay/?utm_source=chatgpt.com

D1 GREEN OPTIONS

D1.2 Shading systems with green elements

Climate-proofed design of outdoor spaces

Source: https://commons.wikimedia.org/

Green shading systems integrate living vegetation into architectural and streetscape elements to provide passive solar control, evaporative cooling, and microclimate regulation. Vegetated pergolas and trellises, green façades, dynamic vertical green screens and green canopies are examples of green shading systems. By combining structural shading with evapotranspiration, they lower surface and ambient temperatures more effectively than inert screens alone.

Scale of intervention

- Urban
- Building

Climate-related hazards

- Extreme temperature events
- Temperature variability
- Heat stress

Processes	Functions	Benefits	Co-benefits
• Evapotranspiration cooling • Shade • Carbon sequestration	• Heat regulation	• Heat stress risk reduction	• Increase in biodiversity • Improvement of air quality • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Contribution to GHG emission reduction

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: Can lower air temperatures by 1–4 °C in shaded areas. Case studies show annual HVAC demand reductions of 10–25 % in buildings equipped with optimized vertical greenery, depending on orientation and plant density. Improves thermal comfort in open spaces and adjacent interiors, preventing heat-related damage. Cooling is very localized; performance strongly depends on façade orientation, irrigation, and maintenance. Leaf loss or drought can reduce benefits when most needed. **Robustness**: Performance varies with species adaptation, maintenance level, and seasonal leaf cover. Vulnerable to drought, pests, wind exposure, and system failure (e.g., irrigation breakdown). Some species lose leaves seasonally, reducing performance when most needed.

Human health, well-being, and quality of life

Social outcomes: Reduces heat stress and associated morbidity; fosters outdoor recreation and social interaction. Visual and sensory connection to vegetation fosters psychological restoration, with measured reductions in self-reported stress by up to 15 % in adjacent offices and public spaces. Poorly maintained systems can appear degraded, reducing perceived safety and aesthetic value; access to benefits limited to adjacent users. **Equity**: Increases pedestrian comfort, promotes equity in access to shaded public spaces. Benefits accrue to all users; equity depends on distribution of installations across neighbourhoods. Often installed preferentially in high-income districts; without deliberate planning, distribution can remain uneven.

Technical resilience

Flexibility: Modular systems allow relocation or retrofitting; plant selection targets site conditions. Pre-vegetated panels fit most vertical/overhead structures. Structural limits, irrigation needs, and urban constraints may restrict installation.

Economic resilience

Economic efficiency: High upfront investment; ongoing irrigation, pruning, and replacement costs are significant. Long-term viability depends on dedicated maintenance budgets.

Environmental resilience

Environmental outcomes: Supports biodiversity, urban greening, and carbon sequestration. Irrigation and maintenance may reduce net gains. **Mitigative capacity:** Marginal carbon uptake; main mitigation via lower HVAC energy. Benefits vary seasonally and require proper maintenance.

Organizational resilience

Timescale: Plant establishment and cooling performance typically manifest within 1–3 years. System performance declines rapidly without continuous irrigation and care, making benefits fragile over time. **Feasibility:** Requires coordination between landscape architects, engineers, and maintenance teams. Requires specialized knowledge and contracts for installation/maintenance; lack of coordination leads to system failures. **Synergies**: Combines effectively with green roofs, rainwater harvesting, and passive cooling strategies. Without integrated planning, shading systems risk being ornamental rather than scalable and functional climate adaptation measures.

References

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KTM D2: Blue options

D2 BLUE OPTIONS

D2.1 Water recycling and reuse systems | Climate-proofed design of buildings and outdoor spaces

Source: www.ide-tech.com

Water recycling and reuse systems help secure a sustainable water supply by reclaiming and treating wastewater for secondary use. This reduces pressure on freshwater resources while maintaining water security for human activities and ecosystems. Treated wastewater can be used in agriculture (irrigation, groundwater recharge), industry (cooling processes), urban areas (parks, toilet flushing), and even drinking water supply when appropriately treated. This measure is particularly valuable in regions facing water scarcity and drought risk, contributing to climate adaptation and sustainable resource management.

Scale of intervention

- Territorial
- Urban
- Building

Climate-related hazards

- Heavy precipitation
- Flood
- Storms
- Drought

Processes	Functions	Benefits	Co-benefits
• Water collection • Water storage and reuse • Water cleaning	• Stormwater management • Water purification	• Flood risk reduction	• Improvement of quality of life • Stimulation of local economies and job creation • Improvement of human health and wellbeing • Reduction in livelihoods losses • Water supply • Increase in self-sufficiency • Improvement of water quality and sediment management • Cost savings

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: High; ensures water availability during dry periods and mitigates drought impacts. Efficiency depends on infrastructure reliability and water quality standards; interruptions or contamination events can reduce benefits. **Robustness**: Moderate to high; depends on regulatory standards and public acceptance. Vulnerable to regulatory changes, public acceptance issues, and maintenance lapses.

Human health, well-being, and quality of life

Social outcomes: Provides water security, reducing stress on communities during drought, and improves public health outcomes. Public perception and trust issues with recycled water, unequal access may leave vulnerable communities underserved, and benefits depend on proper maintenance. **Equity**: Benefits vulnerable areas most affected by water shortages. Uneven deployment or high costs may limit access in low-income communities if not carefully planned.

Technical resilience

Flexibility: Moderate — systems can be adapted to different water sources and treatment levels. Requires appropriate infrastructure, space, and integration with existing urban water networks. Technical complexity can limit scalability.

Economic resilience

Economic efficiency: Cost varies —higher than direct freshwater use but offset by long-term savings and environmental benefits. High upfront investment; cost-effectiveness depends on local water prices, subsidies, and operational management.

Environmental resilience

Environmental outcomes: Reduces freshwater extraction, helping conserve rivers, lakes, and groundwater. Treatment and pumping require energy; improper management can lead to pollution or inefficient water use. **Mitigative capacity**: Indirectly supports carbon reduction by lowering energy use in water treatment and transport. Benefits are moderate; energy and chemical inputs for treatment partially offset gains.

Organizational resilience

Timescale: Implementation can take 5–15 years, depending on scale and social acceptance. **Feasibility**: Requires regulatory frameworks, public awareness, and investment in treatment infrastructure. **Synergies**: Integrates well with water conservation strategies, green infrastructure, and climate adaptation plans. Poor integration with urban planning or lack of stakeholder coordination can limit impact.

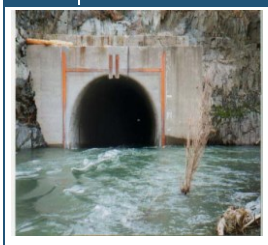
References

https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/water-recycling

D2 BLUE OPTIONS

D2.2 Diversion tunnels

Climate-proofed design of outdoor spaces



Source: www.engr.psu.edu

Diversion tunnels are large underground conduits designed to temporarily store and redirect excess stormwater or wastewater, particularly during extreme rainfall events. These systems alleviate pressure on conventional urban drainage networks and help prevent flooding and combined sewer overflows (CSOs). Methods can vary, including gravity-fed tunnels, pump-assisted systems, or integrated multi-purpose tunnels. Primary benefits include flood risk reduction, improvement of urban water management, and mitigation of wastewater system overloads.

Scale of intervention

- Territorial
- Urban

Climate-related hazards

- Flood (pluvial)
- Heavy precipitation
- Storms

Processes

- Water delay
- Stormwater and wastewater redirection
- Floodwater conveyance

Functions

- Pluvial flood regulation
- Stormwater attenuation

Benefits

- Pluvial flood risk reduction

Co-benefits

- Improvement of quality of life
- Reduction in livelihood losses
- Reduction in the cost of rehabilitation/reconstruction
- Improvement of water quality and sediment management
- Improvement of recreational value and tourism
- Improvement of cultural and social interaction

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: High; significantly reduces urban flood impacts and CSOs. Sensitive to maintenance and inlet/outlet capacity; tunnel failure can compromise effectiveness. **Robustness**: Moderate to high; can perform under varying conditions; tunnel design can be scaled for future extremes, though sensitive to maintenance and inlet/outlet capacity. Performance dependent on maintenance and hydraulic capacity.

Human health, well-being, and quality of life

Social outcomes: Reduces flood-related disruptions, enhances hygiene through better wastewater management, and protects public infrastructure. Construction may cause temporary disruption. **Equity**: Especially beneficial for flood-prone or low-income communities living in vulnerable zones with outdated infrastructure. Access to benefits depends on location; limited direct community engagement.

Technical resilience

Flexibility: Medium; tunnels are not easily modified post-construction but can be designed with modular capacity or integration with smart controls. Not removable but scalable with parallel systems.

Economic resilience

Economic efficiency: Moderate; high initial investment, but long-term savings through avoided damages and fines related to CSO regulations. Cost-competitive when compared with repeated flood damage and retrofits.

Environmental resilience

Environmental outcomes: Supports healthier urban water bodies by reducing pollution loads. **Mitigative capacity**: Indirect—less treatment burden on wastewater treatment plants can reduce energy demand; protects ecosystems from overflow contamination.

Organizational resilience

Timescale: Medium to long—design and construction may span several years; impact is long-lasting and increasingly valuable with intensifying climate events. **Feasibility**: Technically demanding; socially and institutionally feasible with strong planning and funding frameworks. **Synergies**: Integrates well with green-blue infrastructure (e.g., urban wetlands, retention basins), urban master planning, and climate adaptation strategies. Potential for integrating energy generation (e.g., hydropower in tunnels).

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https://planodrenagem.lisboa.pt/fileadmin/pgdl/_ficheiros/Brochura_PGDL_eng.pdf
https://www.researchgate.net/publication/378375839_Lisbon_Master_Plans_and_Nature-Based_Solutions#fullTextFileContent

4.2.2 FACTSHEETS WITH KPIS FOR RESILIENCE ASSESSMENT (RESULT C2)

The section includes the factsheets of local adaptation measures implemented in the Barcelona case study updated with KPIs for resilience assessment derived from T1.2. Below is the list of KPIs validated by the partners for each local adaptation measure for outdoor spaces: cool pavement, porous pavement, and bioswale. Tables 18-20 show the results of KPIs validation: a coloured cell under the partner's name indicates that the indicator has been considered compliant with the respective criterion.

KEY PERFORMANCE INDICATORS TO ASSESS COOL PAVEMENT RESILIENCE					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Cool surfaces in proportion to the number of dwellings	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Recovery Time Indicator (RTI) for Extreme Heat	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Time to recovery adequate level of Land Surface Temperature	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean time to repair	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation protection cost index (APCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Damages for Highways and Railroads due to natural hazards	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation benefits	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
General construction cost index (GCCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Maintenance cost efficiency index (MCEI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Occurrence probability of a certain consequence	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Ambient temperature	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Surface temperature of pavement	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Global solar radiation	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Hours outside comfort temperature	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD

	BCN	BCN	BCN	BCN	BCN
Operational continuity	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time of Recovery	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time for Mitigation	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN

Table 18. Results of KPIs validation by partners - Cool pavement.

KEY PERFORMANCE INDICATORS TO ASSESS POROUS PAVEMENT RESILIENCE					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Drainage system capacity	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Urban drainage stormwater robustness	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean time to repair	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation protection cost index (APCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Damages for Highways and Railroads due to natural hazards	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation benefits	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
General construction cost index (GCCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Maintenance cost efficiency index (MCEI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Occurrence probability of a certain consequence	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Floodwater depth	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Permeability and infiltration rate	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Operational continuity	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time of Recovery	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD

	BCN	BCN	BCN	BCN	BCN
Mean Time for Mitigation	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN

Table 19. Results of KPIs validation by partners – Porous pavement.

KEY PERFORMANCE INDICATORS TO ASSESS BIOSWALE RESILIENCE					
KPIs	**Specific**	**Measurable**	**Achievable**	**Relevant**	**Time-Bound**
Drainage system capacity	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Urban drainage stormwater robustness	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time to Repair	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation Protection Cost Index (APCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Damages for Highways and Railroads due to natural hazards	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Adaptation benefits	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
General Construction Cost Index (GCCI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Maintenance cost efficiency index (MCEI)	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Occurrence probability of a certain consequence	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Floodwater depth	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Permeability and Infiltration Rate	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Operational Continuity	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time of Recovery	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN
Mean Time for Mitigation	ICLEI	ICLEI	ICLEI	ICLEI	ICLEI
	UKA	UKA	UKA	UKA	UKA
	NCSRD	NCSRD	NCSRD	NCSRD	NCSRD
	BCN	BCN	BCN	BCN	BCN

Table 20. Results of KPIs validation by partners – Bioswale.

Based on the validation process, the selected KPIs are those that meet all five criteria for at least one partner (Table 21). The KPIs identified are intended to support the resilience assessment of local adaptation measures within Task 11.2. The following sub-sections present the factsheets developed under Task 2.1, updated to include the validated KPIs. The catalogue does not include dedicated factsheets for each of the three local measures – cool pavement, porous pavement and bioswale. Instead, they are grouped within broader categories of solutions, based on their primary function. Therefore, the KPIs associated with them can also be applied to assess the resilience of other measures included in the same category. The local measures are included within the categories (and the corresponding factsheets of the T2.1 catalogue) illustrated in Table 22.

COOL PAVEMENT	POROUS PAVEMENT	BIOSWALE
Cool surfaces in proportion to the number of dwellings	Drainage system capacity	Drainage system capacity
Time to recovery adequate level of Land Surface Temperature	Mean time to repair	Mean time to repair
Mean time to repair	Adaptation Protection Cost Index (APCI)	Adaptation Protection Cost Index (APCI)
Maintenance cost efficiency index (MCEI)	Permeability and infiltration rate	Permeability and infiltration rate
Ambient temperature	Mean Time of Recovery	Mean Time of Recovery
Surface temperature of pavement	Damages for highways and railroads due to natural hazards	Damages for highways and railroads due to natural hazards
Global solar radiation	Floodwater depth	Floodwater depth
Mean Time of Recovery		
Damages for Highways and Railroads due to natural hazards		

Table 21. Result C2, Final list of KPIs to be associated with local adaptation measures.

LOCAL ADAPTATION MEASURES	KTMs	T2.1 FACTSHEETS
Cool Pavement	KTM C – Physical and Technological (C1: Grey options)	KTM C1.9 – Light-coloured and reflective materials for paving surfaces
Porous Pavement	KTM D - Nature-Based Solutions and Ecosystem-Based Approaches (D2: Blue options)	KTM D2.3 – Infiltration elements
Bioswale	KTM D - Nature-Based Solutions and Ecosystem-Based Approaches (D2: Blue options)	KTM D2.5 – Water channels

Table 22. Correspondence between local adaptation measures and T2.1 factsheets.

4.2.2.1 Cool pavement

C1 GREY OPTIONS

C1.9 LIGHT-COLOURED AND REFLECTIVE MATERIALS FOR PAVING SURFACES | Climate-proofed design of infrastructures and outdoor spaces

Source: urbangreenup.eu

Light-coloured and reflective materials for paving surfaces are designed to reflect more sunlight and absorb less heat compared to traditional dark paving materials. This approach helps to reduce the urban heat island effect, where urban areas become significantly warmer than their rural surroundings due to human activities, minimizing the overheating of urban areas during extreme temperature events such as heatwaves.

Scale of intervention

- Urban

Climate-related hazards

- Extreme temperature events

Functions	Benefits	Co-benefits
• Heat regulation	• Heat stress risk reduction	• Improvement of outdoor and indoor microclimate conditions • Improvement of human health and wellbeing

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: highly effective in reducing surface temperatures, mitigating the urban heat island effect. Effectiveness may diminish over time due to wear and dirt accumulation, reducing reflectivity. Effectiveness depends on widespread adoption and proper maintenance to ensure long-term benefits. **Robustness**: generally durable and can be designed to withstand typical urban traffic and environmental conditions. Susceptible to staining and wear, which can reduce reflectivity and effectiveness.

Human health, well-being, and quality of life

Social outcomes: Improves thermal comfort in urban areas, enhancing the quality of life and reducing heat-related health issues. Initial glare from reflective surfaces can be a concern, potentially affecting drivers and pedestrians until acclimation occurs. **Equity**: Benefits all urban residents by reducing local temperatures and improving air quality. Higher costs may limit implementation in lower-income areas, leading to unequal distribution of benefits.

Technical resilience

Flexibility: Can be applied to various surfaces and integrated into new and existing infrastructure projects. Limited flexibility in regions with frequent snow and ice, where dark surfaces might be preferable for faster melting.

Economic resilience

Economic efficiency: Potential to reduce energy costs related to cooling in nearby buildings; lower maintenance costs due to reduced thermal expansion and contraction. Higher initial costs for materials and installation; effectiveness depends on regular cleaning and maintenance to retain reflectivity.

Environmental resilience

Environmental outcomes: Reduces energy consumption and greenhouse gas emissions associated with air conditioning; can improve local air quality by lowering temperatures. Manufacturing of reflective materials may have environmental impacts; disposal and recycling processes need consideration. **Mitigative capacity:** contributes to the reduction of overheating of the building interior during summer months, energy consumption for cooling and consequent GHG emissions.

Organizational resilience

Timescale: can be quickly applied to new and existing surfaces, allowing for relatively rapid deployment. Time-consuming to apply on a large scale in urban areas; potential delays due to weather and logistical challenges. **Feasibility**: technically feasible with existing materials and construction techniques; adaptable to various urban settings. Feasibility may be constrained by budget limitations and the need for specialized materials. **Synergies**: Complements other urban cooling strategies, such as green roofs and increased vegetation; enhances overall urban resilience. Requires coordination with other urban planning and infrastructure projects to maximize benefits.

RESILIENCE ASSESSMENT

Cool surfaces in proportion to the number of dwellings	*value*	**Time to recovery adequate level of Land Surface Temperature**	*value*			**Mean time to repair**	*value*	**Maintenance Cost Efficiency Index (MCEI)**	*value*
Ambient temperature	*value*	**Surface temperature of pavement**	*value*	**Global Solar Radiation**	*value*	**Mean Time of Recovery**	*value*	**Damages for Highways and Railroads due to natural hazards**	*value*

References

Stano, P., Šteiner, A., Hudeková, Z., Lupač, M., Třebický, V., Novák, J., Šimkovicová, Ľ., Šimkovic, V., Halková, S. (2020). *Catalogue of Selected Adaptation and Mitigation Measures*. Bratislava: Carpathian Development Institute.

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https://urbangreenbluegrids.com/measures/cool-paving-materials/; https://www.urbangreenup.eu/solutions/cool-pavement.kl

4.2.2.2 Porous pavement

D2 BLUE OPTIONS

D2.3	INFILTRATION ELEMENTS	Climate-proofed design of outdoor spaces

Source: urbangreenbluegrids.com

Infiltration components are used to capture surface water runoff and allow it to infiltrate (soak) and filter through to the subsoil layer, before returning it to the water table below. The main types of infiltration components are soakaways, infiltration trenches, infiltration basins, and pervious surfaces. **Soakaways** are square or circular excavations either filled with rubble or lined with brickwork, pre-cast concrete or polyethylene rings/perforated storage structures surrounded by granular backfill. They can be grouped and linked together to drain large areas including highways. **Infiltration trenches** are shallow excavations with rubble or stone that create temporary subsurface storage of stormwater runoff. Ideally, they should receive lateral inflow from an adjacent impermeable surface. **Infiltration basins** are vegetated depressions designed to store runoff on the surface and infiltrate it gradually into the ground. They are dry except in periods of heavy rainfall. **Pervious surfaces** can be either porous or permeable. Porous surfacing is a surface that infiltrates water across the entire surface. Permeable surfacing is formed of material that is itself impervious to water but allows infiltration through the pattern of voids through the surface.

Scale of intervention

- Urban
- Building (surrounding outdoor spaces)

Climate-related hazards

- Flood (pluvial)
- Storms

Processes	Functions	Benefits	Co-benefits
• Evapotranspiration cooling • Water infiltration • Water collection • Water cleaning • Water delay • Water storage	• Pluvial flood regulation • Stormwater attenuation	• Pluvial flood risk reduction	• Increase in biodiversity • Improvement of water quality and sediment management • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Contribution to GHG emission reduction

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: reduce stormwater discharge volume by enhancing groundwater recharge and address problems of low groundwater tables, flood control, and channel erosion. **Robustness**: adequate maintenance is required to provide benefits under changing climate.

Human health, well-being, and quality of life

Social outcomes: reduction of the chances of cars hydroplaning, improvement of vehicle and pedestrian mobility. **Equity**: provide benefits for all residents and users, in particular for drivers and pedestrians.

Technical resilience

Flexibility: soakaways can be built in many shapes. As a sub-surface infiltration device, they require no net land take. Due to their narrow shape, infiltration trenches can be adapted to different sites, and are more flexible than basins. Pervious pavements are flexible as they have modular dimensions and freedom to lay patterns.

Economic resilience

Economic efficiency: cost-effectives options as they ensure savings in maintenance and stormwater management costs.

Environmental resilience

Environmental outcomes: reduce the amount of pollutants that discharge directly to surface waters and reduce pollutant concentrations through physical filtration and biological processes. **Mitigative capacity**: the mitigation benefit relates to the savings of energy and resources to treat, transport and clean rainwater. A significant aspect are the emissions associated with the production of materials (e.g. grass tiles). Materials with a lower carbon footprint during production are preferable.

Organizational resilience

Timescale: if properly installed and maintained, these options can function for decades. **Feasibility**: can be incorporated easily into site landscaping and fits well beside roads. Infiltration trenches and basins are appropriate for most regions, but site-specific conditions (e.g. soil type, water table, drainage area and slope) may restrict their use. They may be less feasible in tidal areas (due to high water tables) or in karst regions (due to concerns with sinkhole formation). Pervious pavements are suitable for light vehicular traffic (not appropriate for high-volume and high-speed roadways). **Synergies**: usually, they are part of a larger stormwater management system, and can be integrated with additional measures.

RESILIENCE ASSESSMENT

Drainage system capacity	*value*	**Mean time to repair**	*value*	**Adaptation Protection Cost Index (APCI)**	*value*	**Permeability and infiltration rate**	*value*
Mean Time of Recovery	*value*	**Damages for Highways and Railroads due to natural hazards**	*value*	**Floodwater Depth**	*value*		

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Additional sources

https://urbangreenbluegrids.com/measures/urban-infiltration-strips/
https://urbangreenbluegrids.com/measures/porous-paving-materials/
https://www.urbangreenup.eu/solutions/green-pavements--green-parking-pavements.kl

4.2.2.3 Bioswale

D2 BLUE OPTIONS

D2.5 WATER CHANNELS | Climate-proofed design of outdoor spaces

Source: susdrain.com

Water channels allow to transfer the surface water runoff (conveyance) across the site. There are a variety of approaches that can be used, such as underground pipes. The preference in terms of delivering sustainable drainage objectives is the conveyance of water through vegetated and open channels or swales. **Swales** are shallow, broad and vegetated channels designed to store and/or convey runoff and remove pollutants. They may be used as conveyance structures to pass the runoff to the next stage of the treatment train and can be designed to promote infiltration where soil and groundwater conditions allow. **Channels and rills** are open surface water channels with hard edges. They are simply channels that water flows along whereby they can have a variety of cross sections to suit the urban landscape, including the use of planting to provide both enhanced visual appeal and water treatment.

Scale of intervention

- Urban

Climate-related hazards

- Flood (pluvial)
- Storms

Processes	Functions	Benefits	Co-benefits
• Evapotranspiration cooling • Water infiltration • Water collection • Water cleaning • Water storage • Water delay • Acquifer recharge • Carbon sequestration	• Pluvial flood regulation • Stormwater attenuation	• Pluvial flood risk reduction	• Increase in biodiversity • Improvement of water quality and sediment management • Improvement of recreational value and tourism • Improvement of cultural and social interaction • Contribution to GHG emission reduction

CONTRIBUTION TO CLIMATE-PROOF BUILT ENVIRONMENT

Physical resilience

Effectiveness: strongly effective in store or convey surface water, reducing runoff rates and volumes and contributing to pluvial flood risk reduction. **Robustness**: adequate maintenance is required to provide benefits under changing climate.

Human health, well-being, and quality of life

Social outcomes: aesthetic value and enhancement of local character with attractive landscape features. Contribute to creating recreational opportunities. **Equity**: provide benefits for all residents and users, drivers and pedestrians.

Technical resilience

Flexibility: applicable to a wide range of situations (new and existing developments), they are typically located next to roads, where they replace conventional gullies and drainage pipe systems, but can also be located in landscaped areas, adjacent to car parks, alongside fields, and in other open spaces.

Economic resilience

Economic efficiency: cost savings vs. conventional practices. Costs can be variable depending on the design (type of vegetation, dimension, connections to upstream and downstream drainage).

Environmental resilience

Environmental outcomes: they offer biodiversity and amenity value and improve water quality of runoff, by removing sediment and particulate pollutants. **Mitigative capacity**: they may also contribute to increasing carbon sequestration and helping to regulate urban temperatures lowering energy demand.

Organizational resilience

Timescale: relative quick implementation with short amortisation time. **Feasibility**: swales often involve a significant increase in land uptake compared to conventional drainage. Channels and rills are relatively narrow features with minimal land-take. Regular inspection and maintenance is essential, for example channels and rills require intensive maintenance once every 5 years (i.e. to remove silt, litter and debris). **Synergies**: they can be incorporated within larger stormwater management systems and used as conveyance features to pass the runoff to the next stage of the treatment train (detention or retention basin).

RESILIENCE ASSESSMENT							
Drainage system capacity	*value*	**Mean time to repair**	*value*	**Adaptation Protection Cost Index (APCI)**	*value*	**Permeability and infiltration rate**	*value*
Mean Time of Recovery	*value*	**Damages for Highways and Railroads due to natural hazards**		*value*		**Floodwater Depth**	*value*

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Susdrain (n.a.). *Filtration overview*. Retrieved 15th July, 2024 from: https://www.susdrain.org/delivering-suds/using-suds/suds-components/filtration/filtration.html.

Additional sources

https://urbangreenbluegrids.com/measures/open-water-channels/
https://www.urbangreenup.eu/solutions/grassed-swales-and-water-retention-pounds.kl

4.3 OUTPUTS FOR TASK 11.2

Key results from T8.1.3 will serve as inputs for **Task 11.2, "Demonstration of the MULTICLIMACT framework at the urban scale"**. T11.2, which has already started and will conclude at M30, aims to test and demonstrate the MULTICLIMACT framework at the Spanish demo site, primarily focused on outdoor urban spaces. In addition to testing the CREMA tool, the task will also include the evaluation of toolkit solutions developed for the Spanish demo site within T8.1. Specifically, T8.1 will contribute to this activity by applying the KPIs identified in T8.1.3 to the adaptation measures currently implemented at the urban scale, in order to assess their contribution to enhancing the resilience of the built environment. In the coming months, the evaluation of the measures will be carried out with the support of the partners involved in their implementation. Depending on the requirements emerging within Task 11.2 and the availability of data, it may be decided to calculate only selected subsets of the proposed KPIs.

5. CONCLUSION AND WAY FORWARD

The report provides a comprehensive review of the existing adaptation policies and measures for enabling a climate-proof built environment at the local level in the context of the Spanish demo case. The review of policies takes into account the territorial (Catalonia Region) and urban (Municipality of Barcelona) levels, collecting and synthesizing relevant policies and measures into a single document for decision-makers. This helps them to develop planning processes and actions aligned with climate goals and oriented towards reducing the negative effects of climate change-related disruptive events, increasing the health and well-being of people, and promoting the quality of life.

The deliverable presents an extensive collection of adaptation policies and measures for the climate-proofing of the built environment organized into key sections covering a review of documents (T8.1.1), an analysis based on the methodology previously developed in T2.1 (T8.1.2), and an update of the T2.1 catalogue of adaptation measure based on review findings and results from T2.1 and T1.2 (T8.1.3). Results from previous tasks were essential for implementing T8.1 activities. From Task 2.1 "*Planning and designing adaptation policies and measures for enabling a climate-proof built environment at different scales*", both the methodology for the analysis of policies and measures, structured around key criteria, and the catalogue of measures were adopted, the latter being further enhanced through T8.1 activities. Furthermore, a selection of KPIs developed under Task 1.2 "*MULTICLIMACT toolkit assessment framework. Quantitative evaluation of resilience enabling DESIGN practices and methods*" was used to update the information included in the catalogue, enabling a quantitative assessment of the resilience of adaptation measures implemented in the demo in the Barcelona case study.

Six policy documents were included in the review and analysed to extract information on the climate-hazards addressed, the sectors covered, the methods adopted or suggested to assess vulnerabilities, risks and resilience features, and adaptation measures recommended or planned for local implementation. Specifically, the analysis of the Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC2030), the Barcelona Resilience Action Plan (RAP) and the Barcelona Climate Plan enable the identification of key measures directly applicable at the local scale. These measures were then compared with those included in the T2.1 catalogue in order to identify additional ones to incorporate. Eight new measures were added - four under "*KTM C: Physical and Technological*" and four under "*KTM D: Nature-Based Solutions and Ecosystem-Based Approaches*" – with two new measures for each sub-KTM, each accompanied by a detailed factsheet. The T2.1 catalogue was further enhanced by identifying quantitative KPIs to be associated with adaptation measures implemented in the Barcelona case study (cool pavements, porous pavements, and bioswale), enabling the resilience assessment within T11.2.

Analysing local policies and measures provides several key advantages, enabling the identification of adaptation measures directly applicable at the local scale and ensuring that the catalogue reflects context-specific needs and priorities. This process helps fill gaps in the existing T2.1 catalogue by highlighting additional measures and aligning interventions with local strategies and regulations. The updated catalogue offers a more comprehensive and locally relevant set of measures, with quantitative KPIs facilitating rigorous resilience assessments, evidence-based planning, and prioritization of interventions. Its structured format, with clearly defined categories and detailed factsheets, enhances replicability, scalability, and clear communication among stakeholders, supporting both strategic decision-making and practical implementation.

In the broader context of adaptation policies and measures evaluation, this study brings innovation as it goes beyond a mere review of existing policies, combining a detailed analysis of local adaptation policies with the identification of adaptation measures and quantitative KPIs, systematically integrated into a structured catalogue. Its key contributions are:

1) **Review and synthesis of existing adaptation policies at multiple levels**. The study provides a comprehensive and structured review of adaptation policies and measures for the built

environment at the territorial (Catalonia) and urban (Barcelona) levels, supporting decision-makers in understanding the scope and relevance of policies within the Spanish demo case.

2) **Identification and recommendation of adaptation measures at different spatial scales**. Key measures directly applicable at multiple spatial scales were identified from local policies. Eight new measures were integrated into the T2.1 catalogue, with detailed factsheets, providing guidance for territorial, urban, and building-level interventions.

3) **Enhancement of the T2.1 catalogue and practical applicability**. The catalogue was further enriched with quantitative KPIs derived from T1.2, enabling rigorous resilience assessments and evidence-based prioritization of local interventions. The resulting catalogue constitutes an evidence-based, practical tool for informed planning, decision-making, and implementation, replicable across contexts, linking strategic planning to measurable resilience outcomes and locally relevant interventions.

These key results ensure flexible usability, as they can be used both as standalone tools and as integrated components within the CREMA tool. The framework is adaptable and can be expanded with additional adaptation measures or quantitative KPIs, allowing for further refinement and integration in future resilience and adaptation assessments.

Looking ahead, the way forward involves the application of the methodologies and measures developed into the real context of the Spanish demo case and their deployment and revision. Specifically, the measures implemented within T11.2 will be assessed by adopting the KPIs identified in this study to verify their feasibility, ensuring that sufficient data, skills, and resources are available for their calculation and practical application in resilience assessment. This process will allow to verify the relevance, applicability, suitability and impacts of the KPIs previously defined, enabling potential adjustment tailored to the specific needs of the local context.

In conclusion, while the development of the activity of T8.1 has led to significant achievements, there is still work to be done to fully unlock their potential. In the subsequent tasks of the MULTICLIMACT project, they will be further refined and demonstrated through a practical application in real-world contexts aimed at enhancing the climate-proofing of the built environment.

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