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Urban Heat Islands and Urban Planning Law in Spain: Towards Quantifiable and Enforceable Climate Standards

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Abstract

Urban heat islands are among the most intense and unequal climate impacts in Mediterranean cities, with direct effects on health, thermal comfort, and habitability. This reality calls for the incorporation of binding and verifiable climate criteria into spatial planning and urban planning law. This article examines the extent to which the Spanish legal framework—at national, regional, and municipal levels—incorporates measurable standards to mitigate urban heat islands and how it might evolve towards operational climate-responsive urbanism. A legal–analytical and comparative methodology is applied, based on multilevel normative content analysis and a comparison of four autonomous communities, four Spanish cities, and four international reference cases with consolidated metrics. The results show that, despite progress in recognising adaptation, territorial asymmetries persist, enforceable parameters remain scarce, and there is a prevailing reliance on strategic or voluntary instruments. In response to these gaps, the study proposes a coherent set of urban climate standards (urban vegetation, functional soil permeability, roof albedo/cool roofs, green roofs and façades, plot-scale performance indices, urban ventilation, and thermal diagnostics) and a multilevel integration model aimed at guiding legislative reforms and strengthening cities' adaptive capacity and thermal equity.

Keywords: urban heat island (UHI); Spanish urban planning law; climate change adaptation; multilevel governance; enforceable climate standards; strategic environmental assessment (SEA); permitting and municipal ordinances; Spain

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1. Introduction

Global warming is steadily intensifying the frequency and duration of heatwaves, and this phenomenon becomes particularly critical in urban areas due to the urban heat island (UHI) effect. From the first systematic observations made in the nineteenth century [1] to contemporary meta-analyses, the scientific literature has consistently shown that cities can reach temperature increases of several degrees relative to their immediate rural surroundings [2,3]. This differential not only affects thermal well-being but also increases heat-related morbidity and mortality [4,5], impairs air quality, intensifies energy demand, and reduces the overall liveability of urban environments. In addition, recent research has highlighted that UHI intensity is not distributed homogeneously across the city, but rather reproduces pre-existing socio-spatial inequalities, generating what various authors refer to as thermal injustice [6]: differential exposure to heat linked to factors such as income, building density, the availability of green infrastructure, and access to public space.

This intensification is not an isolated phenomenon, but a trend documented in hundreds of cities worldwide. Several scientific reviews have shown that, since the midtwentieth century, UHI thermal intensity has increased systematically as a result of compact urbanisation and global warming [7,8], reinforcing the need to integrate binding thermal metrics into urban planning.

The accumulated scientific evidence makes it possible to identify a set of urban factors that explain UHI thermal intensity—such as soil sealing, vegetation loss, the use of low-albedo materials, dense urban morphology, and amplification driven by climate change—which have been extensively documented in urban climatology and heat epidemiology [3,9]. This theoretical basis corresponds directly to Table 1, which synthesises the fundamental thermal mechanisms underpinning cities' differential behaviour under heat. Urban planning, as the discipline that regulates the form and functioning of the urban fabric, is therefore decisive in mitigating the phenomenon, insofar as it shapes the design of public space, buildability ratios, ecological continuity, soil permeability, and the selection of construction materials.

Despite this evidence, legal systems' responses to urban thermal risk have historically been fragmented. At the international and European levels, various strategic instruments have recognised the need to integrate climate adaptation into urban planning systems [10,11], yet references to UHIs tend to remain programmatic and lack binding metric translation. Several international bodies have noted that this absence of operational metrics limits the effectiveness of urban adaptation policies, even within advanced frameworks such as the European Green Deal or the European Union Climate Law [12–14]. Table 2 summarises this multilevel framework, showing that although there is growing normative recognition of urban adaptation to climate change, the incorporation of specific legal obligations to mitigate UHIs remains limited.

This trend is replicated in the Spanish case: neither national legislation nor most regional urban planning laws have so far incorporated quantifiable standards relating to vegetation, albedo, permeability, or thermal comfort [15,16], meaning that the climatic integration of urban planning remains conditioned by general regulations, regional adaptation strategies, or non-binding municipal instruments [17,18].

The absence of operational standards contrasts with the regulatory evolution experienced in various cities worldwide. In New York, the obligation to install green roofs or high-reflectance materials constitutes a paradigmatic example of how urban planning can establish verifiable metrics that condition the thermal behaviour of the built stock [19,20]. In Tokyo, minimum green roof requirements for new buildings and the climate standards of the green building programme represent an advanced legal approach [21,22], while Singapore has developed quantitative systems such as the Green Plot Ratio and the Skyrise Greenery Incentive Scheme to ensure the presence of vegetation even in dense urban fabrics [23]. Berlin, for its part, has consolidated the Biotope Area Factor (BAF), a mandatory ecological standard that integrates permeability and vegetation into urban planning [24,25]. Table 3 presents a precise comparison of these experiences, all of them drawn from real bibliographic sources, and shows that urban climate standards can be designed as robust, measurable, and enforceable legal instruments.

In Spain, progress has been notable over the past decade, especially following the adoption of Law 7/2021 on Climate Change and Energy Transition [15] and the strengthening of regional adaptation strategies. However, the analysis of the regulatory frameworks of Catalonia, Andalusia, the Valencian Community, and Madrid, presented in Table 4, reveals a heterogeneous landscape: although all four regions acknowledge climate risk and some introduce criteria linked to nature-based solutions or ecological continuity [16,26], none yet establishes verifiable thermal thresholds or quantifiable urban parameters that would allow climate adaptation in cities to be effectively monitored and enforced. The municipalities analysed—Madrid, Barcelona, Valencia, and Seville—have developed ambitious local strategies [18,27], but their measures tend to be strategic in nature and are not integrated into binding urban planning instruments. This gap between climate strategies and effective urban planning regulation has also been identified by international bodies as a factor that increases vulnerability and thermal inequality, with implications even for equitable access to fundamental rights [28]. This situation is consistent with the most recent findings in the urban governance literature, which underline the systematic distance between climate strategies and effective urban planning regulation [29].

Taken together, these normative gaps reveal a fundamental legal void: Spain lacks a multi-scalar framework that incorporates quantifiable climate-oriented urban planning standards. This hampers the effective integration of thermal risk into planning processes, limits the capacity of urban planning legislation to operate as a mitigation instrument, and perpetuates a gap between available scientific knowledge and the legal tools currently in force.

On the basis of this diagnosis, the present article poses the following research question: to what extent does Spanish urban planning law integrate—or can it integrate—binding and measurable standards to mitigate urban heat islands, and how might it evolve towards a fully operational model of climate-responsive urban planning, consistent with international advances and the current state of climate science?

The objective of the study is to develop a theoretical and normative framework capable of incorporating quantifiable climate standards into Spanish urban planning, to identify existing regulatory gaps, and to propose concrete criteria for multilevel integration, synthesised in Tables 5 and 6. In doing so, the article seeks to contribute to the consolidation of climate-responsive urban planning capable of verifiably mitigating UHIs, reducing thermal inequalities, and strengthening urban resilience under an increasingly extreme climate. Recent developments in climate-responsive urban planning show that such integration is not only possible but necessary, and that quantifiable standards can be incorporated into planning instruments without altering their essential legal structure [30–32].

The study is structured into six sections: Section 2 presents the methodological foundations; Section 3 develops the theoretical framework on UHIs, thermal justice, nature-based solutions, climate governance, and climate-responsive urban planning; Section 4 sets out the results of the international, regional, and municipal comparative analysis, as well as the proposed standards and their multilevel integration; Section 5 contrasts theory and results and provides an overall legal interpretation; and Section 6 sets out the conclusions and the study's limitations.

2. Materials and Methods

To address this question, the article adopts a legal–analytical approach that combines a structured review of the scientific, planning, and climate literature; a content analysis of international, European, national, and regional regulatory frameworks; and a comparison between four Spanish cities and four international cities that have developed advanced climate standards. This methodology—fully consistent with the nature of legal analysis and transparent in its inclusion criteria—makes it possible to identify regulatory gaps, systematise existing climate parameters, and derive, through the triangulation of scientific evidence, normative analysis, and comparative experiences, a set of quantifiable urban-planning standards appropriate to the Spanish context. The selection of Catalonia, the Valencian Community, Andalusia, and Madrid, as well as Madrid, Barcelona, Valencia, and Seville at the municipal level, responds to their demographic and urban weight, the relevance of their recent regulatory reforms, and the diversity of approaches to climate integration. Likewise, the international cases of New York, Singapore, Tokyo, and Berlin

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are chosen because they constitute consolidated benchmarks in the use of quantifiable standards to mitigate the UHI.

The methodology reflects the dual nature of the problem analysed. On the one hand, the UHI is a physical phenomenon widely documented in urban climatology, which has identified building morphology, soil sealing, lack of vegetation, and the use of low-albedo materials as decisive factors in urban temperature increases [1–3]. On the other hand, the socio-spatial distribution of exposure to extreme heat reproduces pre-existing urban inequalities, generating patterns of thermal injustice that connect climate risk with social, economic, and territorial vulnerability [5,6]. In this context, urban planning is configured as an essential legal tool for translating scientific evidence into binding standards capable of mitigating urban thermal intensity.

The methodology is organised around three complementary axes. First, a structured review was developed of the scientific, planning, and legal literature included in the study's bibliographic corpus. This review was organised into five thematic blocks: (1) physical and environmental mechanisms explaining UHI formation, grounded in classic and contemporary studies in urban climatology [1–3]; (2) thermal inequality and climate justice, based on research demonstrating the differentiated distribution of thermal risk as a function of socio-economic and urban variables [5,6]; (3) nature-based solutions and green infrastructure as mitigation instruments, both within the European green infrastructure framework [33] and in doctrinal and planning proposals centred on climate change adaptation [34,35]; (4) urban climate governance and multi-scalar adaptation, drawing on global frameworks, IPCC reports, and specialised literature on the articulation between urban planning regulation and climate change [11,35,36]; and (5) international experiences that have developed quantifiable urban planning standards, especially in New York, Singapore, Tokyo, and Berlin, whose cases have been widely documented in the literature [19,21,23,24]. The purpose of the review is not statistical exhaustiveness but conceptual coherence, enabling the identification of common patterns in urban science, climate adaptation, and comparative urban planning regulation. The bibliographic search was structured primarily through specialised academic databases and cross-references in key works, using terms related to UHI, thermal injustice, nature-based solutions, urban climate governance, and urban planning standards, with a preference for literature published over the last two decades.

Second, a legal content analysis was conducted on the multilevel regulatory framework that conditions the incorporation of operational climate criteria into urban planning. This analysis covers, at the international level, the environmental principles of the Rio Declaration [37] and subsequent global climate action frameworks; at the European level, strategic communications on green infrastructure and urban adaptation [11,33]; and, domestically, national, regional, and local legislation. At this latter level, the analysis covered Law 7/2021 on Climate Change and Energy Transition [15], which establishes general mandates linked to mitigation and adaptation; the Consolidated Text of the Land and Urban Rehabilitation Act [38], which defines Spain's basic urban planning framework; and the main regional laws with relevance for climate and urban planning, including Catalonia's Law 16/2017 [26], Valencian land-use and urban planning legislation [16], and recent Madrid regulations on the environment and the circular economy [39]. At the municipal level, climate strategies and adaptation plans were analysed, such as Madrid's Energy, Climate and Air Strategy [17], the Special Plan for Green Roofs [40], Valencia's Climate Change Adaptation Plan [18], and Zaragoza's climate strategy [27], which make it possible to observe different degrees of integration of climate criteria into urban planning. The analysis focuses on the legislation in force at the time of drafting the study, prioritising consolidated texts and excluding draft regulations at an early stage of processing in order to ensure comparability.

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To ensure comparability, a matrix of homogeneous categories was applied across all the norms, plans, and instruments analysed. This matrix is structured around six dimensions: (1) explicit recognition of thermal risk and mention of the UHI; (2) the existence of binding climate mandates; (3) incorporation of quantifiable standards related to vegetation, permeability, albedo, or thermal comfort; (4) mechanisms for integrating these standards into urban planning instruments; (5) the presence and enforceability of nature-based solutions; and (6) monitoring, evaluation, and enforcement systems. Table 2 synthesises this multilevel framework and provides the context necessary to apply the matrix to the Spanish system.

The third methodological axis consists of a comparative analysis between the Spanish case and a set of international cities that have adopted quantifiable standards to mitigate the UHI. These include New York's green ordinances, which require the installation of vegetated roofs and reflective materials in new and refurbished buildings [19]; Singapore's incentive and regulation programmes for high-rise greenery, framed within the Skyrise Greenery Incentive Scheme and linked to indicators such as the Green Plot Ratio [23]; Tokyo's Green Building Program, which establishes minimum percentages of green roofs and complementary measures for climate efficiency [21]; and Berlin's Biotope Area Factor, a mandatory ecological metric applied within urban planning that combines vegetation, permeability, and ecosystem services [24,25]. Table 3 synthesises these models, which are subsequently compared with the Spanish framework through Tables 4–6.

The tables play an active methodological role. Table 1 synthesises the physical factors explaining the UHI and justifying the need for climate-oriented urban planning standards [1–3]. Table 2 represents the multilevel normative architecture subjected to analysis. Table 3 compiles quantifiable international standards [19,21,23,24]. Table 4 organises the regional analysis applied to Catalonia, the Valencian Community, Andalusia, and Madrid, showing significant differences in the normative integration of climate [15,16,26,39]. Finally, Tables 5 and 6 present the study's propositional outcome: a set of quantifiable climate-oriented urban planning standards and a multilevel integration model consistent with the distribution of competences in Spanish law [15,16,36,38].

Overall, this methodology makes it possible to rigorously articulate the physical evidence on UHIs, the theoretical reflection on climate justice and nature-based solutions, and the legal analysis of a complex normative system. The combination of a structured literature review, multilevel legal content analysis, and an international comparison of standards provides a solid basis for assessing the position of Spanish urban planning law in the face of the challenge of extreme heat and for formulating operational normative proposals that make it possible to move towards climate-responsive urban planning grounded in verifiable metrics.

3. Theoretical Framework

3.1. Scientific Foundations of the Urban Heat Island

The urban heat island (UHI) is one of the most widely studied and best-characterised local climate phenomena in the scientific literature. Since Howard's pioneering observations [1], research has consistently shown that urban environments can experience significant thermal increases relative to their surrounding rural areas, reflecting a distinctive thermal behaviour derived from the physical transformations associated with the urbanisation process. Contemporary urban climatology has confirmed that the UHI is not a merely meteorological phenomenon, but rather the thermal expression of profound modifications of the Earth's surface that alter the urban energy balance and generate specific microclimates with persistently elevated temperatures [41–43]. Recent studies have expanded this understanding by showing that the magnitude of the phenomenon intensifies as urban densification and the fragmentation of green areas increase—patterns observed systematically in European, North American, and Asian cities [7,8,44–46].

The phenomenon manifests in two complementary forms: the surface UHI—relating to the temperature of pavements, roofs, and façades—and the atmospheric UHI—linked to the warming of air in the urban boundary layer. The surface UHI depends mainly on the radiative and thermal properties of materials, particularly albedo, thermal inertia, and emissivity. Asphalted surfaces or dark roofs can reach increases of more than 15 °C under conditions of intense radiation, subsequently releasing the accumulated heat during the night [47]. The atmospheric UHI, more closely related to the three-dimensional configuration of the urban fabric, typically ranges from 1 °C to 5 °C above peri-urban values, depending on factors such as the height-to-width ratio of streets, the degree of natural ventilation, and the presence or absence of vegetation [2,3,48,49]. The microclimatic literature has shown that these differences can exceed 6 °C in Mediterranean settings with low ventilation and limited shade, confirming the sensitivity of the phenomenon to small morphological variations [9,50]. This type of intervention has been extensively analysed in technical literature on cool roofs, which shows consistent thermal reductions under diverse climatic conditions [32].

The literature identifies several urban factors that explain the formation and magnitude of the UHI. First, soil sealing drastically reduces evapotranspiration, one of the most effective natural mechanisms for dissipating heat. The replacement of permeable surfaces with rigid pavements increases surface temperature and decreases relative humidity, intensifying thermal stress in densely built areas [1,3]. Second, the use of low-albedo materials, such as asphalt or concrete, entails high absorption of solar radiation, which increases the thermal load accumulated during the day and prolongs nocturnal warming. Research on the thermal properties of materials has shown that relatively small variations in albedo can produce significant decreases in surface temperature and improve buildings' energy efficiency [32,51,52].

A third key factor is the loss of urban vegetation, closely linked to reduced shade, reduced evapotranspiration, and greater direct exposure of surfaces to solar radiation. Different studies in urban ecology have shown that the absence of vegetative cover increases air and surface temperatures, especially in vulnerable neighbourhoods with lower availability of green infrastructure [53,54]. Comparative results in Mediterranean and Asian cities confirm that even small, vegetated areas can reduce local temperatures by 1–3 °C, underscoring their value as baseline climate infrastructure [55,56]. Fourth, dense urban morphology—characterised by narrow streets, tall buildings, and compact structures—hinders ventilation and thermal exchange with the external atmosphere, favouring heat trapping and the persistence of high night-time temperatures [2,17]. This morphological influence has been widely documented in studies analysing the relationship between urban geometry and ventilation flows, confirming its role as a structural modulator of urban thermal behaviour [57].

Finally, anthropogenic heat derived from road traffic, air-conditioning systems, urban lighting, or intensive energy use contributes to increasing air temperature, particularly during night-time hours, when the urban atmosphere exhibits a lower capacity for thermal dispersion. The combination of these elements is amplified by climate change, which increases the frequency and intensity of heatwaves, causing UHIs to act as genuine urban thermal amplifiers [3,55]. This amplifying effect has been identified as one of the main synergies between global warming and urbanisation, and it explains the deterioration of urban thermal comfort recorded in recent decades [7].

Taken together, these factors configure an urban thermal system that is highly dependent on the city's physical, functional, and regulatory characteristics. The evidence shows that UHIs are not inevitable phenomena, but rather the cumulative result of urban planning decisions that determine material selection, urban form, the presence of vegetation, soil permeability, and the thermal efficiency of public space. For this reason, urban planning assumes a strategic role in UHI mitigation: by acting on these elements, it can structurally modify the city's thermal behaviour and reduce population exposure to extreme heat. Comparative literature confirms that quantifiable planning standards—such as ecological indices or reflectance requirements—are effective in reducing urban thermal intensity when applied systematically [23,30,31]. This scientific basis constitutes the conceptual foundation that will later justify the formulation of quantifiable climate-oriented urban planning standards.

Table 1. Explanatory factors of Urban Heat Island (UHI) intensity.

Urban Factor	Thermal Mechanism	Associated Scientific Evidence
Soil sealing	Reduces evapotranspiration and increases surface temperature	Howard (1818) [1]; Santamouris (2015) [3]; Zhou et al. (2021) [7]
Low-albedo materials (asphalt, concrete)	Greater absorption of solar radiation; nocturnal release	Santamouris (2014) [31]; Levinson & Akbari (2010) [32]
Loss of urban vegetation	Less shade; lower relative humidity	Harlan et al. (2006) [5]; Fariña Tojo et al. (2013) [54]
Dense urban morphology	Less ventilation and greater heat accumulation	Arellano Ramos & Roca-Cladera (2021) [42]; Arellano Ramos & Roca-Cladera (2016) [56]
Climate change and heat waves	Amplification of urban thermal risk	IPCC (2021) [58]; AEMET (2023)

3.2. Socio-Environmental Effects: Public Health, Vulnerability, and Thermal Justice

The urban heat island is not only a physical phenomenon; it is also a territorial manifestation of socio-environmental inequalities that affect the population in differentiated ways. The literature on thermal vulnerability has widely documented that exposure to extreme heat is unevenly distributed according to socio-economic, demographic, and territorial variables. Key studies conducted in metropolitan areas of the United States and Europe have shown that neighbourhoods with lower income, higher building density, lower vegetative cover, and structural deficiencies in public space experience significantly higher temperatures during extreme heat episodes [5,6,59]. Recent work in Mediterranean and Latin American cities confirms this trend and shows that thermal injustice correlates with indicators of social and environmental vulnerability [50,55]. These patterns reproduce pre-existing socio-spatial inequalities and expose certain groups to a disproportionate climate risk, constituting what various authors describe as "thermal injustice".

From the public health perspective, the evidence is equally compelling. Heat epidemiology has shown that relatively modest increases in air temperature—for example, 1 °C to 2 °C—can increase non-accidental morbidity and mortality, especially among older people, children, individuals with chronic illnesses, or populations without adequate access to shade, ventilation, or green spaces [4,60]. Heatwaves intensify these risks by reducing the capacity for physiological recovery during the night, particularly in areas with high density, low albedo, or scarce vegetation. International reports have also emphasised that these impacts disproportionately affect the most vulnerable groups, making thermal stress a public health issue with a human rights dimension [28].

The unequal distribution of thermal effects turns the UHI into an environmental justice problem. In Mediterranean cities, where prolonged heat exposure coincides with dense urban fabrics and, at times, structural deficits in urban quality, these inequalities are exacerbated and generate cumulative vulnerabilities. Thus, the UHI not only increases energy demand and reduces liveability but also contributes to deepening socio-economic gaps through an unequal distribution of climate risk. This pattern has been identified as a structural element of urban environmental inequality, especially in contexts with insufficient or unevenly distributed green infrastructure [54,56].

From a theoretical standpoint, these patterns justify the need to integrate principles of thermal equity into urban planning law and urban planning practice. Decisions regarding vegetation, soil permeability, materials, or public space design not only determine overall mitigation of the phenomenon, but also directly shape the spatial distribution of climate benefits. For this reason, the literature agrees that addressing thermal inequality requires binding measures that guarantee a minimum and equitable access to conditions of urban climatic comfort, particularly in the most vulnerable neighbourhoods. For various authors, the normative articulation of this principle constitutes a fundamental requirement of contemporary climate justice frameworks [14,36,58].

3.3. Nature-Based Solutions and Urban Climate Mitigation

Nature-based solutions (NBSs) have become firmly established over the last decade as one of the most effective approaches to mitigate the city's thermal effects and improve resilience to climate change. Their scientific foundation rests on the capacity of vegetation and permeable soils to reduce surface and atmospheric temperatures through evapotranspiration processes, shade provision, solar radiation interception, and microclimatic regulation [9,54,61,62]. These mechanisms make it possible to reduce the thermal load of pavements and buildings, improve ventilation within urban space, and reduce UHI intensity, especially during extreme heat episodes.

The relevance of NBSs is greater in areas with high urban density and a scarcity of green spaces, where small interventions—such as street trees, green corridors, vegetated roofs and façades, or re-naturalised schoolyards—can generate significant thermal reductions and improve the liveability of public space. In Mediterranean contexts, characterised by high levels of solar radiation and prolonged summers, empirical evidence shows that the strategic incorporation of vegetation can reduce local surface temperatures by several degrees, attenuate thermal stress, and improve air quality [63–65].

At the European level, green infrastructure has been recognised as an essential element for climate adaptation. The European Union has promoted the need to develop continuous ecological networks operating at multiple scales—regional, metropolitan, and urban—fostering connectivity, the provision of ecosystem services, and resilience to heat [33]. This vision aligns with contemporary urban planning literature, which emphasises that NBS only reach their full potential when integrated into spatial planning and supported by normative instruments that guarantee their implementation and maintenance [34,35].

Comparative experience also highlights the importance of combining vegetation with sustainable water management strategies. Elements such as permeable pavements, sustainable urban drainage systems, rain gardens, shaded water features, or water retention structures can reduce surface temperatures, improve infiltration, and reinforce thermal reduction without significantly increasing water demand. Technical literature stresses that the most effective thermal mitigation derives from integrated interventions combining vegetation, permeability, and solar radiation control [9,31,34,63].

From a doctrinal perspective, NBS constitute an essential pillar of climate-responsive urban planning. Their mitigation potential, widely demonstrated, should be translated into verifiable planning parameters—such as minimum vegetation percentages, ecological indices, permeability coefficients, or shade requirements—that make it possible to monitor compliance and ensure that climate benefits are distributed equitably across the city's neighbourhoods. This theoretical foundation prepares the ground for the formulation of quantifiable urban planning standards that will be developed later in the article.

3.4. Urban Climate Governance and Multilevel Normative Frameworks

Climate change adaptation, and in particular the mitigation of the urban heat island, unfolds within a complex institutional architecture in which international, European, national, regional, and local normative frameworks interact. This multilevel system largely determines cities' capacity to translate scientific knowledge into operational legal instruments and to integrate climate criteria into spatial and urban planning.

At the international level, the United Nations Framework Convention on Climate Change [53], the Paris Agreement [51], and the New Urban Agenda [66] have established general principles of mitigation and adaptation that guide States' climate action. Although these frameworks do not contain specific provisions on urban planning regulation, they do provide the political and legal foundation for promoting climate-responsible interventions across the territory. Literature on urban climate governance highlights that these global commitments have driven greater attention to local-scale adaptation and have stimulated the incorporation of climate criteria into different sectors of urban management [11].

At the European level, the green infrastructure strategy, communications on urban adaptation, initiatives associated with the European Green Deal, and sectoral strategies such as the Sustainable and Smart Mobility Strategy [67] have been decisive in reinforcing the role of urban planning in mitigating climate risks. These policies emphasise the need to integrate nature-based solutions, promote the energy efficiency of the built environment, and develop resilient urban networks through interventions in territorial and urban planning. The European Union has thus played a key role in recognising climate as a structural variable of urban planning, although the binding force of these guidelines depends on their incorporation by Member States [12–14,33,68].

At the national level, Spanish legislation has advanced in integrating climate objectives through Law 21/2013 on Environmental Assessment [69], which requires the assessment of environmental impacts of plans and programmes, and Law 7/2021 on Climate Change and Energy Transition [15], which establishes general mandates relating to mitigation and adaptation. Although spatial planning is a competence of the autonomous communities, this law constitutes an orienting framework that links territorial actions to national climate objectives and requires consideration of risks derived from global warming in sectoral and urban planning. Likewise, the Consolidated Text of the Land and Urban Rehabilitation Act [38], as well as the Long-Term Strategy for the Energy Renovation of the Building Sector [70], incorporate criteria of sustainability, quality of life, and resource efficiency that serve as a legal basis for integrating climate standards into regional and municipal regulation.

The regional level is particularly relevant, as the autonomous communities are directly responsible for defining the regulatory framework for urban planning. Spanish legal scholarship has noted that the incorporation of climate criteria is highly heterogeneous: while some regions have introduced explicit references to adaptation or green infrastructure [16,26], others have progressed through sectoral regulation in environmental or energy matters [39]. This diversity generates a regulatory mosaic that conditions the possibilities of integrating common climate standards and makes it difficult to move towards climate-responsive urban planning that is homogeneous across the territory as a whole [35,36].

Municipalities, as the level closest to the territory, play a fundamental role in implementing climate measures, especially through public space design, urban tree management, building by-laws, mobility plans, or urban re-naturalisation programmes. However, their normative capacity depends on the national and regional framework, making coherent vertical governance and coordination mechanisms essential to ensure compatibility across scales.

Overall, urban climate governance reveals the need for legal frameworks that articulate competences, align climate objectives, and ensure that the different institutional levels act coherently to mitigate thermal risks. This multilevel approach provides the theoretical basis for understanding the regulatory heterogeneity existing in Spain and underpins the formulation of climate integration mechanisms that will later be specified in the article's proposals.

Table 2. Multilevel regulatory framework applicable to climate integration in urban planning (international–EU–Spain).

Regulatory Level	Legal/Strategic Instrument	Relevance for UHI and Climate-Sensitive Planning
International	UNFCCC [53]; Paris Agreement [51]; 2030 Agenda [52]; New Urban Agenda (Habitat III) [66]	Recognition of urban mitigation and adaptation as state obligations
European Union	European Green Deal [12]; European Climate Law [13]; EU Strategy on Adaptation to Climate Change [10]	Introduces the obligation to integrate climate risk into urban planning
Spain (national)	Law 7/2021 on Climate Change and Energy Transition [15]; Law 21/2013 on Environmental Assessment [69]	Requires integrating climate change—including adaptation to urban heat—into spatial planning
Autonomous Communities	Catalonia (Law 16/2017 on Climate Change) [26]; Andalusia (Andalusian Climate Action Plan 2021–2030) [71]; Valencian Community (TRLOTUP 2021 and climate strategies 2030) [16,72–74]; Community of Madrid (Energy, Climate and Air Strategy 2023–2030) [17]	Introduce the obligation to integrate nature-based solutions, climate risk and urban resilience
Municipalities	SECAPs, local climate plans, green by-laws and adaptation strategies	Operational instruments for urban adaptation and mitigation

3.5. Climate-Responsive Urban Planning: Definition, Scope, and Evolution of the Concept

Climate-responsive urban planning has emerged in recent years as a theoretical proposal aimed at structurally integrating the climate variable into spatial planning and urban space regulation. In contrast to traditional approaches focused on functional efficiency, compactness, or balanced growth, climate-responsive urban planning places climate change mitigation and adaptation as constitutive elements of the urban project. This approach recognises that planning and urban regulation directly affect exposure to thermal risk and the city's capacity to respond to extreme phenomena associated with global warming [34,36,58].

The conceptual evolution of this field reflects a transition from sustainable urban planning—oriented towards general objectives of energy efficiency, sustainable mobility, or emissions reduction—towards a paradigm that demands metric precision and scientific grounding. Under current conditions of urban warming, specialised literature emphasises that climate adaptation requires intervening on specific planning variables: urban form, soil permeability, vegetation, albedo, natural ventilation, or ecological continuity. These variables cannot be managed solely through strategic orientations; they must be translated into verifiable standards that condition urban design and building practices [34,35].

Reference authors in Spanish scholarship, such as Cantó López, Ruiz de Apodaca, and García Sánchez, have emphasised that climate change requires reinterpreting the fundamental categories of urban planning law. Aspects such as liveability, environmental efficiency, or the ecological structure of the territory acquire a climatic dimension that calls for new forms of regulation. This literature agrees that urban planning must integrate specific obligations linked to adaptation, including the thermal control of the built environment, the systematic re-naturalisation of urban space, and the incorporation of minimum thresholds of ecosystem services [35,36].

A fundamental element of climate-responsive urban planning is the requirement for quantifiable standards. International and comparative literature has shown that pioneer cities in thermal mitigation—such as New York, Singapore, Tokyo, or Berlin—have achieved significant progress through the introduction of mandatory metrics related to vegetation, permeability, green roofs, shade, thermal efficiency, or material reflectance. These cases illustrate that the principles of climate-responsive urban planning are consolidated only when regulation establishes enforceable parameters integrated into permits, planning instruments, and by-laws [19,21,23,24].

From a conceptual perspective, climate-responsive urban planning therefore constitutes a framework that articulates scientific evidence and urban regulation through verifiable standards. Its purpose is not only to reduce emissions or improve energy performance, but also to ensure that urban form provides adequate conditions of thermal comfort, environmental equity, and resilience. This doctrinal evolution prepares the ground for the justification of the climate-oriented urban planning standards that will be developed later in the article.

3.6. Regulatory Heterogeneity in Spain: Theoretical Understanding of a Fragmented System

Spain presents a decentralised territorial model in which the autonomous communities hold exclusive competence in urban planning. This distribution of competences has generated a diverse normative landscape in which each region has integrated—at different levels—climate criteria into its planning legislation. From a theoretical standpoint, this normative mosaic is a central element for understanding the possibilities and limitations of climate-responsive urban planning in Spain, as well as the need for mechanisms of normative coordination.

Spanish legal scholarship has emphasised that, although some autonomous communities have progressed in incorporating explicit references to climate change and green infrastructure, these advances have not always translated into quantifiable standards. Catalonia, for example, through Climate Change Law 16/2017, has established relevant mandates on mitigation and adaptation. However, its urban planning legislation continues to organise planning without requiring verifiable thermal parameters, revealing a lack of coherence between climate objectives and operational planning tools [26].

The Valencian Community has expressly recognised the importance of green infrastructure in its Consolidated Text of the LOTUP [16] and in its climate strategies [72–74], and it integrates environmental sustainability as a guiding principle of planning. However, the absence of metrics on minimum vegetation, permeability, or thermal comfort limits the ability of regulation to guide UHI mitigation. This case illustrates a pattern identified in the literature: normative recognition of adaptation does not necessarily imply translation into concrete obligations [16,36].

In Madrid, regional regulation has experienced advances in environmental matters, especially linked to the circular economy and urban environmental quality [39,75]. However, these efforts have been developed mainly through sectoral strategies and municipal plans, without yet incorporating climate standards into regional urban planning legislation. The literature identifies here a frequent gap: the presence of ambitious strategic frameworks does not guarantee their integration into binding planning, which limits their real impact on urban form [35,36].

Andalusia presents an even more incipient approach. Its urban planning legislation includes general references to sustainability and environmental protection, but lacks specific provisions related to thermal mitigation or adaptation to extreme heat. Specialised literature considers this case representative of the difficulties of progress in the absence of a national framework establishing minimum standards applicable across the territory [36,71].

From a theoretical standpoint, this regulatory heterogeneity has three fundamental implications. First, it evidences the lack of common criteria capable of guiding urban climate adaptation in a homogeneous manner. Second, it demonstrates that decentralisation, in the absence of adequate coordination mechanisms, leads to territorial inequalities in protection against thermal risk. Third, it confirms the need for a multilevel normative structure capable of integrating climate-oriented urban planning standards at all levels of government.

This conceptual analysis provides the basis for understanding the divergences observed among autonomous communities in the study's empirical results and justifies the importance of the legal integration mechanisms that will be proposed in Tables 5 and 6.

3.7. Conceptual Divergences in Urban Adaptation: Theoretical Contributions from the Comparative Study of Cities

Cities constitute privileged settings for analysing how different institutional frameworks [76–78], administrative capacities, and planning traditions shape adaptation to extreme heat. Although empirical results evidence differences among Spanish municipalities and between them and international cities, from a conceptual perspective these divergences make it possible to extract key lessons about the role of urban planning in UHI mitigation.

The literature on urban governance stresses that cities act as nodes of climate innovation, but also as spaces where institutional, economic, and legal constraints become more visible [11,35,36,79]. Comparing different urban contexts shows that the capacity to integrate the thermal variable into planning depends on structural elements such as the existence of robust climate diagnoses, the degree of technical specialisation within local administrations, the availability of appropriate normative instruments, and articulation across levels of competence. This perspective allows divergences observed among cities to be interpreted not as anomalies, but as expressions of differentiated institutional frameworks. These divergences are clearly reflected in the climate strategies and action plans developed by major Spanish cities [76,80–82].

A central theoretical element is the distinction between strategic climate policies and binding urban planning regulation. The literature notes that many cities develop ambitious climate strategies, but do not necessarily translate them into mandatory planning standards that condition urban form. This fracture between planning and strategy constitutes one of the main challenges of adaptation to extreme heat: without quantifiable obligations, thermal mitigation remains subject to administrative discretion or to contingent political will.

Another relevant aspect is the relationship between administrative capacity and normative complexity. Cities with consolidated planning frameworks, high levels of technicalisation, or a tradition of environmental planning tend to integrate climate criteria more rapidly into their planning instruments. By contrast, contexts with fragmented normative structures or with lower capacity to monitor standards face greater difficulties in incorporating thermal metrics. This dynamic has been documented by multilevel governance literature, which emphasises the importance of vertical and horizontal coordination to overcome the limitations inherent to each municipality [11].

Finally, from a theoretical perspective, city comparisons make it possible to identify common patterns in climate integration: (1) the need for verifiable metrics to ensure the effectiveness of interventions; (2) the relevance of green infrastructure as a structural component of climate-responsive urban planning; (3) the importance of institutional frameworks capable of sustaining climate policies beyond specific political cycles; and (4) the recognition that thermal inequality requires planning instruments that guarantee an equitable distribution of climate benefits.

These conceptual conclusions prepare the ground for the empirical analysis of the cities presented in the Results Section and provide the theoretical basis for the need for climate-oriented urban planning standards such as those proposed in Tables 5 and 6.

3.8. Quantifiable Urban Planning Standards: Theoretical Contributions from International Experience

Comparative literature on climate-responsive urban planning offers a set of benchmarks that help to understand the theoretical value of quantifiable urban planning standards as thermal mitigation instruments. Although the nature and scope of these standards vary across cities, from a conceptual perspective they share the same logic: they translate scientific evidence into verifiable obligations that condition the city's thermal behaviour [19,24].

The first theoretical contribution of international experience is the demonstration that climate standardisation is technically and legally feasible. Consolidated systems in different countries have incorporated binding metrics on vegetation, permeability, green roofs, thermal efficiency, or reflectance, showing that quantified obligations can be integrated into planning permits, by-laws, and environmental assessment processes without compromising administrative operability [19,21,23,31,83]. This finding is fundamental for the Spanish legal debate, where the absence of binding thermal parameters constitutes one of the main normative gaps.

A second theoretical lesson is the relevance of designing standards that combine obligatoriness and flexibility. Comparative literature notes that the most effective instruments are those that establish a minimum threshold—for example, an ecological index, a percentage of vegetation, or a reflectance level—while allowing multiple configurations to meet it. This model favours the adaptation of standards to diverse local contexts without relinquishing legal enforceability or climate coherence [23,23,30].

Third, international experiences show that compliance monitoring is a structural element of the success of climate standards. The most robust normative frameworks incorporate verification, monitoring, and accountability systems that ensure climate metrics do not remain as programmatic statements but rather materialise in concrete planning interventions. From a doctrinal perspective, this approach reinforces the idea that standards should form part of the "hard core" of urban planning law, with clear administrative procedures for their application [21,25,63–65].

Finally, international comparison yields an essential theoretical conclusion: mitigating the urban heat island requires integrating objective measurements into planning. Urban science has identified the variables that determine thermal intensity—vegetation, permeability, albedo, ecological continuity, or urban form—and quantifiable standards constitute the conceptual bridge between that knowledge and urban planning regulation. Thus, comparative experience not only demonstrates regulatory possibilities, but also legitimises the formulation of standards adapted to the Spanish context [23,24].

These theoretical contributions frame the results analysis and underpin the article's normative proposals, in particular the climate-oriented planning standards structured in Table 5 and the multilevel integration mechanisms in Table 6.

3.9. Theoretical Synthesis: Towards an Integrated Conceptual Framework for Climate-Oriented Urban Planning Standards

The review of scientific, planning, and legal knowledge developed in the preceding sections makes it possible to articulate a coherent theoretical framework underpinning the need to incorporate quantifiable climate-oriented urban planning standards into the Spanish normative system. The different blocks analysed—physical foundations of the UHI, socio-environmental impacts, nature-based solutions, multilevel governance, climate-responsive urban planning, and regulatory heterogeneity—converge in a set of structural principles guiding the formulation of operational legal criteria for mitigating extreme urban heat.

First, the scientific literature unequivocally demonstrates the existence of a causal link between the city's physical characteristics and urban thermal intensity [2,3,8,9,58]. Morphology, materials, vegetation, and soil permeability constitute determinant variables that can be legally regulated through quantifiable standards. This point is essential: the parameters explaining the formation of the urban heat island are the same ones upon which urban planning acts, which confers a central role on planning in climate adaptation.

Second, epidemiological and socio-spatial evidence establishes that extreme heat does not affect the entire population equally and that UHIs exacerbate existing inequalities, generating patterns of thermal injustice [5,6]. This finding adds a further normative dimension to the phenomenon: mitigating urban heat is not merely an environmental objective, but also a requirement of territorial equity. Consequently, planning instruments must guarantee minimum thermal conditions across all neighbourhoods, especially those historically exposed to a more vulnerable urban environment. Climate justice demands translating this evidence into verifiable planning obligations.

Third, nature-based solutions constitute a scientific and doctrinal pillar for thermal mitigation, provided that their implementation does not depend exclusively on municipal discretion [9,34,35]. The literature agrees that NBS effectiveness is maximised when they are integrated into planning through quantifiable parameters—vegetation percentage, ecological indices, permeability coefficients, or shade requirements—that ensure their systematic presence throughout the city. This approach integrates ecological, climatic, and social functions, strengthening the relationship between climate-responsive urban planning and environmental justice.

Fourth, urban climate governance reveals that institutional frameworks condition cities' capacity to act on thermal risk [11]. The coexistence of climate strategies, environmental regulation, urban planning rules, and sectoral policies generates a complex architecture requiring coordination and normative coherence. The absence of common standards leads to fragmented responses, with very disparate degrees of climate protection across territories. This finding justifies the need for legal instruments that articulate competences and define binding minimum parameters.

Fifth, the concept of climate-responsive urban planning provides the doctrinal framework integrating these elements. Its theoretical evolution has shown that urban climate adaptation cannot be grounded solely in non-binding strategies or declarations of intent [34–36]. Thermal mitigation requires the incorporation of enforceable standards that systematically condition urban form. This approach places scientific evidence at the centre of urban planning regulation and establishes a conceptual bridge between the physical knowledge of urban climate and the available legal tools.

Finally, the comparative literature shows that quantifiable urban planning standards are not only possible, but also effective and operational [19,21,23–25,30,63]. International experiences demonstrate that metrics on albedo, vegetation, permeability, thermal comfort, or green roofs can be integrated into permits, by-laws, and planning with verifiable results. From a theoretical perspective, these cases provide a fundamental principle: thermal mitigation requires measurable, flexible, and enforceable obligations.

By integrating these elements, the theoretical framework supports a key statement:

Adaptation to urban heat requires an urban planning system equipped with quantifiable climate standards and multilevel normative integration mechanisms that ensure their homogeneous application across the territory.

This approach provides the conceptual basis for the proposals contained in Tables 5 and 6 and guides the empirical analysis developed in the Results Section.

4. Results

4.1. International Comparison of Climate-Oriented Urban Planning Standards: Foundations for the Spanish Proposal

The international comparison shows that different cities worldwide have developed advanced legal instruments to mitigate the urban heat island (UHI), incorporating quantifiable standards that regulate variables such as vegetation, permeability, albedo, buildings' thermal efficiency, and ecologically active surface area. The cases of New York, Singapore, Tokyo, and Berlin provide a consolidated reference for understanding how climate metrics can be integrated into complex planning systems and effectively monitored and enforced.

New York presents one of the most robust regulatory frameworks regarding the thermal mitigation of the built stock. Its ordinances on green roofs and cool roofs establish verifiable obligations for new buildings and certain refurbishment projects, setting minimum solar reflectance levels of 0.70 and requirements for rooftop vegetation installation [19]. This model combines a binding normative mandate with a systematic technical monitoring system, enabling the assessment of surface temperature reduction following the application of the standards. New York's regulatory logic demonstrates how the requirement for thermal metrics can be integrated directly into urban permitting processes.

In Singapore, climate strategy combines regulation and promotion through instruments such as the Skyrise Greenery Incentive Scheme and the Green Plot Ratio (GPR) [23]. The GPR sets minimum ratios of structural vegetation—including green roofs and green façades—proportionate to the built floor area, ensuring the presence of green infrastructure in medium- and large-scale projects within a highly densified urban context. These instruments are complemented by economic incentives conditional on compliance with these metrics, shaping a flexible yet quantitatively demanding model. Technical literature has shown that high-rise greenery in Singapore reduces buildings' surface temperatures by between 2 and 3 °C, confirming the thermal effectiveness of this approach.

Tokyo applies a specific regulatory system through its Green Building Program, which requires the incorporation of a minimum percentage of vegetated roof—frequently 20%—in certain types of buildings [21]. This requirement is justified by technical studies on heat retention and evapotranspiration and is integrated into the administrative assessment of architectural projects, linking permit approval to demonstrated compliance with these standards. Tokyo's case shows that thermal criteria can be tailored to specific typologies, maintaining regulatory proportionality without sacrificing quantitative rigour.

Berlin represents the most consolidated European model thanks to its Biotope Area Factor (BAF), a mandatory ecological standard that determines a minimum coefficient of ecologically effective surface area for each urban plot [24,25]. The BAF assigns differentiated weights to elements such as vegetation on natural ground, trees, green roofs, permeable pavements, or water-retention surfaces, allowing compliance through multiple equivalent combinations. It is essential to clarify—so as to maintain full coherence with Table 3—that the BAF is applied mandatorily to any plot subject to detailed planning or to urban permits that modify usable area, ensuring systematic compliance regardless of project type. This combination of design flexibility and quantified obligation makes the BAF one of the most effective instruments for integrating climate criteria into urban form.

Table 3. International comparison of urban climate standards (U.S., Tokyo, Singapore, Berlin).

City/Country	Climate/Planning Instrument	Quantifiable Standards/Applied Technical Parameters	Verifiable Real Source
New York (U.S.)	Local Laws 92 & 94 (2019)–Sustainable Roof Requirements	Sustainable roofs required for new buildings and major renovations; initial solar reflectance requirement ≥ 0.70 for certain roofs	NYC Department of Buildings [20]
	Cool Roofs Program	Installation of more than 10 million ft^2 of cool roofs; reduction of surface temperature and annual energy savings	NYC Mayor's Office of Sustainability [83]
Singapore	Skyrise Greenery Incentive Scheme (SGIS)	Financial incentives for green roofs and green façades; minimum vegetation ratio per m^2 of built area	Singapore National Parks Board [23]
	Green Plot Ratio (GnPR)	Plot-level quantitative greening index: GnPR $\geq$ 3–4.5 in residential and high-density developments	Wong & Jusuf (2008) [30]
	Thermal efficiency studies of green roofs	Estimated reductions in roof surface temperature and rooftop air temperature with extensive systems in tropical climate	Wong et al. (2003) [64]
Tokyo (Japan)	Tokyo Green Building Program	Mandatory minimum percentages of green roofs for certain new buildings; complementary climate-efficiency measures	Tokyo Metropolitan Government [21,22]
	Advanced thermal research	Numerical models of heat storage and transfer in the urban subsoil	Asaeda & Ca (1996) [65]
Berlin (Germany)	Biotope Area Factor (BAF)	Mandatory ecological index applied in urban planning: minimum effective ecological area coefficients (0.3–0.6 depending on uses)	Berlin Senate (Biotope Area Factor) [24,25]

4.2. Results: Regional Analysis of Catalonia, the Valencian Community, Andalusia, and Madrid

The comparative legal analysis of the urban planning and climate regulations of Catalonia, the Valencian Community, Andalusia, and Madrid reveals a heterogeneous landscape, characterised by uneven progress and by a generalised absence of quantifiable urban planning standards specifically aimed at mitigating the urban heat island. Although all autonomous communities recognise climate change as a territorial and urban challenge, the depth of this integration and its normative operability vary significantly among them.

Catalonia constitutes the case with the most developed climate framework from a strategic perspective. Catalonia's Climate Change Law 16/2017 establishes binding mitigation and adaptation mandates and integrates the climate variable transversally into public policies. However, a detailed examination of Catalan urban planning legislation shows that this strategic ambition has not yet translated into verifiable planning parameters. Territorial and urban planning instruments include references to green infrastructure, resilience, and climate risk, but lack mandatory metrics relating to minimum vegetation, permeability, shade, albedo, or urban ventilation. Catalonia thus presents an advanced structure in conceptual terms, but without thermal standardisation applicable to land-use planning.

The Valencian Community offers an intermediate model. The Consolidated Text of the LOTUP expressly incorporates green infrastructure, ecological connectivity, and climate adaptation as structural elements of planning. These references, supported by recent regional strategies, show a clear legal recognition of the need to integrate climate risk into spatial planning. However, the analysis indicates that Valencian regulations also lack quantifiable thresholds that would allow assessment of the thermal behaviour of the urban environment. The legislation contains no mandatory minimums for vegetation, percentages of permeable surface, plot-based ecological indices, or requirements relating to the albedo of materials. Valencian regulation moves in the right direction, but it remains at a programmatic level that does not guarantee the systematic application of climate criteria in planning.

Andalusia constitutes the weakest case among the territories analysed. Although there are strategic documents related to climate action, Andalusian planning legislation does not incorporate specific thermal mitigation criteria nor planning parameters linked to climatic comfort. Adaptation to heat appears in a dispersed manner and without mechanisms that require modifications to urban form or public space design. There are no normative references to vegetation percentages, minimum permeability, ecological indices, shade conditions, or ventilation parameters. This absence of normative integration places Andalusia at a notable disadvantage in addressing UHI mitigation through stable legal instruments.

Madrid's case is distinctive: it presents a relatively advanced strategic climate framework, with instruments such as the Energy, Climate and Air Strategy and various specific ordinances—including the Special Plan for Green Roofs—which promote re-naturalisation and urban adaptation measures. Nevertheless, these advances have not been incorporated into regional urban planning legislation, which remains disconnected from the climate agenda. The Community of Madrid, like the others, lacks quantifiable urban planning standards and mandatory criteria aimed at reducing surface or atmospheric temperatures through parameters of vegetation, permeability, albedo, or ventilation. The contrast between strategic ambition and the absence of binding normative mechanisms constitutes one of this territory's most characteristic features.

Table 4. Analytical comparison among the four Autonomous Communities (Catalonia, Andalusia, Valencian Community, Madrid).

Autonomous Community	Climate–Planning Regulatory Framework	Integration of UHI in Planning	Type of Climate Parameters Introduced
Catalonia	Law 16/2017 on Climate Change of Catalonia [26]	General obligation to integrate climate risks into territorial and urban plans	Climate vulnerability indicators; reference to nature-based solutions
Andalusia	Andalusian Climate Action Plan 2021–2030 [75]	Requires sufficient provision of green areas connected as a network and strengthening green infrastructure	Ecological connectivity and permeable surfaces
Valencian Community	TRLOTUP 2021; climate and energy strategies 2030 [16,71–73]	Systematic integration of nature-based solutions and climate risk into territorial and urban planning	Green corridors, permeable pavements, climate analysis
Community of Madrid	Energy, Climate and Air Strategy 2023–2030 [17]	Sectoral and urban plans incorporate indicators of climate and thermal vulnerability	Vulnerability assessment; recommendation of nature-based solutions

The simultaneous comparison of the four cases shows a consistent pattern: no autonomous community has yet incorporated verifiable climate-oriented urban planning standards, despite the existence of detailed diagnoses and adaptation strategies. Catalonia stands out for its advanced strategic framework; the Valencian Community for relevant but insufficiently operational normative recognition; Madrid for climate-related sectoral activity not reflected in binding planning; and Andalusia for particularly limited climate integration. This diversity shows the absence of a common reference framework and confirms the need to establish homogeneous climate standards and multilevel integration mechanisms, as subsequently developed in Tables 5 and 6.

4.3. Results: Municipal Analysis of Madrid, Barcelona, Valencia, and Seville

The examination of municipal policies in Madrid, Barcelona, Valencia, and Seville reveals a common pattern: all cities have advanced climate diagnoses and specific strategies recognising the relevance of the urban heat island and its socio-environmental impacts, but none has managed to translate these advances into the binding core of its urban planning regulations. The disparity between the strategic level and the regulatory level therefore constitutes the main finding of the municipal analysis.

Madrid presents one of the broadest strategic developments in climate matters, with instruments such as the Energy, Climate and Air Strategy and the Special Plan for Green Roofs [17,40]. These documents identify areas of high thermal vulnerability, promote the implementation of vegetated roofs, support nature-based interventions, and establish lines of action to reduce heat exposure. However, despite their technical scope, these measures have not been incorporated into general planning or into mandatory urban regulation. Climate guidelines operate as recommendations or sectoral programmes, without quantifiable parameters on vegetation, permeability, shade, or albedo that would allow their application to be monitored and enforced.

Barcelona stands out for a consolidated trajectory in urban re-naturalisation, climate shelters, increased urban tree cover, and thermal comfort criteria applied to strategic projects. Municipal planning has promoted green corridors, public space transformations oriented towards thermal well-being, and technical manuals including ventilation and shading criteria [35,36]. However, these advances do not translate into enforceable planning standards. There are no minimum metrics for urban greenery, plot-based ecological indices, permeability requirements, or reflectance parameters conditioning the approval of new developments. Climate action is articulated primarily through projects and programmes, rather than through general planning obligations.

Valencia is another example of this dissociation. Its Climate Change Adaptation Plan [18] offers one of the most comprehensive diagnoses of urban thermal vulnerability, including detailed exposure maps and proposed interventions based on vegetation, permeability, and bioclimatic design. Nonetheless, these measures have not been integrated into the urban planning instruments currently in force, which still lack verifiable thermal mitigation standards. Valencia's strategic proposals lack a normative framework ensuring their systematic implementation, limiting their capacity to transform the urban fabric's climatic behaviour.

In Seville, the thermal problem is especially intense due to the convergence of climatic, morphological, and social factors. The city has developed significant comfort-oriented interventions, including bioclimatic actions in highly exposed areas and pilot re-naturalisation projects. However, as in the other cases, these initiatives have not been incorporated into planning instruments with general normative force. Municipal and regional urban planning regulations do not provide specific standards on shade, permeability, vegetation, or materials, revealing a clear disconnection between the magnitude of climate risk and the legal mechanisms available to mitigate it [27].

The municipal analysis therefore yields three fundamental conclusions. First, all the cities studied have robust diagnoses and detailed climate strategies, but they lack the legal instruments required to ensure implementation. Second, adaptation to heat is articulated in a fragmented manner and depends excessively on isolated projects, without mandatory mechanisms guaranteeing structural mitigation of the urban heat island. Third, the absence of quantifiable urban planning standards in the four cities confirms the need to move towards a normative framework that translates scientific evidence and sectoral strategies into verifiable obligations, consistent with the international standards analysed in Section 4.1.

This set of findings fully justifies the formulation of the climate-oriented urban planning standards set out in Table 5 and demonstrates that municipal adaptation will remain insufficient as long as parameters applicable at the general planning scale are not established.

4.4. Results: Formulation of Quantifiable Climate-Oriented Urban Planning Standards

The combined analysis of scientific evidence, international frameworks, and the gaps detected in the Spanish legal system makes it possible to formulate a coherent set of quantifiable climate-oriented urban planning standards, synthesised in Table 5. These standards are not abstract recommendations, but rather the normative translation of the factors explaining the formation of the urban heat island and of the comparative experiences of cities that have already incorporated climate metrics into their urban regulation.

The first regulatory domain concerns urban vegetation, formulated in Table 5 as a minimum tree-cover ratio $\geq$ 30% in consolidated areas. This standard is justified by the capacity of tree canopy cover to reduce air and surface temperatures through shade and evapotranspiration, as well as to improve thermal comfort in public space. Experiences such as Barcelona's superblocks or ecological ratio models applied in Singapore show that it is possible to set quantifiable thresholds of structural greenery that effectively condition urban form and climatic liveability [23,84]. In the Spanish context, where none of the cities analysed has neighbourhood- or route-scale tree-cover obligations, this standard addresses one of the most evident shortcomings.

The second standard concerns permeable surfaces, understood as surfaces that are functionally infiltrating and/or have the capacity for retention, flow attenuation (detention), and evapotranspiration, thereby partially restoring the urban hydrological cycle while simultaneously reducing the "hot platform" effect. For new urban developments, a minimum threshold of 40% functional permeability is proposed, calculated over the net area of the development site (including open spaces and the street network, as determined by the relevant planning instrument), and excluding surfaces that are merely unpaved but lack an effective capacity for infiltration or retention. Instruments such as the Biotope Area Factor (BAF)—which assigns coefficients to permeable and vegetated surfaces—demonstrate that it is feasible to establish verifiable minimum percentages as requirements for planning approval and permitting [24,25]. The absence of thresholds of this kind in Spanish regional and municipal regulation underscores the relevance of this standard.

The third standard, relating to minimum roof albedo, is specified in Table 5 as an initial solar reflectance $\geq$ 0.70 (or an equivalent Solar Reflectance Index (SRI), depending on roof typology) for certain categories of roofs. This threshold is supported by the evidence accumulated through cool-roof programmes and by studies on the radiative properties of urban materials [19,52]. Requiring a minimum reflectance value reduces the absorption of solar radiation, lowers surface temperatures, and may contribute to reducing cooling energy demand. Its verification is technically straightforward, making it a suitable standard for incorporation into building ordinances and project appraisal procedures.

The fourth regulatory domain focuses on green roofs and façades, formulated as an obligation to allocate at least 20% of roof area to vegetated solutions for certain building typologies. Table 5 links this standard to evidence showing 2–3 °C reductions in buildings equipped with high-rise greenery systems and to regulatory experiences such as Tokyo's and other contexts where green roofs have been integrated into legislation [21]. In a Mediterranean context, this standard combines thermal mitigation, improved energy performance, and the creation of urban habitats, and it directly addresses the absence of mandatory green roof requirements in current Spanish regulation.

The fifth proposed standard introduces a plot-level climate index, inspired by instruments such as Singapore's Green Plot Ratio (GPR). Table 5 formulates it as a GPR $\geq$ 4 in densely built areas, implying that each plot must reach a minimum value of ecologically effective surface area relative to its total area [23]. This index integrates vegetation, permeability, and nature-based solutions within a single metric, providing flexibility while maintaining an enforceable climate threshold. Its incorporation into the Spanish system would enable a shift from qualitative criteria to measurable plot-scale obligations.

The sixth standard concerns urban ventilation corridors, defined in Table 5 as the mandatory identification of such corridors in general planning. This standard acts on urban form configuration, ensuring that main street networks and certain open spaces are arranged to facilitate the entry and circulation of cooler air, reducing heat accumulation in dense areas. Experiences such as the planning of ventilation axes within Barcelona's metropolitan planning demonstrate the potential of this approach to mitigate atmospheric UHIs [57]. The absence of comparable requirements in Spanish general plans constitutes a relevant gap that this standard is intended to address.

Finally, Table 5 includes a standard of mandatory thermal assessment in urban planning, requiring the preparation of risk maps and microclimatic analysis in each PGOU. This standard is supported by mandates already present in Law 7/2021 on Climate Change and Energy Transition and in the National Climate Change Adaptation Plan, as well as in the European Adaptation Strategy [2,10,15]. Its function is to ensure that each new general plan or planning revision incorporates a detailed climate diagnosis and derives from it specific mitigation measures, so that the thermal dimension ceases to be ancillary and becomes a structural condition of urban planning.

Table 5. Proposal for climate-sensitive planning standards for Spanish legislation (the article's proposed framework).

Regulatory Field	**Proposed Climate Standard**	**Scientific/Legal Justification**	**International Reference Experiences**
Urban vegetation	Minimum tree canopy ratio $\geq$ 30% in consolidated areas	ISGlobal (2022) [4] indicates an approximate one-third reduction in mortality attributable to the urban heat island with 30% tree cover	Superblocks (Barcelona) [84]; Green Plot Ratio (GnPR) in Singapore [30]
Permeable surfaces	$\geq$40% permeability in new developments	Reduces runoff and overheating by increasing infiltration and evapotranspiration	Berlin's Biotope Area Factor (BAF) [24,25]
Minimum roof albedo	Initial solar reflectance $\geq$ 0.70	Significant reductions in surface temperature and cooling energy demand	Sustainable/Cool Roofs in New York [19,20,83]; Levinson & Akbari (2010) [32]

Table 5. *Cont.*

Regulatory Field	Proposed Climate Standard	Scientific/Legal Justification	International Reference Experiences
Green roofs and façades	Requirement of ≥20% green roofs in new buildings	Reductions of 2–3 °C in local air temperature and greater drops in roof surface temperature	Tokyo Green Building Program [21,22]; Wong et al. (2003) [64]
Plot-level climate index	Green Plot Ratio (GnPR) ≥ 4 in dense areas	Significant increase in urban cooling associated with higher levels of structural vegetation	Green Plot Ratio in Singapore [30]
Ventilation corridors	Mandatory identification in general planning	Improves urban thermal circulation through open and continuous ventilation axes	Barcelona Metropolitan Urban Master Plan (PDUm) [57]
Mandatory thermal assessment	Heat-risk maps and microclimate analysis in each General Urban Plan (PGOU)	Law 7/2021, art. 21 [15], and the MITECO methodological guide for climate-risk assessment [29] require integrating climate risk into territorial and urban planning	EU Strategy on Adaptation to Climate Change [10]

Note: The values of some standards included in this table (for example, the 30% tree canopy cover associated with an approximate one-third reduction in mortality attributable to the urban heat island; the roof albedo requirements of ≥0.70 for cool roofs; or the minimum percentages of green roofs and the Green Plot Ratio ranges used in Singapore and Tokyo) reproduce thresholds used literally in the scientific literature and in consolidated regulatory experiences. Other values (such as the minimum 40% soil permeability or the setting of a specific minimum plot-level climate index) are proposal-based and are formulated from that empirical evidence and those experiences, adapted to the Spanish legal-planning context.

4.5. Results: Multilevel Integration of Climate-Oriented Urban Planning Standards and Normative Mechanisms for Their Incorporation

The effective integration of quantifiable climate-oriented urban planning standards requires an institutional model consistent with the distribution of competences within the Spanish system. Table 6 synthesises this proposal through an articulation of functions across the national, regional, and municipal levels, complemented by inter-administrative coordination mechanisms and a system of continuous climate evaluation. The purpose is to ensure that the standards can be deployed homogeneously across the territory, avoiding normative fragmentation and guaranteeing their operational application in planning and urban regulation.

At the national level lie the instruments required to define countrywide climate-related thresholds and to establish harmonised technical methodologies. Pursuant to the State's power to enact basic environmental legislation (Article 149.1.23 of the Spanish Constitution), it is for this level to set baseline minimum requirements—quantitative thresholds where appropriate and, where relevant, verifiable duties, operational criteria, and procedural requirements—concerning urban vegetation, soil permeability, roof albedo, ventilation corridors, and climate-diagnostic obligations, so that no Autonomous Community may lower these baseline criteria. Likewise, the national level should provide comparable methodologies to measure and verify these standards, ensuring a unified technical basis that facilitates their application across territorial scales. Incorporating these determinations into the applicable national regulatory framework, together with technical regulatory developments, would make it possible to establish a common framework within which Autonomous Communities and municipalities can operate coherently, without prejudice to their further development and implementation within their respective competences.

On this basis, the Autonomous Communities should incorporate climate standards into their urban-planning legislation and into the regulations governing the various planning instruments. This integration entails defining minimum ecological indices, percentages of permeability and vegetation, rules on protection from heat in public space, and provisions aimed at preserving ventilation corridors. It should also provide for the regional adaptation of the Plot-Scale Climatic Index/Green Plot Ratio, setting minimum values by land-use category and establishing its method of calculation and verification. In addition, regulation is required as to how thermal diagnostics are incorporated into general, partial, or special plans, as well as the procedures for verification and follow-up. Territorial strategies and regional adaptation plans may serve as complementary frameworks guiding the application of these standards in a manner consistent with the environmental and climatic structure of each territory. Moreover, autonomous communities should establish periodic review mechanisms enabling planning instruments to be updated when climatic indicators reveal thermal deterioration or non-compliance with the defined thresholds.

At the municipal level, standards are applied directly to the territory. General plans should include binding provisions concerning minimum structural vegetation, soil permeability, the configuration of urban space to promote ventilation, and thermal-comfort conditions in public space. Special plans may strengthen these obligations in areas exposed to higher thermal risk, allowing for targeted interventions aimed at re-naturalisation or the structural shading of vulnerable zones. Municipal building and urbanisation ordinances function as immediate instruments to regulate high-reflectance materials, the mandatory use of vegetated or cool roofs, tree planting on plots and along streets, and climate criteria applicable to the design of open space. Effective implementation of these obligations is ensured through ordinary permitting procedures and urban-planning enforcement mechanisms, which allow compliance with standards to be scrutinised in each intervention. In particular, the calculation of the Plot-Scale Climatic Index/Green Plot Ratio should be integrated as a verifiable requirement within permits and within development or detailed planning instruments, as appropriate.

For this model to function, mechanisms of vertical coordination between administrations are essential. It is necessary to ensure the smooth transfer of climate information produced at national and regional levels into municipal planning, as well as procedures that guarantee that common standards are adequately translated into regional and local regulation. Vertical coordination also requires consultation mechanisms in cases involving amendments to urban-planning instruments with climatic implications, thereby avoiding misalignments between administrative scales and ensuring overall regulatory coherence.

Horizontal coordination constitutes another fundamental element of the model. At the regional level, it enables the adoption of common criteria among territories with similar climatic conditions, fostering coherence and preventing territorial inequalities in the level of climate protection. At the municipal level—particularly in metropolitan areas—cooperation among municipalities facilitates the joint planning of ventilation corridors, continuous green infrastructure, or shared climatic systems, which are indispensable for addressing phenomena that transcend administrative boundaries.

The system is completed by a framework of continuous climate evaluation that ensures its ongoing updating. The periodic preparation of thermal maps and urban diagnostics makes it possible to calibrate the city's actual climatic performance and to assess the effectiveness of the standards implemented. This evaluation is especially relevant when it is systematically integrated into the strategic environmental assessment of planning instruments and into the technical documentation of the general plan, so that diagnostic work and, where appropriate, microclimatic modelling operate as a verifiable basis for urban-planning determinations. Where indicators reveal thermal deterioration or the insufficiency of measures, the review of planning instruments and the updating of applied parameters should be triggered. Regular publication of monitoring reports contributes to transparency, public scrutiny, and the legitimacy of the model.

Overall, the proposal developed on the basis of Table 6 establishes a multilevel integration system that enables climate-related urban standards to be translated into effective obligations. The model articulates differentiated yet complementary functions across levels of government and ensures that climate criteria can be applied homogeneously across the territory, overcoming existing fragmentation and equipping urban-planning law with tools capable of responding in a structural manner to increasing thermal risk.

Table 6. Multilevel integration of climate-sensitive planning standards in Spanish legislation.

Proposed Climate Standard (Table 5)	National Level (Law 7/2021 + National Land Law + CTE)	Regional Level (Regional Planning Law)	Municipal Level (PGOU/by-Laws/SECAPs)
1. Vegetation cover $\geq$ 30%	Basic obligation to include thermal comfort indicators and a minimum shade ratio in vulnerable areas.	Specification of parameters: % vegetation cover by urban fabric; requirement for green corridors.	Climate zoning: heat maps; street-by-street tree-planting obligation; climate shelters.
2. Permeability $\geq$ 40% in new developments	Include in the Land Law the basic duty to "not increase impermeabilization without ecological compensation".	Detailed regulation: mandatory % of absorbent surface; limitation of asphalt paving.	Urbanization by-law: mandatory SUDS; permeable pavements in public space.
3. Minimum roof albedo $\geq$ 0.70	Amend the Building Technical Code (CTE) to include reflectance requirements in Section HE.	Incorporation into regional rehabilitation rules and energy-efficiency programs.	Building by-law: requirement in permits for new builds and major renovations.
4. $\geq$20% green roofs in new buildings	Amend the CTE to add a new Basic Document "DB-CU: Climate-Sensitive Urban Roofs".	Detail of building typologies subject to the obligation; regional tax incentives.	Local urban greening by-law: grants, subsidies and catalogs of suitable roofs.
5. Green Plot Ratio $\geq$ 4	National recognition of the "Plot-Level Climate Index" as a basic standard.	Adaptation of the index by Autonomous Community: minimums by urban land category.	Mandatory calculation in permits and in detailed planning (PPE, PERI).
6. Identification of ventilation corridors	Include in Strategic Environmental Assessment: obligation of microclimate modeling in PGOU.	Regional designation of "structural ventilation axes" in territorial plans.	Street layout and alignments designed to allow natural ventilation (Barcelona superilles case).
7. Mandatory thermal assessment in each PGOU	Amend art. 21 of Law 7/2021 to require thermal maps and climate scenarios.	Regional standardized methodologies for urban climate studies.	Inclusion in planning documents: climate diagnosis and mandatory measures.

5. Discussion

The findings make it possible to interpret, in an integrated manner, the degree to which verifiable climate-related criteria have been incorporated into Spanish urban-planning law and, at the same time, to assess the extent to which the system may evolve towards an operational form of climate-responsive urbanism. The first point to highlight is that the physical drivers that explain the formation and persistence of the urban heat island (UHI), synthesised in Table 1, are not variables external to urban planning, but rather dimensions that can be directly regulated through decisions on vegetation, materials, permeability, morphology, and ventilation. Scientific evidence shows that these factors are measurable and can be translated into urban-planning parameters that are quantifiable or, where appropriate, into procedural requirements and performance criteria that are likewise verifiable, which challenges the notion—still implicitly present in part of regional legislation—that the UHI is a purely physical phenomenon beyond the reach of legal intervention. The results indicate, to the contrary, that urban planning has sufficient instruments to act upon the variables that modulate urban temperature, thereby providing a legal foundation for the formulation of climate standards.

A second finding concerns the structural dimension of thermal inequality. Although the literature has shown that extreme heat affects neighbourhoods unevenly—particularly those with less vegetation, higher density, or lower urban quality—neither the regional laws nor the municipal instruments analysed incorporate parameters aimed at correcting these inequities. This regulatory gap confirms that the system recognises climate risk but lacks binding mechanisms to redistribute thermal equity or to guarantee minimum conditions of climatic habitability. The discussion therefore takes on essential legal relevance: climate standards not only reduce thermal intensity but also fulfil a redistributive function by ensuring minimum thresholds in the most vulnerable environments.

The international comparison summarised in Table 3 reinforces the feasibility of the proposed urban standards. Cities such as New York, Singapore, Tokyo, and Berlin have consolidated mandatory metrics relating to vegetation, permeability, ecological indices, or vegetated roofs and, where relevant, cool-roof requirements and reflectance parameters through technical building regulations, integrating them into both planning and building regulation. These cases demonstrate that climate standardisation is technically and legally achievable even in dense and complex urban contexts. The difference with Spain does not lie in technical or knowledge constraints, but rather in the absence of a regulatory framework that compels the transformation of urban form in accordance with thermal criteria.

The regional results set out in Table 4 confirm this gap. Despite the existence of explicit references to climate adaptation and green infrastructure, none of the regions analysed has incorporated quantifiable and systematically verifiable standards into its urban-planning legislation. Strategic progress is not translated into operational obligations, generating a persistent distance between the declaratory and the regulatory levels. This disconnection constitutes one of the structural deficits of the Spanish legal system and prevents climate adaptation from being implemented systematically on the ground.

Finally, the multilevel integration model set out in Table 6 makes it possible to reconcile scientific evidence with the constitutional allocation of competences. The results show that the legal feasibility of the system rests on a clear distribution of functions: the State sets minimum requirements and common methodologies; the autonomous communities incorporate them into their urban-planning laws and regulations; and municipalities apply them through planning instruments and ordinances. This architecture also enables plot-scale climate performance indices (e.g., a Plot-Scale Climatic Index/Green Plot Ratio) to be integrated as verifiable conditions within development planning and permitting procedures, strengthening traceability between the standard and its administrative enforcement. This architecture responds directly to the need for institutional coherence identified in the theoretical framework and makes it possible to articulate a system capable of integrating verifiable standards into urban planning.

Beyond the individual standards proposed, the core methodological contribution of this study lies in the first explicit application of the Green Plot Ratio within a European urban-planning legal framework, combined with mandatory thermal diagnostics as enforceable regulatory requirements, thereby moving climate-oriented urban planning beyond a descriptive checklist towards a quantifiable and operational legal model.

Overall, the findings fully address the research question: Spanish urban-planning law does not currently incorporate binding and measurable standards to mitigate UHIs, but it can integrate them through a coordinated combination of national baseline rules, regional development, and municipal application. The proposal advanced in this study offers a realistic normative pathway, compatible with Spain's competential structure, for moving towards fully operational climate-responsive urbanism.

6. Conclusions

The analysis demonstrates that, despite the growing severity of the UHI in the Mediterranean context and the consolidated scientific evidence on its causes and effects, Spanish urban-planning law has not yet incorporated quantifiable climate standards capable of mitigating thermal risk in a systematic manner. State legislation, regional regulation, and municipal planning formally acknowledge the need for adaptation, but do so through programmatic formulations lacking minimum thresholds for vegetation, permeability, albedo, shade, or thermal comfort, as well as lacking systematic procedural requirements for diagnosis and verification. This absence of metrics and control mechanisms explains the difficulties the system faces in integrating the thermal dimension into urban ordering.

The international comparison confirms that quantifiable urban standards are legally feasible and produce verifiable thermal outcomes. The distance between those cases and Spain does not lie in the availability of technical or scientific knowledge, but in the lack of a normative articulation capable of translating that knowledge into enforceable obligations. The results support the conclusion that the Spanish system can evolve towards operational climate-responsive urbanism through a normative architecture that combines homogeneous national baseline rules, regional development through urban-planning laws and regulations, and municipal implementation through planning instruments and ordinances.

The study proposes a coherent set of standards—relating to vegetation, permeability, albedo, ventilation, and comfort—as well as plot-scale climate performance indices (Plot-Scale Climatic Index/Green Plot Ratio), together with the legal vehicles necessary for their multilevel integration. This model constitutes a viable roadmap to strengthen the adaptive capacity of Spanish cities, reduce urban thermal intensity, and diminish territorial inequalities in exposure to extreme heat. In doing so, the research helps fill a relevant doctrinal gap and provides a solid framework for future legislative reforms in the field of climate-responsive urbanism.

Study limitations

The study has several limitations that should be taken into account. The comparative analysis focuses on four autonomous communities and four Spanish cities, which makes it possible to identify robust patterns but does not cover the full territorial diversity. In addition, the article does not include climate modelling to quantify the thermal effects of the proposed standards; while the article adopts a legal–analytical approach, future research could complement this normative dimension with bioclimatic simulations. Finally, the work analyses consolidated legislation and experiences without addressing ongoing legislative processes, which may introduce some temporal distance with respect to future reforms.

Future research lines

In light of these limitations, several research lines are identified. It is necessary to expand the analysis to a larger number of autonomous communities and cities in order to obtain a complete diagnosis of the degree of climate integration in Spanish urban planning. It would also be appropriate to combine the legal assessment of standards with interdisciplinary studies modelling their thermal impact and analysing their contribution to comfort, public health, and territorial equity. It is likewise relevant to examine in greater depth the administrative and political factors conditioning the adoption of climate standards, in order to identify barriers and opportunities for reform. Finally, future research could develop methodologies for monitoring and enforcing compliance with the standards, a key aspect to ensure their real effectiveness in cities.

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Abbreviations

The following abbreviations are used in this manuscript:

UHI	Urban Heat Islands
TFEU	Treaty on the Functioning of the European Union
CJEU	Court of Justice of the European Union
UNFCCC	United Nations on Climate Change
TRLOTUP	Consolidated Text of the Territorial Planning Law, Urban Planning and Landscape of the Valencian Community
AEMET	Spanish Meteorological Agency
BAF	Biotope Area Factor
IPCC	Intergovernmental Panel on Climate Change
ISGLOBAL	Barcelona Institute of Global Health
SDG	Sustainable Development Goals
PACES	Action Plans for Climate and Sustainable Energy
GHG	Greenhouse gas emissions
PGOU	General Urban Planning Plan
TRLSRU	Consolidated Text of the Land and Urban Rehabilitation Law

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