

MAIN CODE

urban climate shelters
in schoolyards

Report D1.1

Theoretical review of Urban Climate Shelters in schoolyards

WP 1 | Conceptualising MAINCODE Methodology

Task 1.1 | Define the theoretical background of UCS

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Theoretical review of Urban Climate Shelters in schoolyards

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1. Introduction: What is this Document About

Work Package 1 (WPI), led by POLITO and co-led by SDU, carries out a comprehensive literature review and case study analysis on climate shelters, contributing to the development of the MAINCODE theoretical framework. **Task 1.1** focuses on building this framework with the aim of collecting state-of-the-art research and providing a **deeper understanding of both the theoretical foundations and practical applications of climate shelters within academic and policy debates**. Specifically, Report D1.1 reviews both scientific and grey literature and identifies emerging best practices at national and local levels, with particular emphasis on the implementation of climate shelters in schoolyards (Figure 1).

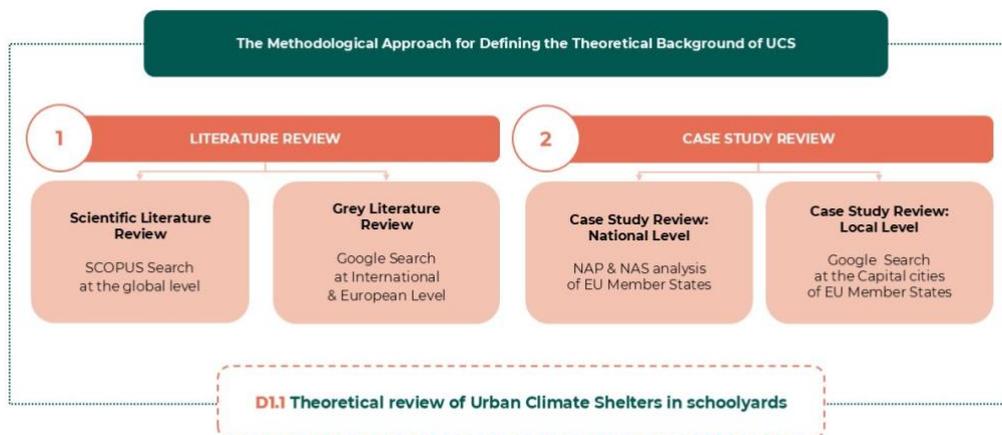


Figure 1 | MAINCODE methodological approach (Source: Authors' elaboration)

As a result, five conceptual dimensions for defining Urban Climate Shelters (UCS) were identified, each representing a critical component of the climate shelter framework and ensuring both theoretical coherence and relevance to contemporary urban adaptation discourse. Finally, **Report D1.1 positions Urban Climate Shelters (UCS) as a long-term strategy for climate mitigation and adaptation in urban contexts that aim to protect populations, particularly the most vulnerable groups, during extreme climate events by integrating NbS and co-design processes in a network of safe, inclusive, and accessible public spaces to enhance urban liveability, improve human health, and promote regenerative urbanism**. The Report advocates transforming public spaces into climate shelters through NbS and co-design as a promising model for urban cooling demonstration projects. From a practical standpoint, the case study review reveals **three approaches to climate shelter development**: the **Pilot Approach**, focused on standalone interventions; the **Thematic Approach**, involving multiple projects within a single urban space typology; and the **Sheltered City Approach**, representing a comprehensive strategy with interconnected climate shelters across diverse urban areas, supporting more robust local climate adaptation actions.

2. Methodology for Defining Urban Climate Shelters (UCS)

This section outlines the methodological approach adopted to investigate the theoretical foundations of climate shelters, leading to the MAINCODE conceptualisation of Urban Climate Shelters (UCS). The methodology was structured to maximise the identification of **relevant academic studies**, **grey literature**, and **practical cases**. The approach integrates principles of scoping review, conceptual analysis, and qualitative content evaluation. As illustrated in Figure 2, the process follows five sequential steps.

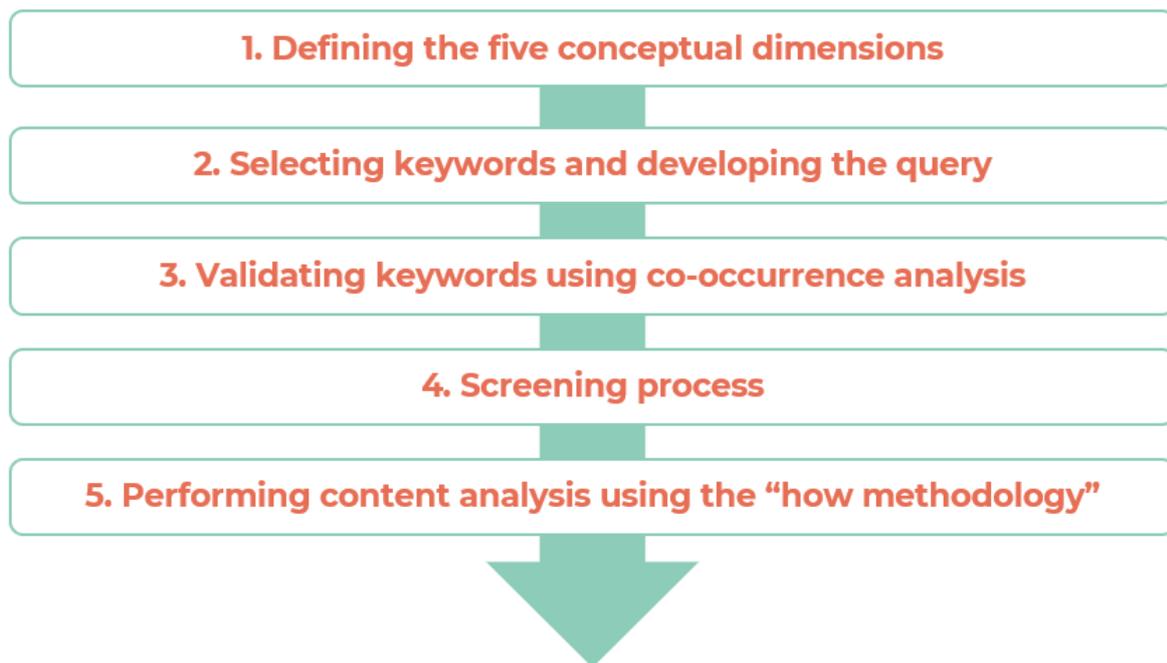


Figure 2 | The Methodological Approach for Defining the Theoretical Background of UCS.
(Source: Authors' elaboration)

A. Defining the five conceptual dimensions

The methodological process began with the identification of conceptual dimensions of climate shelter. **Five dimensions were identified**, each representing a critical element of the climate shelters framework, ensuring both theoretical coherence and relevance to current urban adaptation discourse. Following this process, Figure 3 presents the five conceptual dimensions: (i) Framing the urban context as a boundary for action; (ii) Exploring pathways for climate mitigation and adaptation; (iii) Integrating Nature-based Solutions; (iv) Transforming the school environment; and (v) Fostering co-design processes.



Figure 3 | MAINCODE Five conceptual dimensions. (Source: Authors' elaboration)

B. Selecting keywords and developing a query

Due to the novelty and limited use of the term climate shelter, special attention was given to identifying related or synonymous terms. An initial list of **sixteen keywords** was compiled, reflecting various disciplinary perspectives and linguistic variations. Each keyword was carefully analysed, and some terms were excluded based on their misalignment with the study's focus. Based on the revision of the keywords, the resulting query contains:

"climate shelter*" OR "climate oasis" OR "climatic oasis" OR "urban cooling shelter*" OR "urban cool island*" OR "cooling hub*" OR "shaded shelter*" OR "urban oasis" OR "cooling oasis" OR "urban cool spot*"

The query was adapted and applied to two types of sources:

- **Literature review**
 - a. **Scientific literature:** The search was conducted in SCOPUS database using "Title, Abstract, and Keywords," with no geographical, disciplinary and temporal limitations to ensure broad coverage.
 - b. **Grey literature:** The same query was applied using Google search engine, adding the terms "*project*" and/or "*report*", focusing on international organisations (e.g., UN agencies, NGOs, and development institutions).
- **Case study review**
 - a. **Case studies at the national level:** The query was used to search if climate shelter concept was present into the 27 EU Member States National Adaptation Strategies (NAS) or National Adaptation Plans (NAP). To optimise the result, each keyword was broken down into individual words and translated into the national language, if necessary.
 - b. **Case studies at the local level:** The query was tailored by adding specific city names (e.g., "Barcelona"). The analysis was carried out using the EU 244 capitals of the NUTS2¹.

¹ As defined by Eurostat, the Nomenclature of territorial units for statistics (from the French version *Nomenclature des Unités territoriales statistiques*) is a geographical nomenclature subdividing the economic territory of the EU into regions at three different levels (NUTS 1, 2 and 3 respectively, moving from larger to smaller territorial units).

C. Validating keyword using co-occurrence analysis

To validate the coherence and relevance of the selected keywords, a **bibliometric co-occurrence analysis** was conducted using VOSviewer software, based on the 120 publications retrieved through the SCOPUS query.

The analysis revealed **four main thematic clusters**, confirming the range and relevance of the selected literature and supporting the robustness of the review approach:

- Barcelona as a key reference in the practical applications of climate shelters.
- Technical research on microclimates.
- Solution-oriented studies (policy, design, implementation).
- Public health and vulnerability to heat.

D. Screening process

To guide the selection process, the five conceptual dimensions were translated into guiding questions and applied through a structured two-level screening, as outlined in Table 1. The screening was conducted in the following way:

- **Literature review: Three dimensions were applied as mandatory** – Framing urban context as a boundary for action; Exploring pathways for climate mitigation and adaptation; and Integrating Nature-based Solutions - to allow for a broad inclusion of publications. Articles that did not meet all three criteria were excluded. **The other two dimensions were considered desirable but not mandatory.** This rational reflects the theoretical foundation of the study and help identify the most relevant publications and documents for conceptualising Urban Climate Shelters.
- **Case study review: All five dimensions were treated as mandatory.** This stricter selection ensured that each case aligned closely with the research objectives. Only case studies that met all five criteria were included in the final sample.

Finally, each document was reviewed manually, and responses were recorded as “yes,” “no,” or “not specified” based on the clarity and detail provided in the text.

Conceptual Dimensions	Guiding questions	Guiding answers	Literature Criteria	Case study Criteria
(i) Framing urban context as a boundary for action	Does it mention an urban space that serves as a climate shelter?	YES NO Not Specified	✓	✓
(ii) Exploring pathways for climate mitigation and adaptation	Are climate shelters presented as a solution or strategy for climate mitigation and/or adaptation?		✓	✓
(iii) Integrating Nature-based Solutions	Do climate shelters incorporate nature-based solutions (NbS) or other green strategies?		✓	✓
(iv) Transforming the school environment	Does the text discuss any connection between climate shelters and schools?		✗	✓
(v) Fostering co-design processes	Does the climate shelter process involve co-design or participatory approaches?		✗	✓

Table 1 | Guidelines for elimination process. (Source: Authors' elaboration)

E. Performing content analysis using the “How Methodology”

The final phase involved a **qualitative content analysis** using a custom approach referred to as the “**How Methodology**” (see Table 2). This approach was designed as it can be suitable for analysing emerging or evolving concepts that lack common definitions or established analytical frameworks.

The analysis was divided into two parts:

- **Theoretical Foundations:** Applied only to the scientific and grey literature, this step examined the type of framework adopted, the terminology used, and how climate shelters were defined and described. It enabled a comparative understanding of how different disciplines and authors conceptualise the idea of climate shelters.
- **Conceptual Dimensions:** Applied to all sources, this part explored how each of the five previously defined dimensions was addressed in practice. Five questions guided the analysis, focusing on how climate shelters were framed in relation to urban space, climate mitigation and adaptation, Nature-based Solutions (NbS), school environments, and co-design processes.

By consistently asking “how” across both theoretical foundations and conceptual dimensions, the “How Methodology” provided a deeper understanding of both the theoretical basis and practical application of climate shelters in academic and policy discourse.

Theoretical Foundations	HOW does the article establish its foundation, through a case study or a theoretical framework?
	HOW is the concept named?
	HOW is the concept of climate shelter defined?
Conceptual Dimensions	HOW does it mention an urban space that serves as a climate shelter?
	HOW climate shelters present a solution/strategy for climate mitigation and/or adaptation?
	HOW do climate shelters incorporate Nature-based Solutions (NbS) or other green strategies?
	HOW does the article address climate shelters and school environments?
	HOW does the climate shelter development process involve co-design approaches?

Table 2 | The guiding questions of the “How Methodology”. (Source: Authors’ elaboration)

3. Literature Review

The literature review was grounded in a **dual process**, combining scientific and grey sources to explore the emerging concept of climate shelters (Figure 4). Given its limited presence in academic discourse, the review aimed to identify existing definitions, frameworks, and applications. While academic sources provided useful insights, they also revealed conceptual and practical gaps. These limitations were even more evident in institutional and policy documents, where the topic remains largely overlooked. A selection of relevant documents was therefore examined to complement and contrast with academic perspectives. The insights from this process are discussed in the following sections.

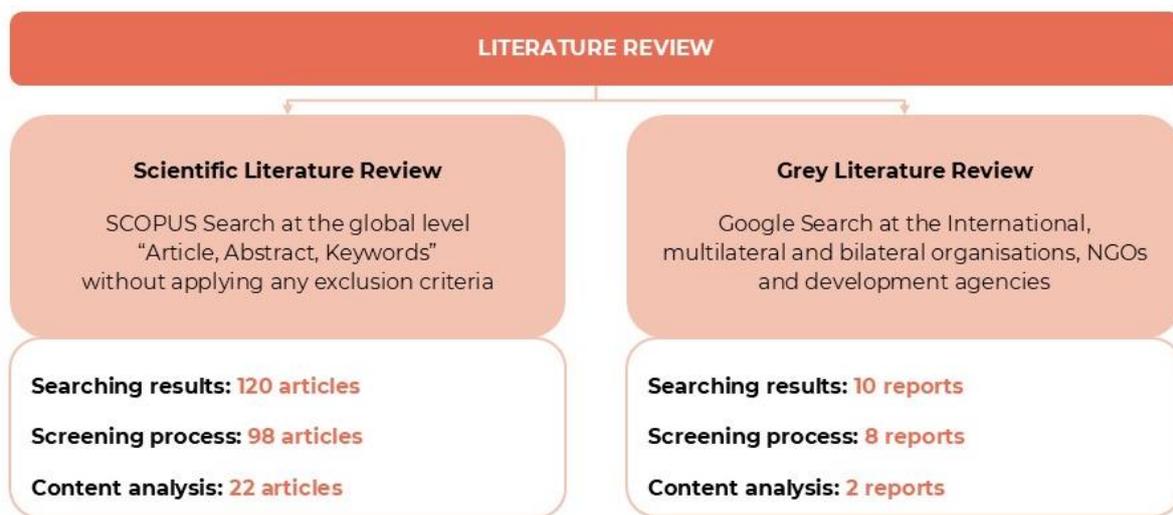


Figure 4 | Overview of literature review. (Source: Authors' elaboration)

3.1 Findings from the scientific literature review

The scientific literature review aims at identifying academic contributions and theoretical gaps related to the emerging concept of climate shelters. The review was conducted in March 2025 and began with a scoping of academic literature, identifying 120 publications, and subsequently narrowed down to 22 publications directly relevant to the study (Figure 5). **The results highlight that the selected 22 publications cover a broad range of disciplines**, including urban health, energy and building performance, public policy, and ecological planning. Among the 22 selected publications, only two appear in the same journal – Journal of Urban Forestry - highlighting the multidisciplinary nature of research on climate shelter (Table 3).

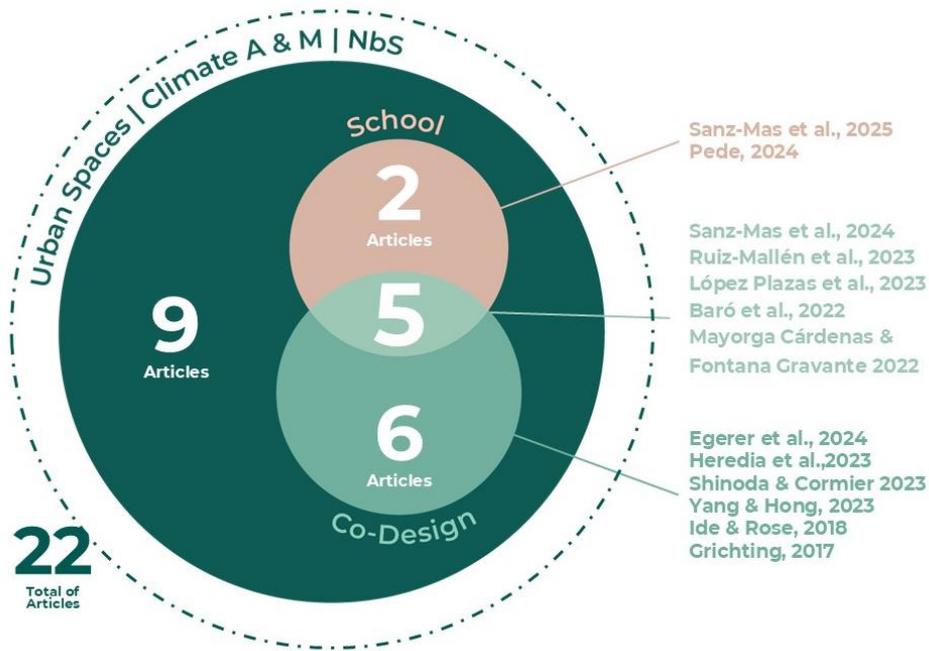


Figure 5 | Selected publications and the relationship with MAINCODE's conceptual dimensions. (Source: Authors' elaboration)

The temporal analysis reveals that **academic interest in climate shelters has increased significantly over the last decade, with a notable rise since 2017** (Figure 6). Publication frequency peaked in 2023, with eight publications, and remained high in 2024, with seven publications. Although data for 2025 is partial due to the timing of this analysis, it suggests continued scholarly engagement.

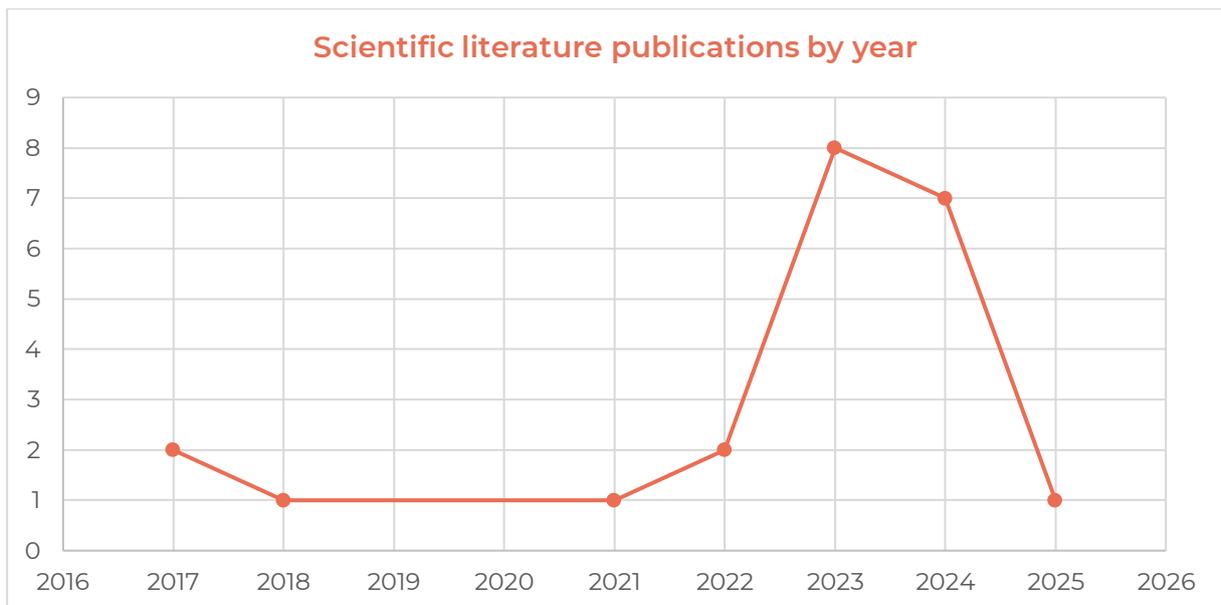


Figure 6 | Scientific literature publications timeline. (Source: Authors' elaboration)

A key theoretical insight is the predominance of empirical case studies, 21 out of 22 publications used this approach, suggesting the field is still developing its conceptual foundations (Figure 7). Geographically, research is concentrated in Southern Europe, especially Barcelona, which appears in eight publications, followed by Madrid with two. Other case studies are located in France, China, South Korea, Germany, Brazil, and the United States.

Regarding terminology, the term “climate shelter” appeared in ten publications, followed by “urban oasis/oases” in seven. Other related terms appeared less frequently, each cited once, including “cooling oases/islands,” “urban cooling shelters,” “nature-based climate school shelters,” and “urban cool spots”. **Despite the increasing number of empirical studies, only a few publications offer explicit definitions of climate shelters.** These few efforts emphasise their protective and nature-based functions, particularly in relation to vulnerable populations. However, **the absence of a shared definition and the limited theoretical development underline the need for a clearer and more coherent academic framework for the concept.**

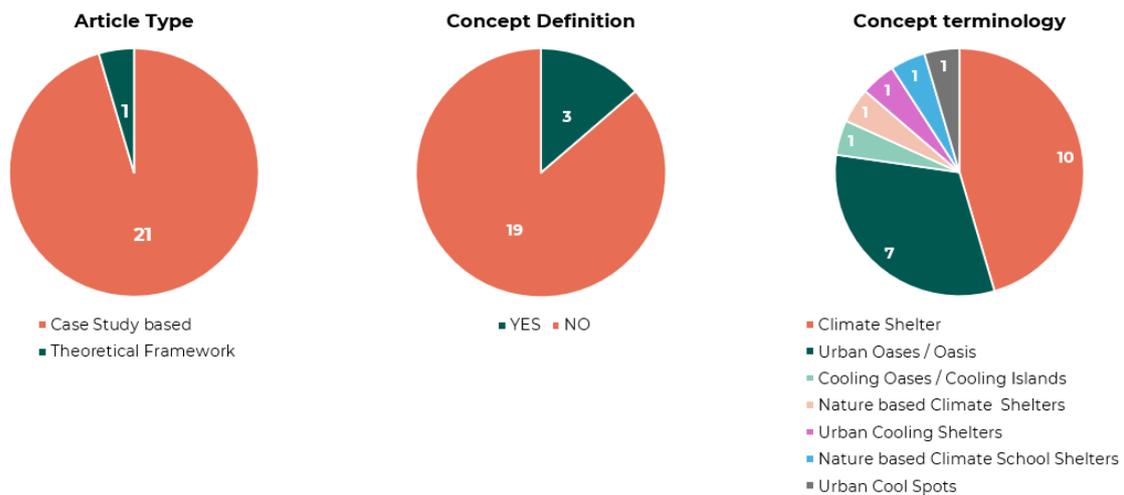


Figure 7 | Epistemology of the climate shelter concept. (Source: Authors' elaboration)

Overall, the **review highlights both the richness and the fragmentation of current academic discourse on climate shelters.** Although empirical case studies (particularly from Mediterranean urban contexts) are increasingly present, **the literature still lacks a coherent theoretical foundation and a shared definition of the concept.** Among the sources examined (Table 3), only Ruiz-Mallén et al. (2023) attempts to provide a formal theoretical framework. This gap underscores the relevance and urgency of conducting a structured literature review that not only synthesises existing knowledge but also supports the academic consolidation of climate shelters as a concept, a policy tool, and a design approach.

Author(s) (Year)	Field area	Case Study vs Theoretical	Term Used for the Concept	Definition of the Concept
(Sanz-Mas et al., 2024)	<i>Journal of Urban Health</i>	Case study	Climate Shelter	NO
(López Plazas et al., 2023)	<i>Journal of Cleaner Production</i>	Case study	Climate Shelter	NO
(Ruiz-Mallén et al., 2023)	<i>Urban Sustainability</i>	Theoretical framework	Nature based Climate School Shelters (NbCSS)	YES
(Baró et al., 2022)	<i>Urban Book Series</i>	Case study	Climate Shelter	NO
(Mayorga Cárdenas & Fontana Gravante, 2022)	<i>Resilient and Sustainable Cities: Research, Policy and Practice</i>	Case study	Climate Shelter	NO
(Sanz-Mas et al., 2025)	<i>International Journal of Public Health</i>	Case study	Climate Shelter	NO
(Egerer et al., 2024)	<i>Ecosystems and People</i>	Case study	Urban Oases	NO
(Pede, 2024)	<i>Urban Research and Practice</i>	Case study	Climate Shelter	NO
(Heredia et al., 2023)	<i>Living with Energy Poverty Perspectives from the Global North and South</i>	Case study	Climatic Shelter	NO
(Shinoda & Cormier, 2023)	<i>Landscape Architecture Frontiers</i>	Case study	Urban Oasis	NO
(Yang & Hong, 2023)	<i>City and Environment Interactions</i>	Case study	Urban Oases	NO
(Ide et al., 2018)	<i>Journal of Green Building</i>	Case study	Urban Oasis	NO
(Grichting, 2017)	<i>Future of Food: Journal on Food, Agriculture and Society</i>	Case study	Urban Oasis	NO
(Anderson et al., 2024)	<i>Urban Forestry and Urban Greening</i>	Case study	Cooling Oases / Cooling Islands	NO
(Montero-Gutiérrez et al., 2024)	<i>Energy and Buildings</i>	Case study	Climate Shelter	NO
(Torrego-Gómez et al., 2024)	<i>Energy Research and Social Science</i>	Case study	Climate Shelter	NO
(Vasconcelos et al., 2024)	<i>Urban Forestry and Urban Greening</i>	Case study	Nature based Climate Shelters	YES
(Amorim-Maia et al., 2023)	<i>Landscape and Urban Planning</i>	Case study	Climate Shelter	YES
(Kim et al., 2023)	<i>Landscape and Ecological Engineering</i>	Case study	Urban Cooling Shelters	NO
(Kurtz & Frandoloso, 2022)	<i>Handbook of Sustainability Science in the Future</i>	Case study	Urban Oasis	NO
(Stavropoulos-Laffaille et al., 2021)	<i>Journal of Physics: Conference Series</i>	Case study	Urban Cool Spots	NO
(Wei & Si, 2017)	<i>Procedia Engineering</i>	Case study	Urban Oasis	NO

Table 3 | Overview of selected publications on climate shelters. (Source: Authors' elaboration)

3.2 Findings from the Grey Literature Review

The grey literature identified ten sources that were published by organisations such as UN-Habitat, the World Bank, C40, and ARUP (Table 4). Although the grey literature served to fill gaps left by the scientific literature, **the findings underscore a limited number of documents that directly refer to the concept of climate shelter**. Regarding the terminology used for the concept, it varied across documents, with “urban oasis” being the most frequently used term, followed by “cooling hubs,” “climate shelters,” and “cool zones” (Figure 8). Among these, two reports were selected for in-depth analysis due to their relevance to the study. Firstly, the 2023 Report “Urban oasis construction manual for arid Regions in Mexico” published by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is intended for community leaders, citizens, and professionals who wish to apply urban oasis as an urban strategy. This report especially defined “a nature-based solution which attempts to create multifunctional, safe and inclusive spaces which offer environmental and social benefits together with the community (experts, local residents, volunteers and the authorities)” (Niparaja & Urbaneria EPI Mexico, 2023). Secondly, the 2021 Report “Green and Thriving neighbourhood” by C40 and ARUP incorporates the concept of climate shelter, presented as “cooler zones”, which addresses the urban transition to net zero within the 15-minute city planning strategy (Chartier et al., 2021). In this Report, trees are mentioned as a specific NbS that can provide shading and act as climate shelters. **The findings highlight a need for greater conceptual clarity and wider dissemination of the term within both professional and policy discourse.**

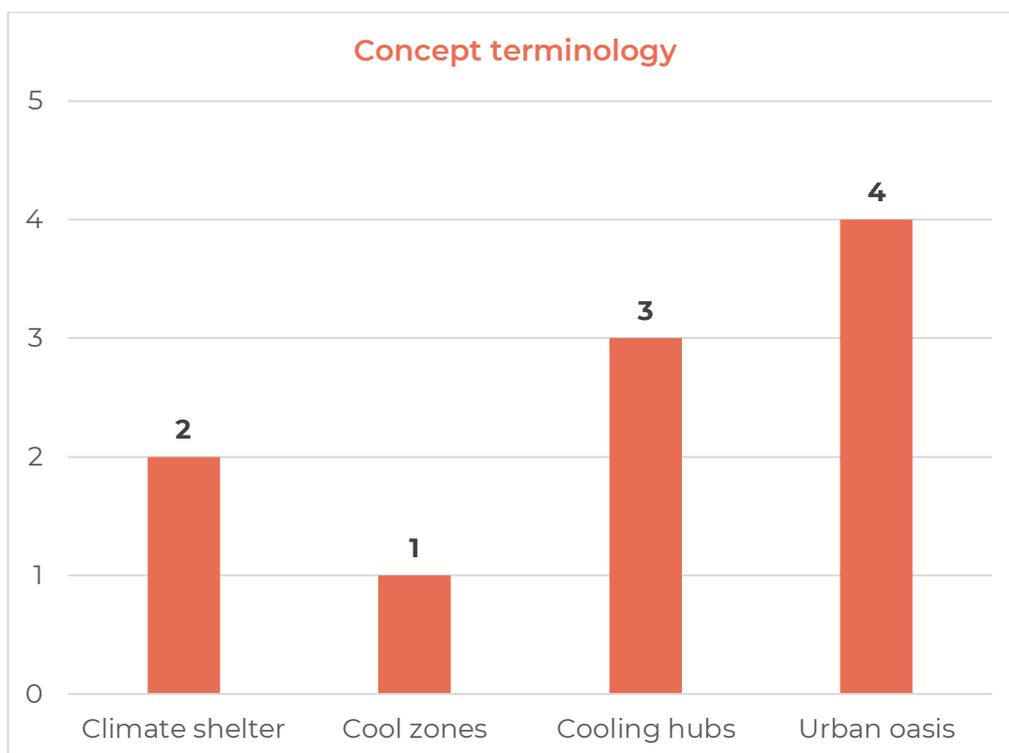


Figure 8 | Concept terminologies in the grey literature. (Source: Authors' elaboration)

Title	Source	Term Used for the Concept	Definition of the Concept	Selected
Al-Ahasa city profile	<i>Town Planning of the Ministry of Municipality and Rural Affairs of the Government of the Kingdom of Saudi Arabia and UN-Habitat</i>	Urban Oasis	NO	NO
Green and Thriving neighborhood	<i>C40 and ARUP</i>	Cool Zones	NO	YES
Creating inclusive and effective climate shelters	<i>BCNUEJ and ICTA</i>	Climate Shelters	NO	NO
Intersectional climate change adaptation	<i>Eurac research, center for climate change and transformation</i>	Climate Shelter	NO	NO
Urban oasis construction manual for arid Regions in Mexico	<i>Nipajara and Urbaneria EPI Mexico</i>	Urban Oasis	YES	YES
Global report on urban health	<i>WHO and UN-Habitat</i>	Urban Oasis	NO	NO
Guidelines on urban and peri-urban forestry	<i>Food and Agriculture Organisation of the United Nations</i>	Urban Oasis	NO	NO
Integrated Cooling Systems: Harnessing synergies and co-benefits across users, technologies and policies	<i>World bank</i>	Cooling Hubs	NO	NO
Rural cooling- A techno-socio-economic structural development challenge	<i>University of Birmingham</i>	Cooling Hubs	NO	NO
Sustainable and resilient cold-chains. The 2050 imperative	<i>Center for sustainable cooling</i>	Cooling Hubs	NO	NO

Table 4 | Overview of grey literature on climate shelters. (Source: Authors' elaboration)

4. Case Study Review

This section presented a review of case studies conducted through the **dual approach of national and local levels** (Figure 9). This analysis started from a review of national-level adaptation documents to assess whether any **connections exist between local implementation actions and national climate policy frameworks**. Furthermore, the review examined cities that have implemented climate shelters, followed by a content analysis to better understand how the concept is applied in practice, particularly in relation to the five conceptual dimensions defined previously.



Figure 9 | Overview of case study review. (Source: Authors' elaboration)

4.1 Case study review: National level analysis

This section presented the **review of publicly accessible online National Adaptation Strategies (NAS) and National Adaptation Plans (NAP) of the 27 EU Member States**, aiming to assess whether the concept of climate shelters is referenced at the national level. To enhance the comprehensiveness of the search and accommodate differences in terminology used in various national contexts, the query was adapted accordingly. This included breaking down keywords into individual terms, translating them into local languages when necessary, and supplementing them with additional terms.

The results of the review are categorised into three groups:

- **Explicit reference to climate shelters**, which includes Countries that directly use the term climate shelter or similar keywords in their NAS or NAP documents.
- **Implicit reference to climate shelters**, which applies to Countries that do not use the term climate shelter or similar but include phrases that can be interpreted as similar to the concept of climate shelter.
- **No reference to climate shelters**, indicating that neither the term climate shelter nor any similar concepts and phrases were identified in the documents reviewed.

Among the 27 EU Member States NAS and NAP reviewed, **only three Countries - Austria, France, and Spain - refers explicitly to the climate shelter concept in their national adaptation documents** (Figure 10); all these references appear in the NAP (Figure 11). The Austria NAP contains terms such as “cooling rooms” and “cool spaces” (BMNT, 2019) while the France NAP includes the term “cool islands” (Ministry of the Ecological Transition Biodiversity Forests Sea and Fisheries, 2025). Meanwhile, the Spain NAP explicitly uses the term “climate refugia” (MITECO, 2020). Notably, no country refers to the concept explicitly in both of its NAS and NAP documents.

Eight Countries - Ireland, Luxembourg, Germany, Italy, Croatia, Slovenia, Estonia, and Latvia - make implicit references to the climate shelter concept in their national adaptation documents (Figure 10). The Ireland joint NAS & NAP mentions “creating urban green spaces and cooling urban areas” (DCEE, 2024). Similarly, the Luxembourg joint NAS & NAP includes “use climate-regulating areas for multiple purposes” (Ministry of the Environment Climate and Biodiversity, 2018). The Germany NAS states “accessibility cooling green space” (BMUKN, 2024). The Italy NAS points out the “redistribution of urban greenery with the function of interrupting the heat island effect” (MATM, 2015). Likewise, the Croatia NAS includes “regeneration of the urban fabric using nature-based solutions” (Croatian Parliament, 2020). The Slovenia NAS document highlights “green urban infrastructure, which helps to lower temperatures” (MOP, 2021). Similarly, the Estonia NAS contains “microclimatic cooling measures in the urban environment” (Ministry of the Environment, 2017). Lastly, the Latvia NAP brings up “air cooling systems in public spaces” (VARAM, 2019). Overall, these examples demonstrate that although the term climate shelter or similar keywords are not explicitly used in the national adaptation documents, the measures described align closely with the principles underlying the concept of climate shelter. Finally, the analysis identified that the remaining **16 Countries make no reference to climate shelters, similar concepts or phrases in their national adaptation documents.**

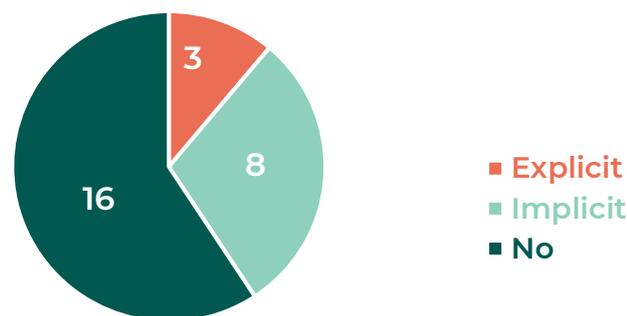


Figure 10 | NAS & NAP review results. (Source: Authors' elaboration)

In summary, the review of the NAS and NAP reflects the **limited presence of the climate shelter concept at the national level**, with only a few examples of implicit references and even fewer explicit mentions (Figure 11). Furthermore, **it underscores the lack of consensus on a terminology for the concept**, similar to what is observed in the literature review.

Review of NAS & NAP

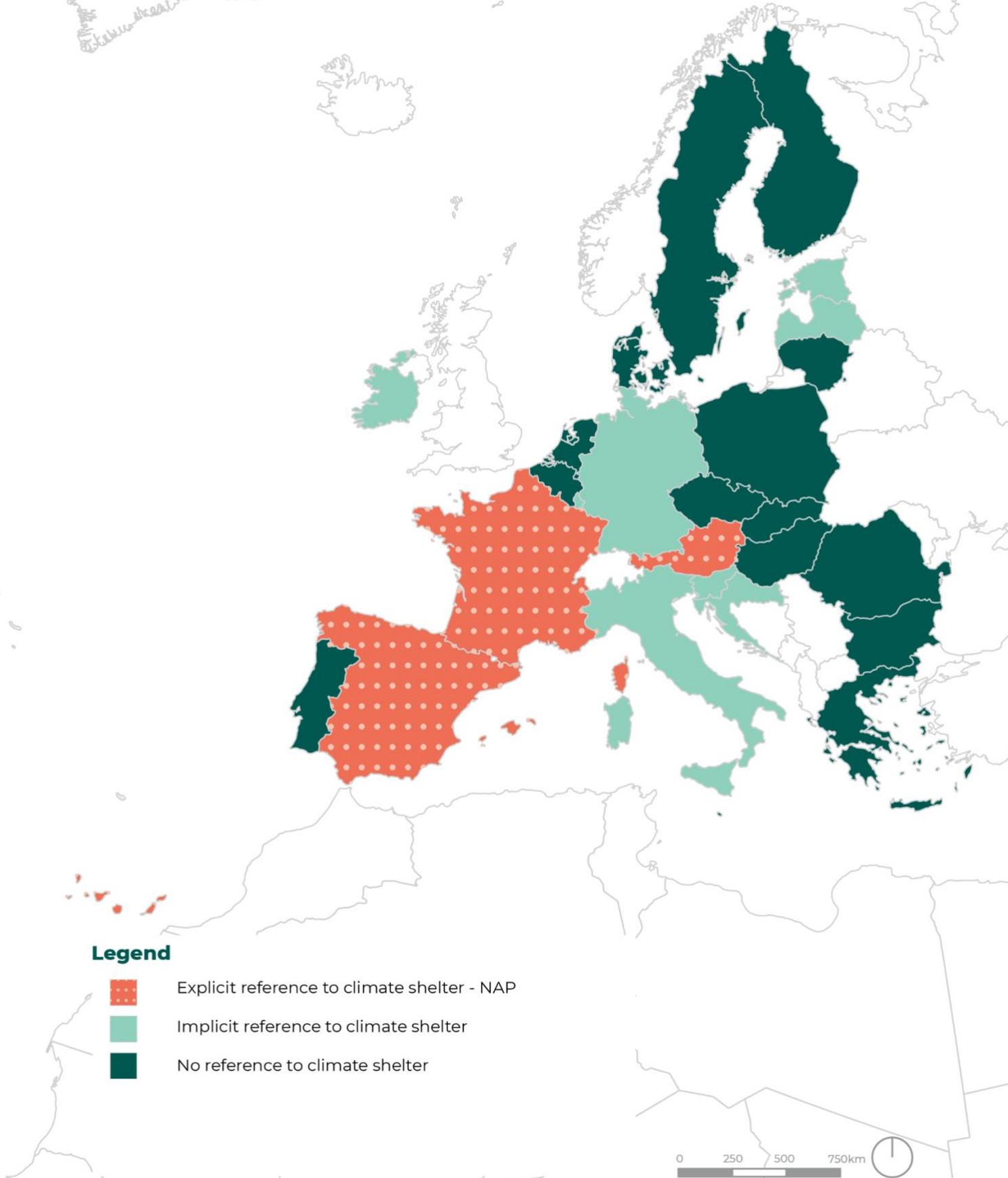


Figure 11 | NAP & NAS review. (Source: Authors' elaboration)

4.2 Case Study review: Local level analysis

The review of the case studies at the local level was conducted on the capital cities of the EU NUTS-2 level in order to establish a standardised spatial unit for comprehensive research. The validated keyword query is then combined with the name of each city and executed using the Google search engine.

The first step search focused on identifying cities that have implemented climate shelters. It is conducted by addressing two conceptual dimensions: (i) Framing the urban context as a boundary for action; and (ii) Exploring pathways for climate mitigation and adaptation. The results present that out of 244 EU capital cities, **58 cities are identified as executing climate shelters** (Figure 12). In addition, to examine the potential relationship between the national adaptation policies and local actions, a spatial overlay analysis was conducted by comparing the results of the review of NAS and NAP documents with the 58 identified cities. This approach is applied to assess whether the existence of references to climate shelter or similar concepts in NAS and NAP documents corresponds to their implementation at the local level. Based on the analysis of the overlaid map, it can be observed that there is no direct relation, indicating that such references in national adaptation documents do not necessarily lead to the implementation of climate shelter at the local level (Figure 13). For instance, The Netherlands, Belgium, Portugal, Poland and Hungary do not refer to the concept in their NAS or NAP, yet they have still experimented with multiple climate shelters at the local level. However, cities in France and Spain - whose national adaptation strategies and plans explicitly reference climate shelters - make up half of the identified 58 cases.

The second step search focused on identifying cities that have implemented climate shelters in schools by using nature and co-design process. It is conducted by addressing the other conceptual dimensions: (iii) Integrating Nature-based Solutions; (iv) Transforming the school environment; and (v) Fostering co-design processes (Figure 14).

The final step selected 20 cities as case studies, based on their alignment with the MAINCODE conceptual dimensions. This shortlist served as the basis for the content analysis (Figure 15).

Climate shelter analysis



Legend

- Cities with climate shelters



Figure 12 | Climate shelter analysis. (Source: Authors' elaboration)

NAS & NAP review and cities with climate shelters

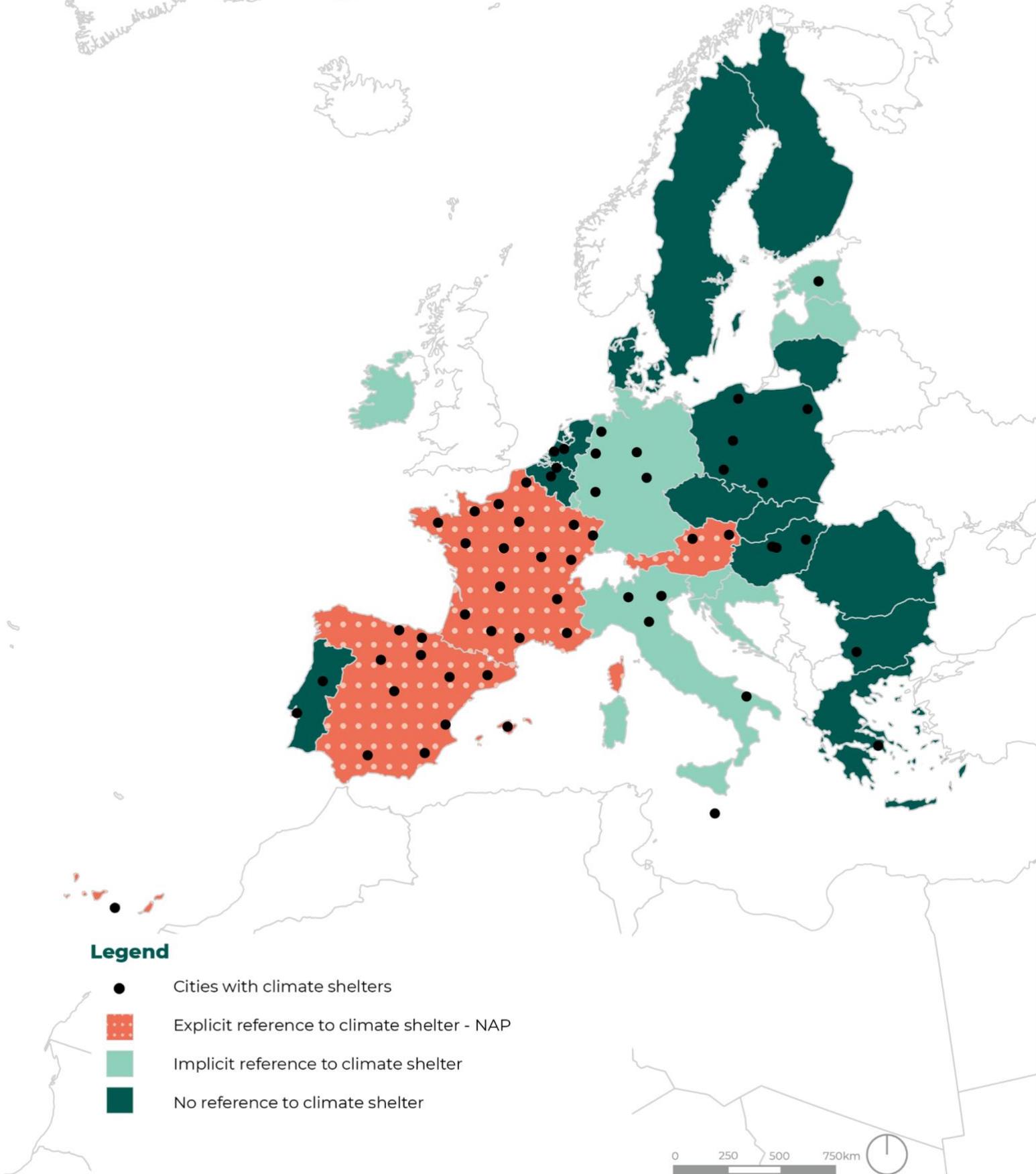


Figure 13 | NAP & NAS review and cities with climate shelter. (Source: Authors' elaboration)

Climate shelter analysis grounded in MAINCODE's five dimensions

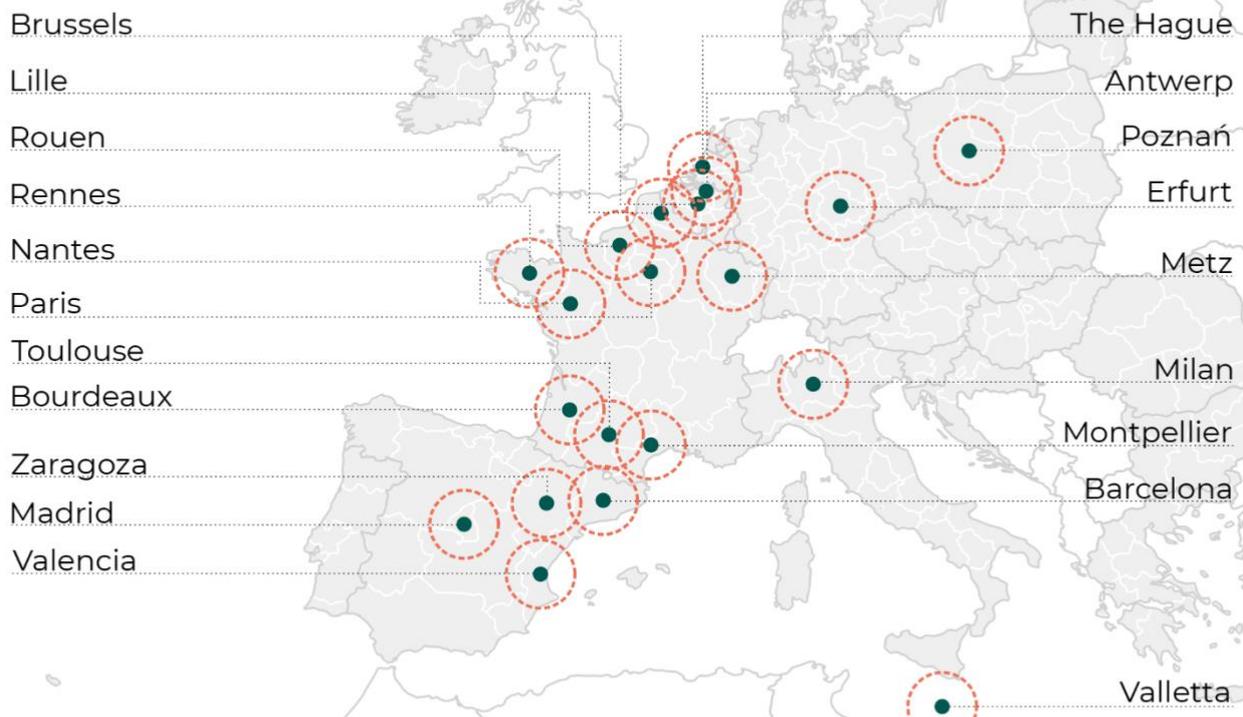
Legend

- Cities with climate shelters
- Climate shelters in schools
- Climate shelters in schools through NbS
- Climate shelters in schools through NbS and co-design



Figure 14 | Climate shelter analysis grounded in MAINCODE's five dimensions. (Source: Authors' elaboration)

Selected MAINCODE case studies



Legend

 Cities with climate shelters incorporating MAINCODE's five conceptual dimensions



Figure 15 | Selected MAINCODE case studies. (Source: Authors' elaboration)

Figure 16 summarises the analysis of case studies at the local level. Out of 244 capital cities, 58 cities are identified as having implemented climate shelters, addressing both the urban and climate change conceptual dimensions. Among these 58 cities, 35 have implemented climate shelters in schools, and within this group, 33 of them have incorporated NbS. Finally, of these 33 cities, 20 cities have implemented climate shelters through co-design approaches. This resulted in the selection of these 20 cities as case studies, as the basis for the content analysis.

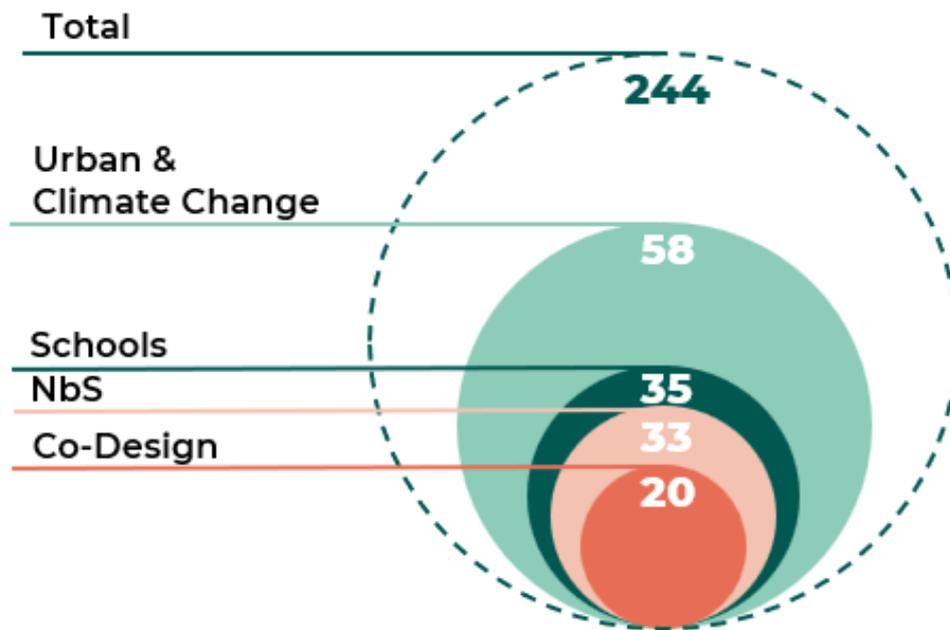


Figure 16 | Results of the case studies review. (Source: Authors' elaboration)

The **results of the content analysis revealed that each case study has its unique characteristics**, despite being analysed comparatively across the five MAINCODE conceptual dimensions. However, there are some common features shared among all of them:

- **There is no specific definition for “climate shelters”** besides the Barcelona case, which understands them as spaces where you can protect yourself from the heat during the summer and the cold during the winter.
- **The quantity of schools transformed into climate shelters varies across cities**, ranging from isolated pilot projects to comprehensive sheltered city approaches. This variation may reflect differences in political will, resource availability, or local climate strategies.
- **There are significant differences in how climate shelter transformations are approached regionally.** In Northern Europe, there is a more coaching-based approach to school transformation, with a smaller budget. Furthermore, the transformation is primarily carried out to bring students closer to nature and as an educational strategy. While in Southern Europe, the transformation stems from

municipal development, with a larger budget and as a response to climate hazards, especially urban heat islands.

- **The starting date of the case studies shows significant variation, ranging from 2008 to today.** For example, the city of The Hague initiated such efforts as early as 2008, while others launched initiatives between 2017 and 2025 (Figure 17).
- **Budgets for the transformation of school as climate shelters vary widely,** depending on the scale and ambition of the project. Simpler interventions receive lower grants, while more comprehensive redesigns require higher grants (Figure 18).

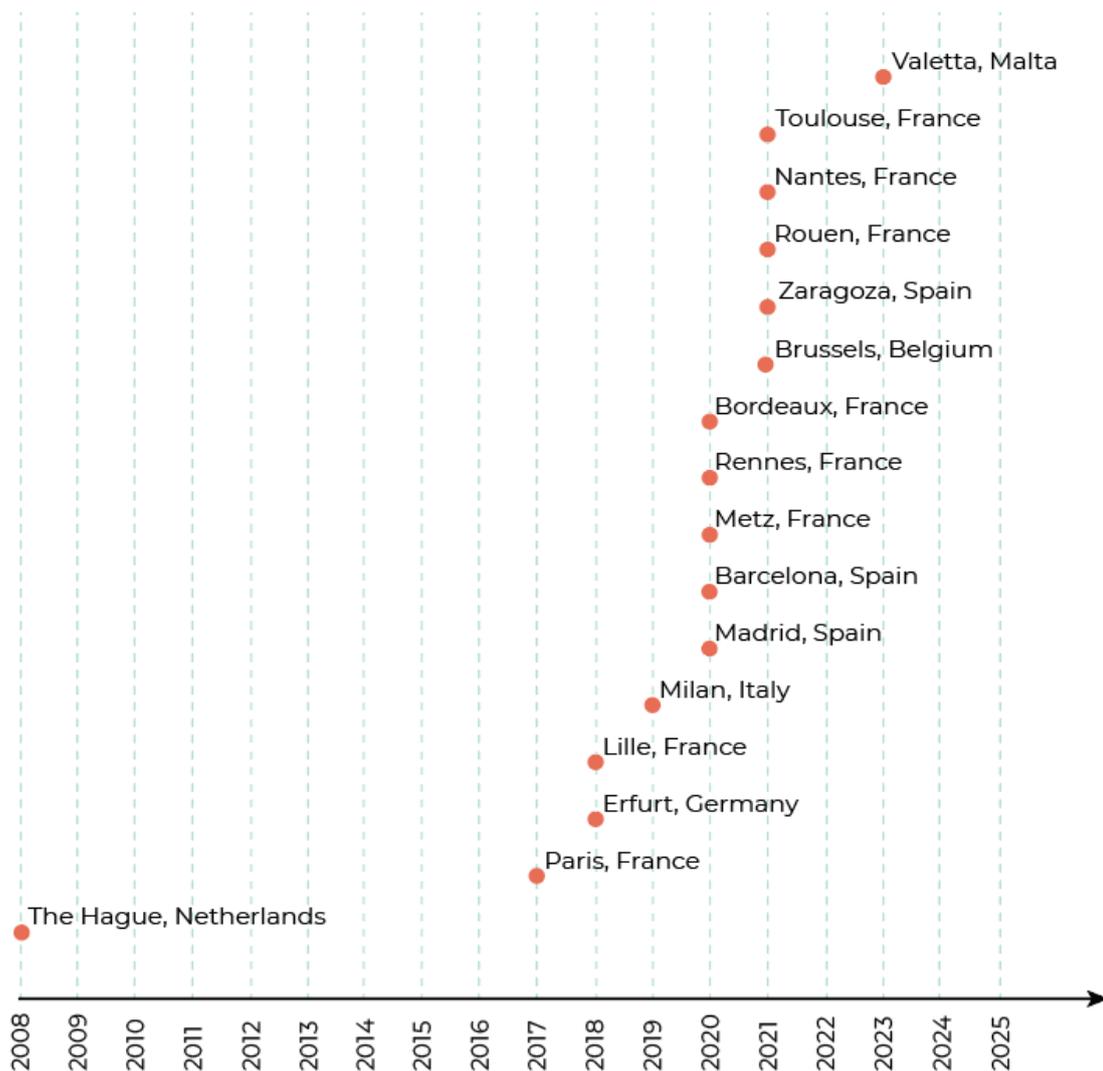


Figure 17 | Case studies starting dates. (Source: Authors' elaboration)

Case studies budget analysis

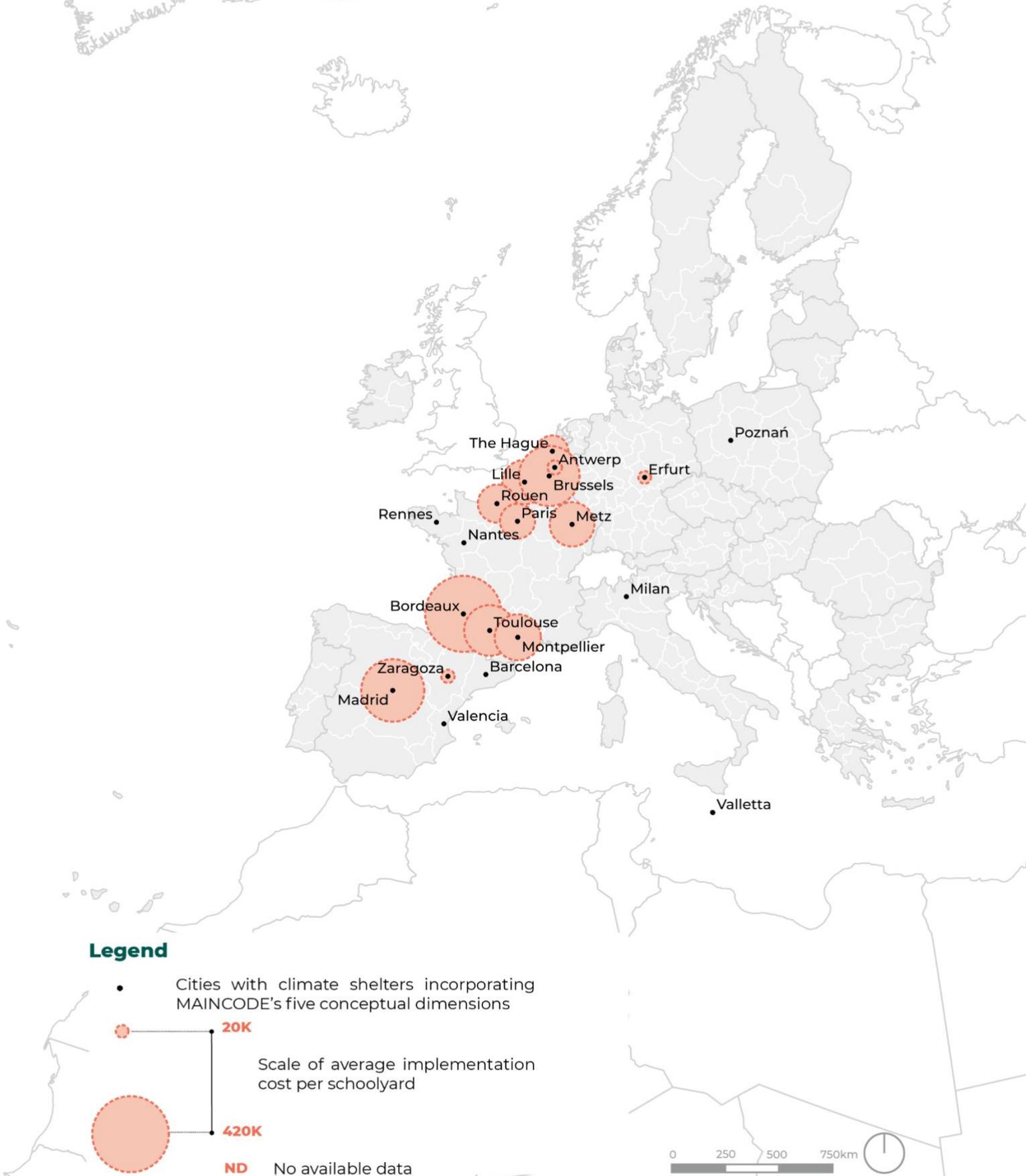


Figure 18 | Case studies budget analysis (Source: Authors' elaboration)

5. Conceptual Dimensions for Defining Urban Climate Shelters (UCS)

The following section presents each of the five conceptual dimensions for defining Urban Climate Shelters (UCS) in greater depth, drawing on the insights from the literature review and case study review. This examination aims to clarify the specific role and contribution of each dimension within the broader framework of climate shelter.

5.1 Framing urban context as a boundary of action

The first conceptual dimension is defining the urban context as a basis for action, which serves as a strategic and spatial boundary for implementing climate mitigation and adaptation initiatives locally. Within this context, **a diversity of urban spaces can function as climate shelters**, including indoor and outdoor public spaces, school environments, green spaces, university campuses, critical infrastructure, and small-scale sites. These examples show that **small-scale urban actions can have a significant impact on everyday life**. Although small in scope, they are sometimes incorporated into broader urban strategies that promote climate mitigation and adaptation, and social cohesion.

5.2 Exploring pathways for climate mitigation and adaptation

In terms of **climate mitigation**, climate shelters as green interventions help reduce air and surface temperatures, contributing to urban cooling and climate regulation, and supporting global efforts to limit warming to 1.5–2°C. From a **climate adaptation** perspective, climate shelters address intensifying heat, provide thermal comfort, ensure equitable climate protection, and improve biodiversity. Achieving these goals also requires integrated policies across sectors such as health, climate, and disaster risk reduction. Furthermore, **climate shelter strategies extend beyond physical infrastructure** by including climate education, promoting behavioural change, fostering community engagement, and raising public awareness.

5.3 Integrating Nature-based Solutions

The integration of Nature-based Solutions (NbS) has a central role in climate shelter initiative. They provide opportunities for regular contact with nature in everyday life. Common green interventions within Nature-based Solutions (NbS) include replacing asphalt with permeable surfaces, planting trees and gardens, installing green walls, integrating shade structures made from eco-friendly materials, and enhancing rainwater management systems. In addition, blue infrastructures such as rain gardens, bioswales, ponds, and stormwater systems complement green interventions. Finally, **this approach provides multiple co-benefits for healthy and heat resilient cities, including microclimate regulation, enhancement of biodiversity, and reduction of heat stress.**

5.4 Transforming the school environment

Schools can play a key role as climate shelters due to their widespread distribution, neighbourhood accessibility, and ability to serve vulnerable populations, particularly children, who are highly sensitive to extreme temperatures. **Transforming school environments into climate shelters offers multiple co-benefits, including improved child well-being.** These spaces also promote climate education and outdoor learning in redesigned schoolyards. Additionally, they support cognitive development and learning, encourage creative and inclusive play, foster social cohesion, and contribute to the Sustainable Development Goals (SDGs), particularly SDG4 – Quality Education. Typically, the transformation of school environments into climate shelters integrates NbS and climate-responsive materials, enhancing thermal comfort for students and staff. Moreover, **redesigned schoolyards can remain accessible to the public after school hours, offering safe shelter during extreme weather conditions.**

5.5 Fostering co-design processes

The process of co-designing in the context of climate shelters involves actively engaging stakeholders in various stages of planning and implementation. This includes sharing ideas and feedback, monitoring and evaluating interventions, and participating in maintenance. Additionally, a range of stakeholders are typically involved in these processes, such as community members, end users, technical experts, and designers. In school settings, stakeholders include students, teachers, school managers, and parents. Common methods used to facilitate co-design include workshops, community consultations, and collaborative design sessions. The goals of co-design are varied. These approaches aim to **foster dialogue, empower children's voices, promote health and biodiversity, and strengthen the sense of belonging.** Co-design also supports long-term sustainability by ensuring that transformations reflect the needs and priorities of the communities they serve.

6. Conclusion: A Definition of Urban Climate Shelters (UCS)

In an era of intensifying climate change and frequent environmental extremes, **cities are increasingly vulnerable to rising temperatures and related urban health risks**. Despite various adaptation strategies being implemented at the local level for heatwave mitigation, critical gaps remain in effectively addressing urban overheating. **Among emerging responses, climate shelters hold great promise**. Yet, despite growing experimentation in cities worldwide, **the concept of climate shelter remains underdeveloped in academic discourse, lacking a clear definition and robust theoretical foundation**. This Report responds to this gap by conducting a foundational literature review and case study review that highlights the empirical orientation of existing work and the absence of conceptual clarity. Building on the MAINCODE five conceptual dimensions developed and analysed in this study, **the following definition provides a conceptual and operational understanding of Urban Climate Shelters (UCS)** that will inform MAINCODE next steps.

Urban Climate Shelters (UCS) refer to a long-term strategy for climate mitigation and adaptation in urban contexts that aim to protect populations, particularly the most vulnerable groups, during extreme climate events by integrating NbS and co-design processes in a network of safe, inclusive, and accessible public spaces to enhance urban liveability, improve human health, and promote regenerative urbanism.

Within this definition, the following key concepts are emphasising:

- **Long-term strategy:** UCS are designed as enduring responses to climate challenges, contributing to global climate goals at the urban scale. Unlike temporary emergency shelters, they reflect the need for sustained planning and permanent integration into urban systems.
- **Protection of vulnerable groups:** UCS prioritise the needs of populations most at risk, such as children, the elderly, low-income communities, migrants, and women, whose capacity to cope with climate impacts is often limited.
- **Response to extreme climate events:** While particularly suited to addressing the growing frequency and severity of heatwaves, UCS can also provide co-benefits in managing other risks, including heavy rainfall and urban flooding.
- **Integration of Nature-based Solutions:** UCS transform grey, impermeable areas into green, permeable spaces that improve thermal comfort, support biodiversity, and enhance overall environmental quality.
- **Co-design processes:** UCS are grounded in participatory approaches that engage citizens, planners, educators, and experts in the design and management of interventions. These processes foster community ownership, strengthen social cohesion, and promote long-term stewardship.

- **Network of inclusive public spaces:** UCS are not isolated interventions but part of a connected urban spaces, including schools, libraries, community centres, and parks, that ensures broad accessibility, safety, and usability throughout the city.
- **Regenerative urbanism:** UCS align with circular economy principles and the goals of the Driving Urban Transition (DUT) Partnership. They contribute to ecosystem restoration, biodiversity enhancement, and improved public health and well-being.

From a practical standpoint, the case study review reveals **three different approaches to climate shelter development** (Figure 19). Specifically:

- **Pilot Approach** involves the implementation of a **single and stand-alone project**, typically used to test innovative concepts and evaluate their feasibility before broader adoption. An example is the Milano School Oasis strategy, which is currently applying this approach through an initial pilot project in a school at the Crescenzago district. As outlined in the Milan's Air and Climate Plan, schools are envisioned to be progressively transformed into urban cooling spots by 2050.
- **Thematic Approach** involves the implementation of **multiple projects focused on a specific typology of urban space**, allowing for targeted interventions and the development of specialised knowledge. For instance, the City of Paris is currently applying this approach through its large-scale Oasis Schoolyards program, which has officially transformed over 130 schoolyards into green, climate-resilient spaces as of 2025, with a target to reach all 770 public schoolyards by 2040. This initiative is a key part of Paris Climate Plan and Resilience Strategy.
- **Sheltered City Approach** involves a **coordinated set of projects implemented across diverse yet interconnected types of urban spaces, aiming to create an integrated network of climate shelters**. For example, the City of Barcelona has adopted this approach in alignment with its commitment to sustainable urban development and the Barcelona Climate Plan, promoting a holistic response to urban heat and climate risks. These shelters, located in public parks and gardens, schoolyards, civic centres and libraries, sports centres, and community buildings, are strategically distributed to ensure that 98% of the population has access to one within a 10-minute walk, with 68% reachable within 5 minutes.

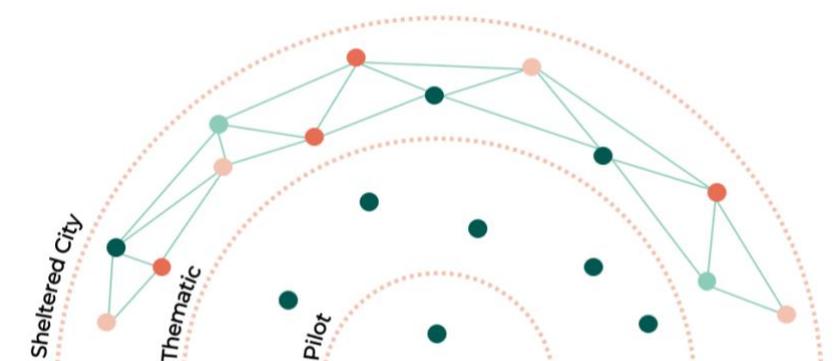


Figure 19 | Approaches to climate shelter development (Source: Authors' elaboration)

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